November 22, 1971

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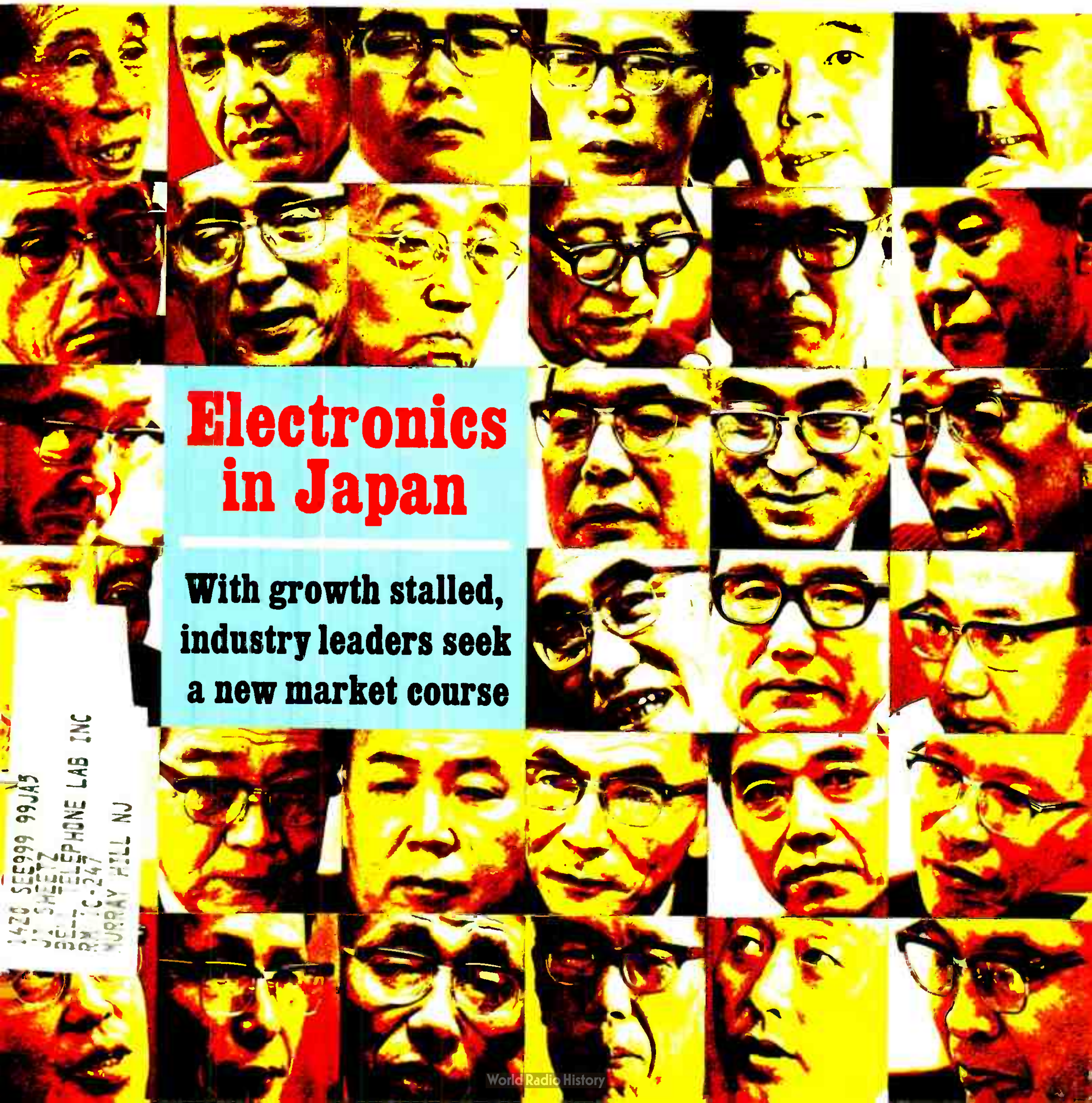
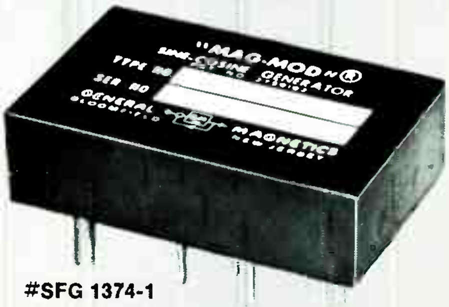
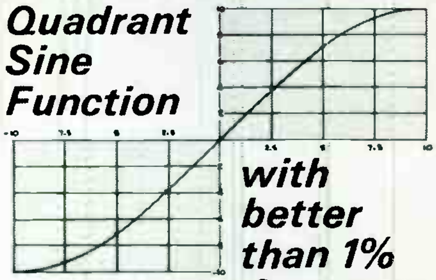


Sine-Cosine Function Generator



#SFG 1374-1

Provides A Two Quadrant Sine Function with better than 1% Accuracy



- Scaled for ±10V input and output
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- No external offset adjustments required
- Terminal provided to allow four quadrant operation

Specifications Include:

DC accuracy: ± (0.1% + 0.6% x E_{IN}/10V)

DC accuracy over the complete temperature range: ± (0.25% + 0.75% x E_{IN}/10V

Input impedance (pin 1): 9.3K Ω

Input voltage range (pin 1): ±10V DC

Rated output-voltage: ±10V DC

Rated output-current: ±5ma

Output impedance: 1 Ω

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- Precision Analog Divider
- Precision A.C. Regulators
- Demodulators
- Transformers

Analog Computing Applications

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- Multiplying
- Dividing
- Squaring
- Modulating
- Automatic Gain Control
- Demodulation
- RMS Computation
- Phase Measurement
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X & Y input signal ranges: 0 to ±3V Peak

Maximum static and dynamic product error: ½% of point or 2 MVRMS, whichever is greater, over entire temperature range

Input impedance: X = 10K; Y = 10K

Full scale output: 3 VRMS

Minimum load resistance for full scale output: 2000 ohms

Output impedance: Less than 50 ohms

X input bandwidth: ±0.5db, 0 to 200 hertz

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	HP 8447A Preamp	HP 8447B Preamp	HP 8447C Pwr. Amp.	HP 8447D Preamp	HP 8447E Pwr. Amp.	HP 8447F Preamp/Pwr. Amp.
Frequency Range	0.1-400 MHz	0.4-1.3 GHz	30-300 MHz	0.1-1300 MHz	0.1-1300 MHz	0.1-1300 MHz
Nominal Gain	20 dB	22 dB	30 dB	26 dB	22 dB	48 dB
Gain Flatness	±0.5 dB	±1 dB	±1 dB	±1.5 dB	±1.5 dB	±3 dB
Noise Figure	<5 dB	<5 dB to 1.0 GHz <6 dB, 1.0-1.3 GHz	<11 dB	<8 dB	<11 dB	<8 dB
Output Power @ 1 dB Gain Compression	>+7 dBm	>−3 dBm	>+17 dBm	>+7 dBm	>+14 dBm	>+14 dBm
Price	$550	$600	$450	$650	$700	$1175

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Are quartz oscillators good enough for your communication system?

Let's face it. Your system's performance is directly related to the quality of its frequency source. And that's why so many people are switching to atomic frequency standards.

We say this although we make some of the best quartz oscillators on the market. But then we make the best alternative.

The HP 5065A Rubidium Frequency Standard is 100 times more stable than quartz. For example, the long-term stability is 1×10^{-11} per month, and the short-term stability is 5×10^{-12} for one second averaging—the best guaranteed rubidium stability available. This means better accuracy over longer intervals between calibration and better signal to noise ratios.

Then there's our 3-year Rubidium Frequency Vapor Reference warranty. This covers the operation of the entire module, not just the gas cell part which only goes wrong once in a blue moon anyway.

So if you're working in color TV, navigation or communication systems, we can solve many of your worries. The 5065A, which costs $7500, has proved itself in the field for the past three years.

Should your applications require even greater long-term stability, ask about our Cesium Beam Frequency Standard. Its long-term drift is virtually unmeasurable.

In fact, we're the only company that can supply you with all three types of frequency source—quartz, rubidium and cesium. And your local HP field engineer is the one source for all your frequency needs. So give him a call. Or write us for complete information at Hewlett-Packard, Palo Alto, California 94304; Europe: 1217 Meyrin-Geneva, Switzerland.

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FREQUENCY STANDARDS

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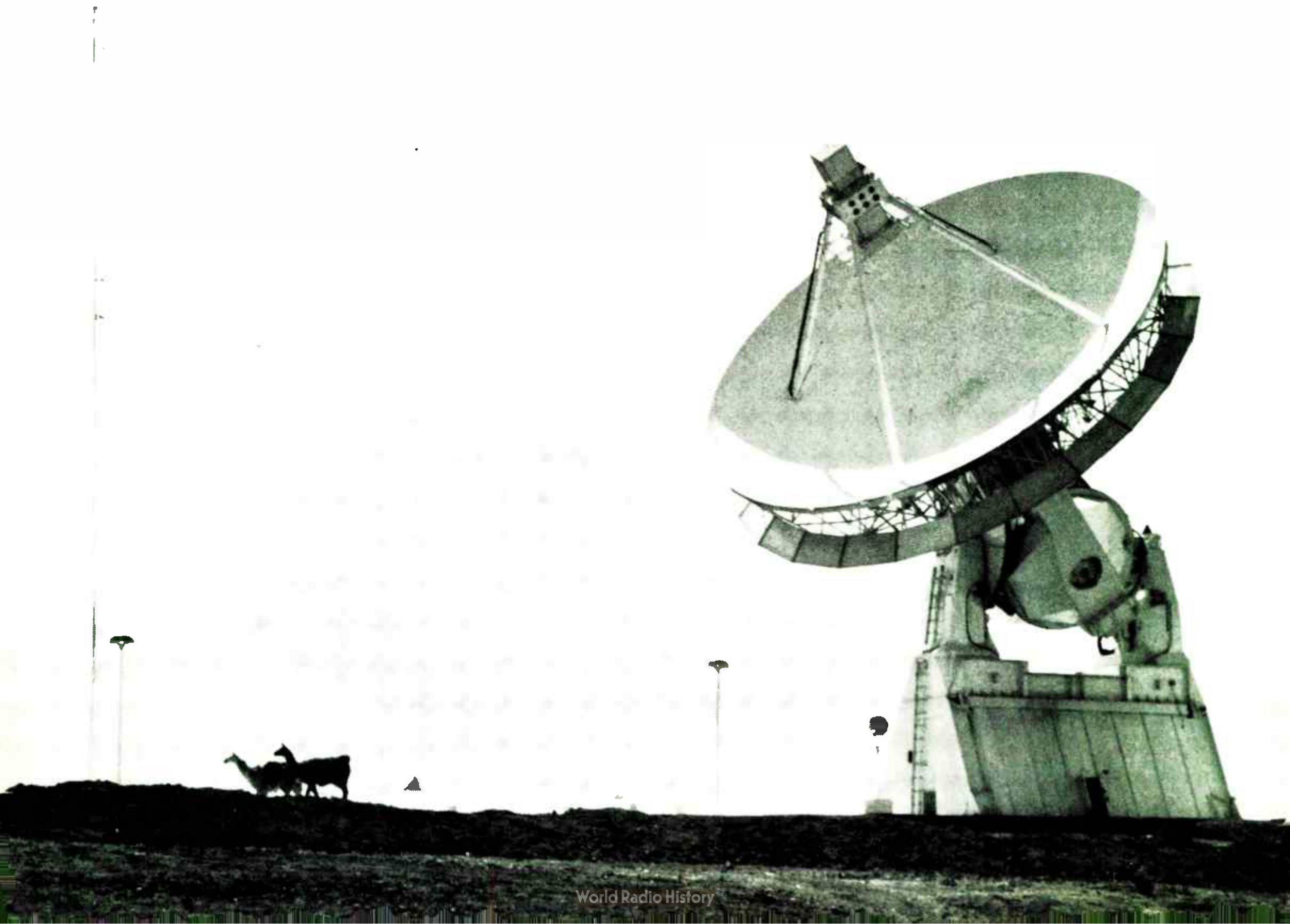

Electronics

The International Magazine of Electronics Technology

November 22, 1971

Volume No. 44, Number 24

Electronics

Publisher's letter

We doubled-teamed it once again to put together this year's special report on Japanese electronics markets (see page 119). Art Erikson, our Paris-based Managing Editor, International, put in a three-week stint in Tokyo, making the rounds with our man in the Far East, Charlie Cohen.

Like everyone involved in electronics in Japan, Erikson and Cohen checked in at the Ministry of International Trade and Industry (MITI), the mentor and guide for key industries in Japan. Writes Erikson:

"Although electronics in Japan marches to MITI's meter, you'd never guess it when you first see the agency's drab and austere headquarters in Tokyo. Nothing at first glance suggests the kind of place where decisions affecting billions of dollars of business are made.

"The lobby, if you can call it that, is no more than an oversized corridor badly in need of paint. You go up to your appointment in what seems to be a freight elevator long ago tarted up to carry passengers. The offices are vast fields of desks crammed close together amidst clumps of filing cabinets. The man who heads the electronics policy section receives visitors out in the open in a niche big enough to hold a settee, a coffee table, and two chairs.

The appearances, truly, are deceiving. And you sense that as your interview progresses. There's a constant stream of businessmen flowing through the area, nearly all freshly groomed and carrying the anxious look of executives waiting for a favorable decision.

"Leavetakings between businessmen and the MITI bureaucrats are marked by lots of polite bowing. And nearly all businessmen continue to bow to MITI's 'administrative guidance' when they're on their own home ground—their company boardrooms.

MITI has considerable clout to convince businessmen to go along with the decisions it makes—all of them intended to keep the Japanese in firm control of key industries. It portions out import licenses, for example, for the MOS/LSI chips that go into desk calculators. MITI also has the key say on who can license what from whom when it comes to technology imports.

"But MITI men insist their most potent argument is the way they reach their decisions. All their policies are a consensus worked out by industry and government officials. And they say industry members predominate on the committees where the consensus decisions are worked out. A rundown of the membership list for the electronics and data-processing groups bears them out.

"One difficulty of intensive interviewing in Japan is coping with the vast liquid intake that politeness requires. A girl bearing green tea, black tea, coffee, or cola invariably appears early in the interview. During a session one hot day at the Nippon Telegraph and Telephone Corp., a secretary turned up with a milky-looking concoction tinkling with ice. It turned out to be one of the best-tasting soft drinks I've ever had, something called calpis. It's citrusy and sweet even though it's simply a kind of fermented milk."

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1 A linear regulator produces no switching noise or spikes to mess up your logic or SCR's to hack-up the power line.

2 A forced-cooled dissipator requires *no* derating, delivers full output—or can be shorted indefinitely, *at* 71°C with no external heat sinking. The source of moving air is built-in.

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4 A fast-acting, overvoltage crowbar can be set from the panel to stand guard at a selected maximum voltage. There's an adjustable crowbar delay you can use to minimize the false alarm rate.

5 You can get them in modular form, with recessed screwdriver controls or in smart laboratory-dress with a pair of flush meters and knobs for the controls.

6 Three sizes house a selection of four power ratings in two voltage ranges. (See the table below.)

MODEL	DC OUTPUT RANGE		OUTPUT IMPEDANCE· Ohms + Microhenries			RACK SIZE	PRICE♦
	VOLTS	AMPS	d-c to 100Hz	100Hz to 1kHz	1kHz to 100kHz+μH		
CPS 6–10M	0–6	0–10	30X10⁻⁶	0.02	0.05+1	¼	$ 392.00
CPS 6–22M	0–6	0–22	14X10⁻⁶	0.02	0.05+1	½	626.00
CPS 6–45M	0–6	0–45	7X10⁻⁶	0.02	0.05+1	½	707.00
CPS 6–90M	0–6	0–90	3.5X10⁻⁶	0.02	0.05+1	Full	1,065.00
CPS 15–6M	0–15	0–6	125X10⁻⁶	0.02	0.05+1	¼	392.00
CPS 15–12M	0–15	0–12	63X10⁻⁶	0.02	0.05+1	½	626.00
CPS 15–25M	0–15	0–25	30X10⁻⁶	0.02	0.05+1	½	707.00
CPS 15–50M	0–15	0–50	15X10⁻⁶	0.02	0.05+1	Full	1,065.00

♦ Price is for metered unit, deduct $30.00 for modular style.

Kepco's CPS models aren't skimpy bargain-basement supplies. They're carefully designed, cool-running, husky power sources that you can depend upon. We've got them on the shelf. Your Kepco representative will be glad to arrange a demonstration.

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Readers comment

Acceleration

To the Editor: In the Aug. 2 issue, p. 16, you quote Harry W. Painter, technical director of the Picatinny Arsenal, as saying that he expects integrated circuits and electronics to find their way into more and more fuzes in "high-acceleration (30 g) systems because of their ruggedness." The actual level of acceleration encountered should be 30,000 g, not 30 g.

Rubin T. Weiss
Picatinny Arsenal
Dover, N.J.

Hard rider

To the Editor: The article on military electronics [July 5, p. 24] describes plans to investigate domain-tip devices as possible replacements for disk and drum memories because of the latters' fragility. My company makes a disk memory for military and industrial hard-ride applications such as those cited by the Navy in the article. It has successfully completed shock and vibration tests and is proving of considerable interest to military and defense establishments in the UK for mobile, seaborne, and airborne systems. Its price brings it well within the "0.1 and 0.3 cent per bit" margin quoted.

C.W. Layton
Process Peripherals Ltd.
Thatcham, Berkshire, England

Mask standards

To the Editor: The Electronics Newsletter of July 5 cites user problems concerning the quality of chrome masks: poor substrates, pinholes in the chrome film, and lack of reproducibility of photoresist properties. We feel that progress could be made by introducing standards for the quality control of mask blanks. For example, it is still common to claim very low pinhole densities without giving any details about the magnification used for inspection, or stating the lower limit of pinhole size. Both customers and manufacturers would profit from a general agreement on standards.

G. Zinsmeister
Balzers AG
Balzers, Liechtenstein

40 years ago

From the pages of Electronics, November 1931

The development of thermionic tubes has opened an entirely new field in the control of theater lighting. This development has made possible the obtaining of pre-set dimming, proportional dimming and a small compact switchboard such as has been heretofore impossible. The pre-set dimming feature allows an operation whereby a board may be set up for any desired number of effects in advance, so that those effects may be called for at the will of the switchboard operator simply by operating a single control.

Proportional dimming, a new feature, allows the lights to be controlled in a manner so that they may be dimmed out in combinations and obtain the same color tone throughout the dimming process. The third desirable feature is that a small compact control board may be arranged so that it can be placed as desired in the orchestra pit, or some similar location so that the operator becomes a light-artist, taking his place in the performance along with the organist or other artists.

Industry at last seems to be making the discovery that a beam of light, in itself requiring no power, and no space for its location when not in service, can be made to control machinery consuming vast quantities of power and housed in considerable space, or instead of controlling power, this same light beam can be used economically to save power by turning off illumination when predetermined conditions of natural light prevail.

New manufacturers of light-sensitive equipment entering the field, and increased interest on the part of general industry in apparatus already on the market, are indications of the increasing consciousness of the engineering public that a new medium of control and a new machine for economy is at hand, a beam of light and a light-sensitive relay.

Newcomers to the field are Allen-Bradley of Milwaukee, Struthers Dunn of Philadelphia, Burgess, and Weston.

PCM on microwave

Ten years experience in PCM microwave technology. That's Canadian Marconi Company's record. A record you may not have been aware of — because our major customers don't say too much about their purchases.

But now you, the commercial communications user, can benefit from CMC's experience in PCM-on-radio.

Our MCS 6900 MICROWAVE COMMUNICATIONS SYSTEM* is an integrated multiplex/radio combination designed to serve your voice and data communications needs — digitally.

Plan now to meet the ever-increasing demands which will be placed on your communications systems in the future. Go digital. With the MCS 6900.

Contact us for more information. Let us tell you about the better way to communicate.

*The MCS 6900 12.2-12.7GHz model is FCC-type accepted for use under Part 91, Industrial Radio Service.

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CMC

Circle 9 on reader service card

DIRECTIONS MOS

First in a series of explorations to illuminate the numerous facets of the MOS technology ...Why, How, What, and Where.

MOS vs. Bipolar

Struggle For Survival? Or A Place For Each

MOS sales rose nearly $50 million in 1970 to account for some 18% of total digital sales. No rampaging whirlwind sweeping all from its path. The increase, however, was principally due to the efforts of a few smaller semiconductor companies. Now that some of the major manufacturers are showing significant progress in development of the MOS art, interest is accelerating. MOS technology is heading toward dominance of digital electronics. The questions are, to what degree, and when.

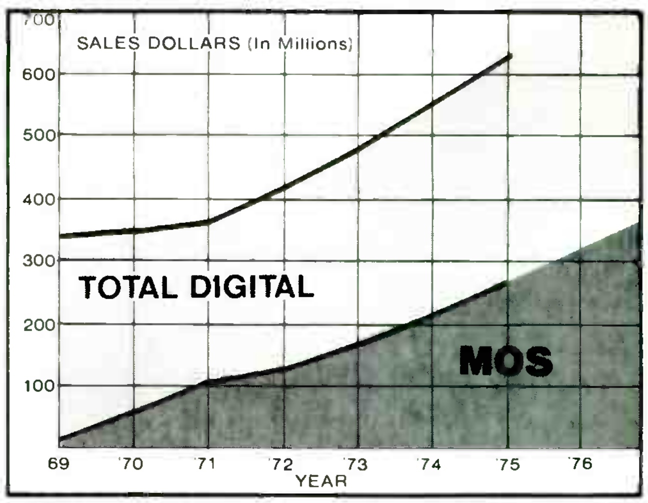
On the conservative side is the Electronic Industries Association, with a projection of 45% by 1975. The more enthusiastic prognostications of groups engaged exclusively with MOS technology place the MOS share at a majority 55% share by that year. Certainly, an examination of the merits of MOS warrants enthusiasm, and consideration of the speed with which new technologies are implemented today justifies a shift to MOS in equipment designs. Yet, the hazards of going too far too fast are so great that the choice between bipolar and MOS circuits ranks as a vital decision facing the designer of future equipment.

The Obvious — Plus and Minus

Today's state-of-the-art has bipolar circuits operating well beyond 100 MHz. MOS presently has an upper frequency limit around 25 MHz. Obviously, for the very high speed requirements bipolar is the automatic choice. MOS circuits have the big advantage in power dissipation, operating in the nW/gate region. Bipolar structures bottom out at about 1 mW/gate. So, MOS for low power dissipation (or low-voltage operation) is a must. Technical considerations clearly place some equipment squarely with each of the two choices. Still, the much wider range of applications can be satisfied with both the lesser speeds of MOS and a power level within bipolar limits.

The Case For MOS

Why the steep growth curve for MOS? Advocates say the answer is LOWER SYSTEM COST. Several factors contribute to the smaller size of the MOS chip for an



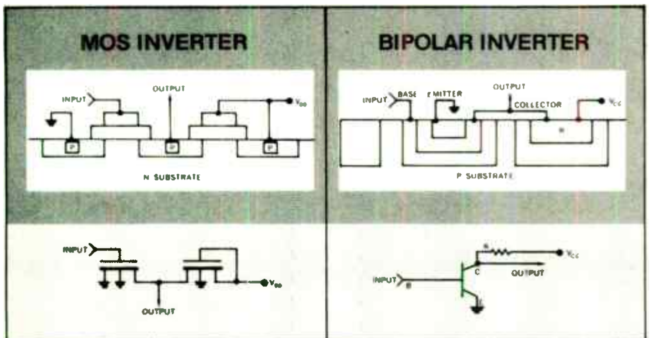
equivalent function, thus providing lower material costs. Smaller chips improve yields by minimizing circuit loss to randomly distributed wafer defects — another cost saver for MOS. The lesser number of process cycles in MOS fabrication is still another cost saver. A by-product advantage of the greater MOS chip density is the practicality of LSI now — still in the exotic category from the bipolar standpoint. When we accept as axiomatic that "the greater number of functions on a monolithic chip, the lower the potential cost per function," practical LSI is a significant cost bonus. Higher LSI yields are, in turn, supported by the relatively simpler processing cycle of MOS.

For the equipment manufacturer planning to build enough units to make the design cost of custom circuits practical, additional overall systems savings can be realized. The savings in PC boards, system size, and reduced assembly cost, all due to fewer packages and interconnects, complement well the lower cost per function of the more complex chip. A ten percent system saving expectation is conservative.

The Bipolar Side

Circuit complexity of many designs today is reasonably within bipolar practicality. Under this condition, the chip size-related MOS cost advantage is nullified. The savings advantage of fewer process steps can be cancelled by the huge production runs of the established bipolar lines. So where systems aren't large enough to warrant LSI, bipolar appears to be the answer for the present.

There is another important consideration, even when LSI is advantageous. The desire for proprietary chip architecture can compel custom circuit design, and in these cases custom design costs form a major part of each device cost. Close figuring is required to calculate



DIFFUSIONS		MASKING STEPS	DIFFUSIONS		MASKING STEPS
1	Source-drain	Diffusion	1	Isolation	Isolation
2		Gate	2	Buried Layer	Buried Layer
3		Pre Ohmic	3	Base	Base
4		Metal	4	Emitter	Emitter
5		Passivation	5		Metal Delineation
			6		Metal Etch

whether or not custom MOS/LSI chip costs are, indeed, lower than the cost of the greater number of mass-produced, simpler bipolar functions. Not all MOS/LSI will be custom, however. Standard MOS shift registers and memories are easily tailored, often less expensively than the same circuitry could be built with smaller bipolar units. This factor tilts the decision toward MOS again. But there are still other factors to consider.

Potential service cost with so large a portion of the total circuitry on one chip is an MOS/LSI deterrent. A

COST COMPARISON ESTIMATE FOR BIPOLAR AND MOS SYSTEMS
Number of Systems to be built — 1000

ITEM	BIPOLAR		MOS	
	No.	PRICE	No.	PRICE
No. of IC Packages (per system)	100		2	
Cost per Package		$0.40		$25.00
Total Package Cost		$40.00		$50.00
No. of PC Board and Connectors	4		1	
Cost per Board		$5.00		$5.00
Total Board Cost		$20.00		$5.00
Total Parts Cost		$60.00		$55.00
Manufacturing Cost (Estimated at twice the materials cost)		$120.00		$110.00
TOTAL COST		$180.00		$165.00

relatively long development cycle for very complex circuits is an obstacle, as is the possible commitment to a single supply source. A good, long-term future for bipolar devices appears to be inevitable.

Overcoming Some MOS Obstacles

Reduction or elimination of design-time and development-cost limitations of custom LSI is an area of active concern, and progress is good. In fact, custom systems have now been designed and built at lower cost than comparable designs with standard bipolar devices. When this is the norm, a formidable objection to MOS will have been dismissed.

Where Do We Stand Now

Some equipment manufacturers have completely embraced MOS. The desk calculator and electronic watch markets are good examples. The swing to MOS for other equipment is predictable. Medical equipment, particularly for attachment to the body, is a natural candidate. So is the automotive market, because of its low cost and low power drain requirement. On the other hand, high-speed computer circuitry appears wedded to bipolar designs at least for the immediate future. Driver circuits will also remain bipolar until MOS circuits can provide a significant amount of power. The probability of mixing MOS and bipolar circuits is yet another design alternative.

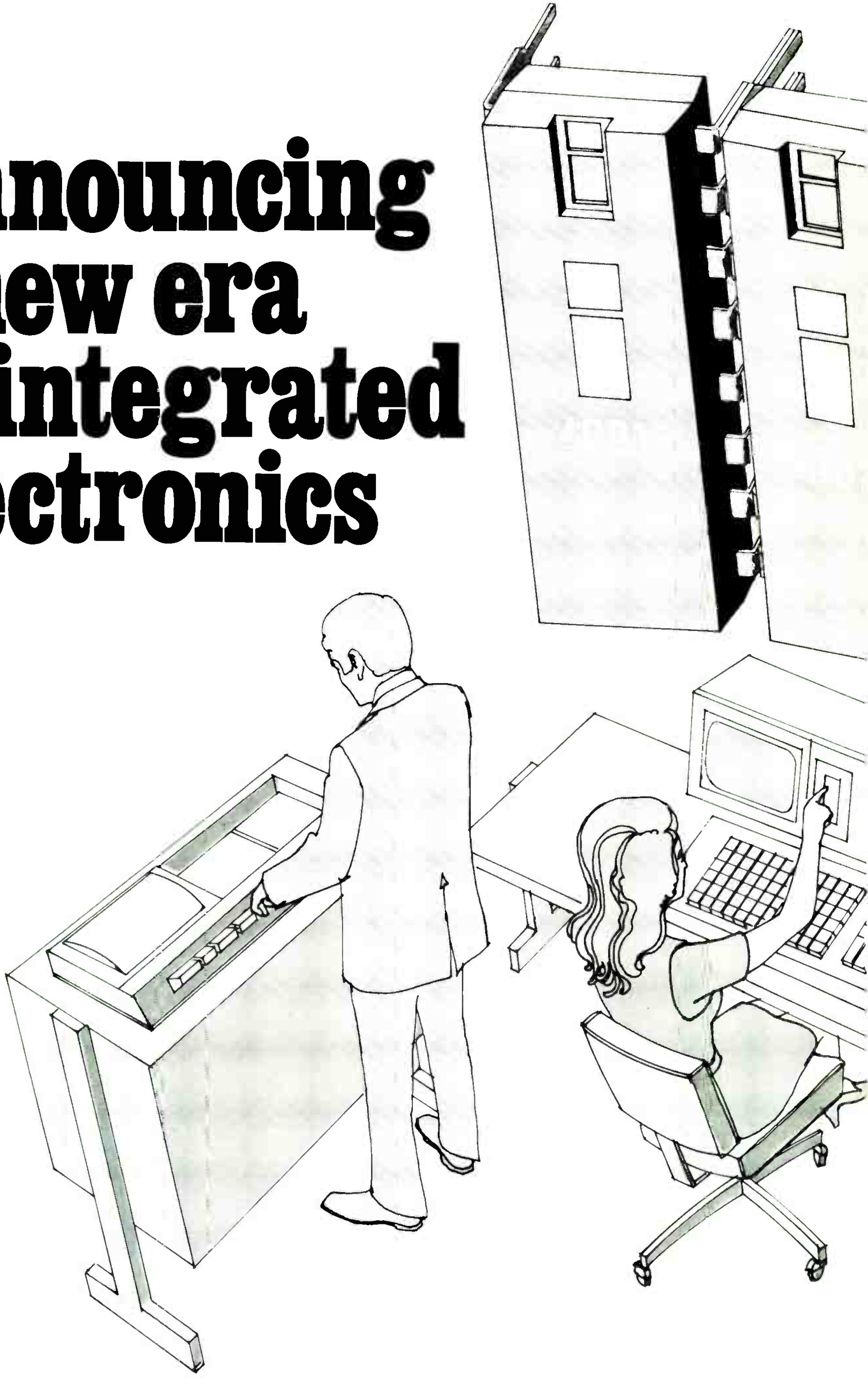
Summing up, bipolar is here for some time to come, with MOS increasing its share of the load to half or better. MOS vs. bipolar — the verdict? A place for each, at least until mid-decade, and opportunities for creative design have never been greater, nor the rewards for success more promising.

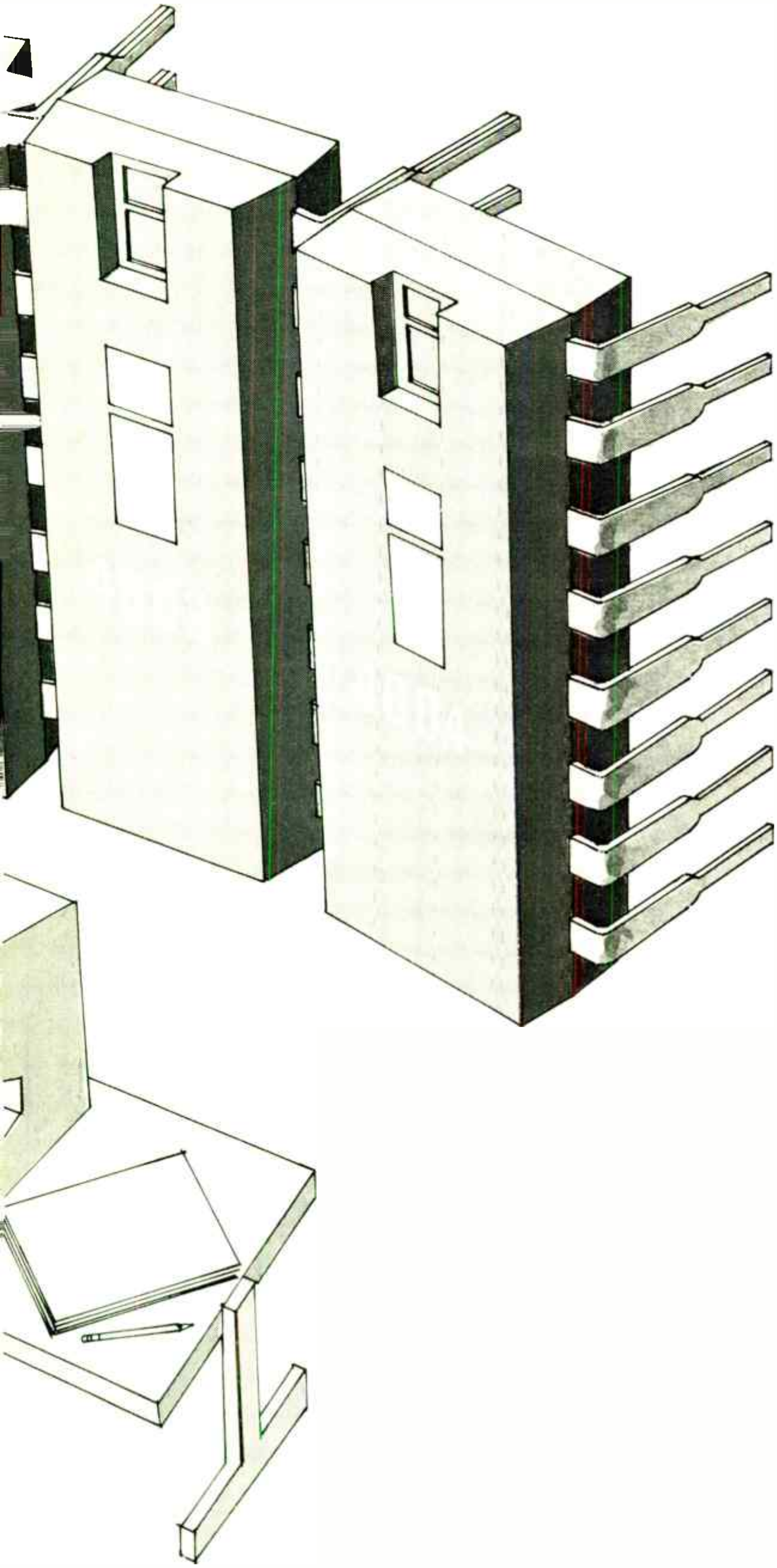
Motorola is committed in both MOS and bipolar technologies to the delivery of the electronic equipment industry's device requirements, whichever they may be. This is the first in a series designed to present a realistic, objective analysis of the position of the MOS technology in a dynamic, competitive industry. For an examination of this and other aspects of the MOS technology in greater depth than is permitted here, circle the reader service number or write to Motorola Semiconductor Products Inc., P. O. Box 20912, Phoenix, Arizona 85036.

MOTOROLA MOS
Directions in digital designs

Coming next — A LOOK AT "THE MANY FACES OF MOS"

Announcing a new era of integrated electronics





People

Gabor exhorts society to channel growth

The award of the 1971 Nobel Prize for Physics to the "father of holography," Dennis Gabor, is bringing into much wider circulation the Hungarian-born physicist's sharp views of the threat to civilization posed by the impact of rampant technology.

Both in public speeches and in his new book, "Innovations" (Oxford University Press, 1971), Gabor has foreseen considerable dangers caused by man's "ability to turn inventions into destruction" and by his "attentiveness to material growth" for the sake of growth. Rather than concentrating on growth, society, Gabor says, should strive for excellence in applying the myriad of technological accomplishments at its disposal.

And Gabor himself has contributed prodigiously to this store of accomplishments. Presently a staff scientist for CBS Laboratories, a division of Columbia Broadcasting System, Stamford, Conn., the 71-year-old scientist holds over 100 patents in the field of optics, communications, and color television.

His invention of holography, the lenseless photographic technique of producing three-dimensional objects by projecting lightwave interference patterns on a glass plate, goes back 23 years to when he was a research engineer with a British electrical engineering firm. He had gone to England in the 1930s, a refugee from Hitler's Germany, where, in 1927, he had earned a doctorate in electrical engineering at the Technische Hochschule in Berlin. His research assistant and good friend there was Peter Goldmark, now the president of CBS Laboratories.

In 1948, Gabor joined the faculty of the Imperial College of Science and Technology in London, staying almost 20 years. Now he's professor emeritus of applied electronic physics, spending only about six months a year at CBS in Stamford. He became a consultant to CBS in 1960, and joined its staff in 1967.

At CBS, Gabor was part of the engineering team that developed the Electronic Video Recording system now being brought to the commercial marketplace.

Another Gabor invention for which CBS holds out great commercial possibilities applies holographic techniques to produce three-dimensional movies viewed without special eyeglasses. CBS is reported to be in "preliminary negotiations" with several movie companies and camera equipment manufacturers for the system.

Gabor: Excellence in applying technology.

Two of Gabor's latest projects also involve holography. One involves "ultraradio sonography"—a technique for looking at various parts of the body in three-dimensions using acoustic holography. And the other project involves "panoramic holography" which might offer a touch of the excellence in life Gabor wishes for society. When illuminated from above with white, not laser, light, this new hologram offers a picture that has unlimited depth.

It's high time for low power

Low-power ICs are becoming a high-volume business that's looking attractive to engineers with the classic work-for-yourself itch. The result is new companies like Micro Power Systems of Santa Clara, Calif., formed to specialize in these circuits—used, typically, in such places as pacemakers and timepieces—in

Tri-State* logic marches on...

Then:

DM8093 Tri-State Quad Buffer
DM8230 Bus Line Demultiplexer
DM8831 Party Line Driver
DM8551 Quad-D Flip Flop
DM8094 Tri-State Quad Buffer
DM8598 (SN7488 Compatible) 256-Bit Expandable ROM
DM8214 Dual 4-Line-to-1 Multiplexer

Now:

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DM8123 (FSC9322 or SN74157 Compatible) Quad 2-Input Multiplexer
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DM8554 Binary Counter/Latch
DM8552 Decimal Counter/Latch
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DM85L51 Low Power Quad-D Flip Flop
DM0000 Quad Transceiver-Transmitter Disable
DM0000 Quad Transceiver-Transmitter/Receiver Disable

If what you're doing has anything to do with mini computers or *any* digital design, why not deal directly with the source: National Semiconductor Corporation, 2900 Semiconductor Drive, Santa Clara, California 95051. Phone (408) 732-5000. TWX: (910) 339-9240. Cable: NATSEMICON.

National

*Tri-State is a trademark of National Semiconductor Corporation.

People

both bipolar and MOS versions.

Micro Power is actually built around two men: John Hall, its president, and John Marshall, vice president. Their thinking, as expressed by Hall, is that to succeed in low-power circuits, as in any other business, "you must produce a reliable and a high-quality product." And to do this, he adds, you have to concentrate on low power to the exclusion of all else.

Both men spent three years designing and building low-power circuits at Intersil, and before that, they worked together for about three years at Union Carbide where some of the basic work in low-power and low-noise circuits was done. Hall conducted some of the fundamental projects leading to a viable low-voltage C/MOS process, and Marshall worked in the area of super data transistors and on silicon-nitride passivation techniques.

Marshall says that in order to build low-power bipolar circuits, high-gain transistors must be used. These transistors have large gains at normal operating voltages and thus at the lower operating voltages employed in low-power circuits, they exhibit a decent gain. Normal transistors are just not useful at low operating voltages.

For both bipolar and MOS low-power circuits, Marshall says, a passivation layer is necessary, and this is where his work on silicon nitride came into play. He says that while a silicon-nitride passivation layer on all devices produced by Micro Power Systems "might increase costs slightly," it will increase reliability greatly. Recently, he adds, "as the cost of ICs has gone down, so has the quality. But we will give the user the quality he needs."

Marshall sees the low-power IC business as being a custom one, so the firm doesn't plan to introduce any standard products. "But later on," he says, "some of our customers will see the advantage of their letting us sell the same parts to others, and thus they will become somewhat standard." Besides the digital bipolar and MOS products, Hall and Marshall plan to produce precision linear circuits.

The most spectacular improvement in comparators since the 710.

527 and 529

You get a major boost in accuracy. At incredibly high speeds. 300% faster than any other voltage comparator available to date—including that old standby the 710.

527 and 529. Two more products in Signetics new third generation linears—a vastly improved IC series developed to jump performance capabilities without penalties.

Both chips offer breakthrough transit time. A 10ns propagation delay for our 529 comparator. (Vs. 40-60 ns for the slower 710.) With input impedance of 5 kΩ, typical bias current of 5 µA.

At 15ns, the 527 trades a sliver of input-output speed for ten times higher input impedance, 50 kΩ, and seven times lower input bias current, 0.7 µA. (Vs. the 20-30 µA of 710.)

And the best is yet to come. Both comparators carry complementary Schottky-diode outputs, Q and $\bar{Q}$, a revolutionary two-gates-to-a-chip concept that minimizes system delay enormously. TTL and ECL compatible, operating from balanced ±5V to ±15V power supplies.

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Do what you're doing better, or find something better to do. Signetics third generation linears let you have it both ways—improvement without penalty. With the ultra fast 527 and 529 comparators, as well as our 531 high slew rate op amp, 533 micro power op amp, 536 FET input op amp, 537 precision op amp, 528 4-channel sense amp, and 550 voltage regulator. All at your Signetics distributor or sales rep.

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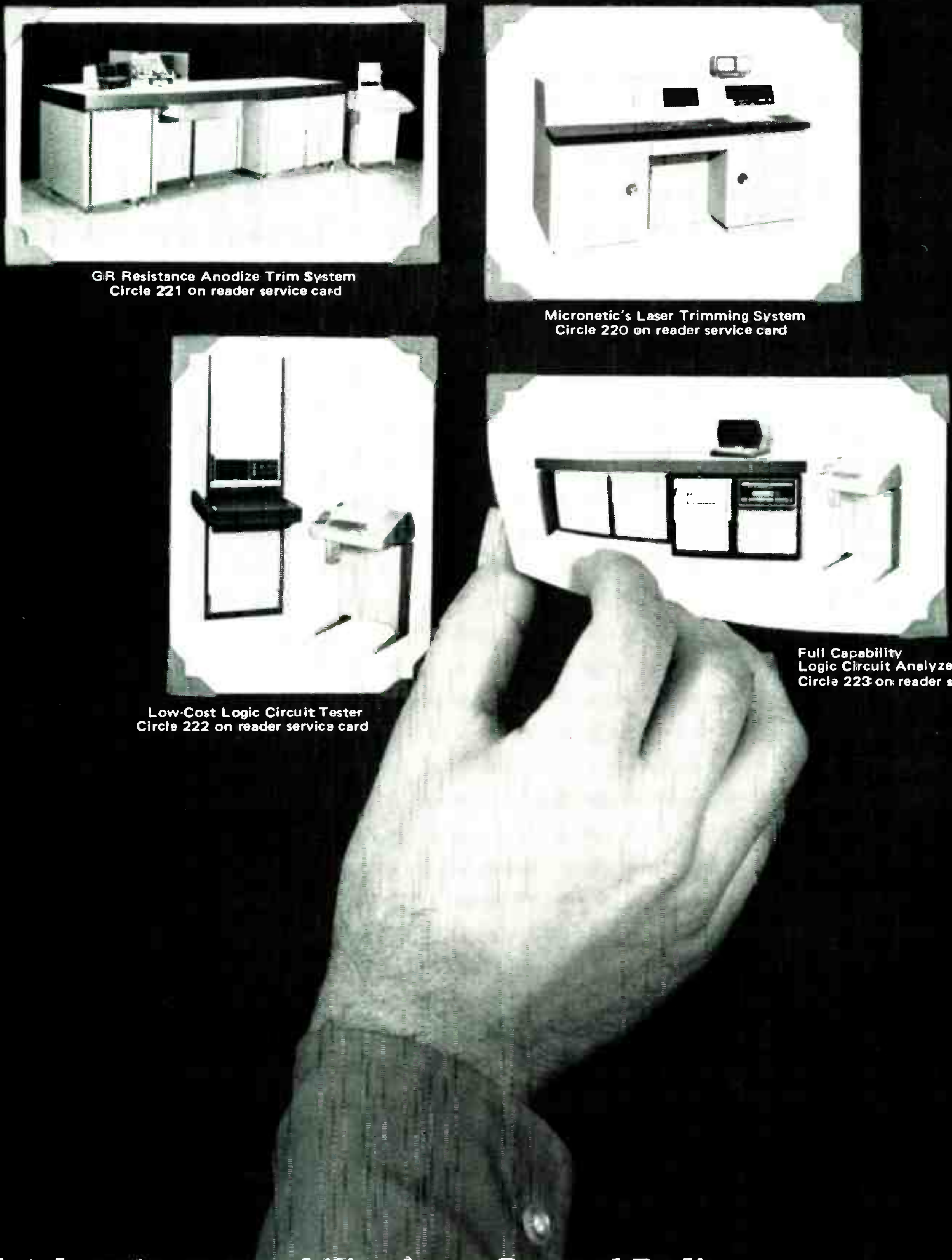
The GR Systems Family



GR Resistance Anodize Trim System
Circle 221 on reader service card

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Low-Cost Logic Circuit Tester
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Full Capability
Logic Circuit Analyzer
Circle 223 on reader service ca

Total systems capability from General Radio

The new 1792 Logic-Test System is GR's answer to all you guys who looked at our 1790 and said:

Yes, but I also want . . . multiple logic-level testing capability as standard
Yes, but I also want . . . a big 12-inch screen display
Yes, but I also want . . . parametric-testing capability
Yes, but I also want . . . time-measurement capability
Yes, but I also want . . . a high-speed word generator for MOS testing
Yes, but I also want . . . a high-speed disc for mass software storage

The 1792 is a powerful system offering several options to give you all the capabilities listed above. Select only the options you need to satisfy your current requirements. You can add more later as your needs grow.

Now consider this . . . GR has sold more than twice as many computer-controlled logic-circuit analyzers as *all three* of its closest competitors *combined*.

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- Variety --- center-gap (FDR-3), (FDR-4) and offset-gap (FDR-7) contacts, each designed for minimized chatter.
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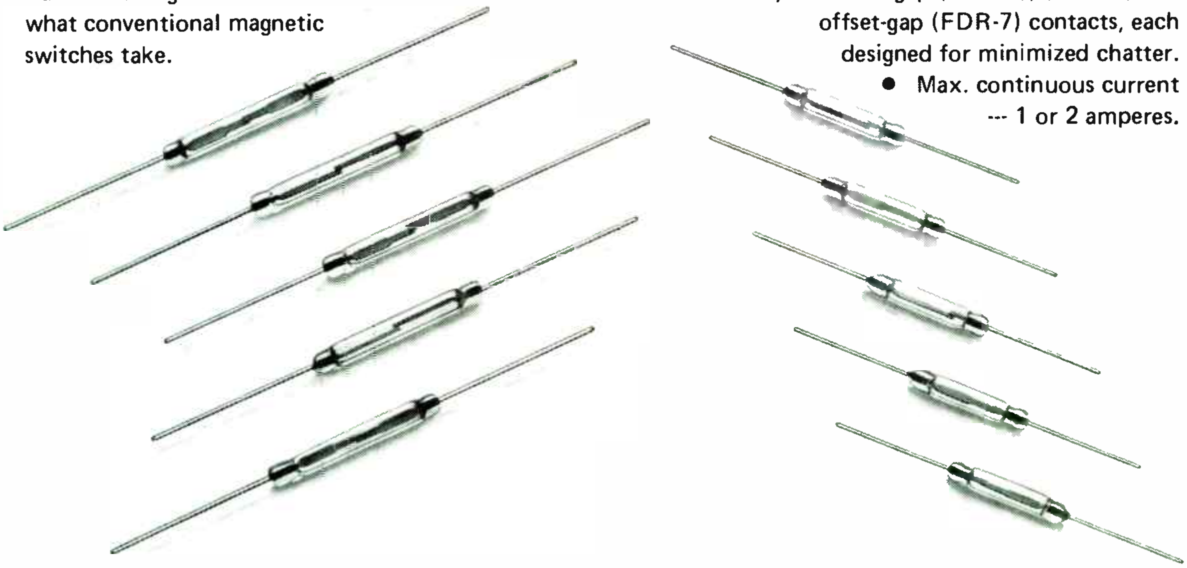

Reed switch		Contact form	Contact rating	Carry current	Pull-in amp-turn	Orop-out amp-turn	Operate time	Release time	Initial contact resistance	Breakdown voltage	Shock	Life
FDR-3	FDR-31-002			1 A		10 min.		50 µs max.		500 V DC minimum		
	FDR-31-102	A (make) Center gap	DC 5 VA max. (DC 50V max., DC 0.5A max.)	2 A	20~60	11~25 min.	800 µs max.		150 millohms max.		30G	10 million (10^7)
FDR-4				1 A		8 min.		100 µs max.		350 V DC minimum		
FDR-7		A (make) Offset gap			20~52	11 min.		50 µs max.				

- Available with pre-soldered terminals.
- Glass diameter (max): 2.8ϕ mm (FDR-3, 4 and 7)
- Full length: 56 mm (FDR-3), 44.2 mm (FDR-4), 40 mm (FDR-7)
- Glass length: 21.5 mm (FDR-3), 16.5 mm (FDR-4), 15.0 mm (FDR-7)

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Marunouchi, Tokyo, Japan

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Meetings

Ultrasonics Symposium: IEEE, Carillon Hotel, Miami Beach, Dec. 6-9.

Vehicular Technology Conference: IEEE, Sheraton-Cadillac Hotel, Detroit, Dec. 7-9.

Reliability Symposium: IEEE, El Cortez, San Diego, Jan. 25-27.

Power Engineering Society Winter Meeting: IEEE, Statler Hilton Hotel, New York, Jan. 30-Feb. 4.

Aerospace & Electronics Systems Winter Convention (WINCON): IEEE, Biltmore, Los Angeles, Feb. 8-10.

International Solid State Circuits Conference: IEEE, Sheraton Hotel, University of Pennsylvania, Philadelphia, Feb. 16-18.

International Geoscience Electronics Symposium: IEEE, Marriott Twin Bridges Motor Hotel, Washington, D.C., April 9-14.

International Conference on Magnetics (INTERMAG): IEE, Kyoto International Conference Hall, Kyoto, Japan, April 10-13.

Southwestern IEEE Conference & Exhibition (SWIEEECO): IEEE, Baker Hotel, & Dallas Mem. Aud., Dallas, Texas, April 19-21.

Off-shore Technology Conference: IEEE, Astrohall, Houston, Texas, April 30-May 3.

CALL FOR PAPERS

1972 IEEE International Symposium on Electromagnetic Compatibility: Arlington Heights, Ill., July 18-20, 1972. All reviews are to be submitted by Dec. 14, 1971, to J.J. Krstandsky, Chairman, Program Committee, IIT Research Institute, 10 West 35th Street, Chicago, Ill.

1972 USNC/URSI–IEEE Spring Meeting: Statler Hilton Hotel, Washington, D.C., April 13-15, 1972. Jan. 28, 1972 is the deadline date for submission of abstracts to Dr. John V. Evans, Sec. USNC/URSI, Lincoln Laboratory MIT, Lex., Mass.

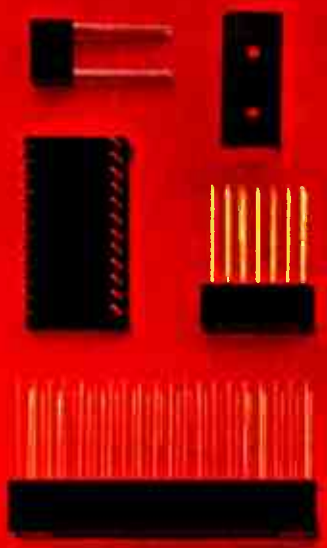
Select-a-Socket

Closed entry wire wrap sockets

Series C81/91

Individually replaceable contacts, glass-filled nylon body, bonded gold stripe on nickel silver for plated phosphor bronze contacts, removable cover for open entry.

Pin Nos.: 8, 14, 16, 18, 24, 28, 36, 40

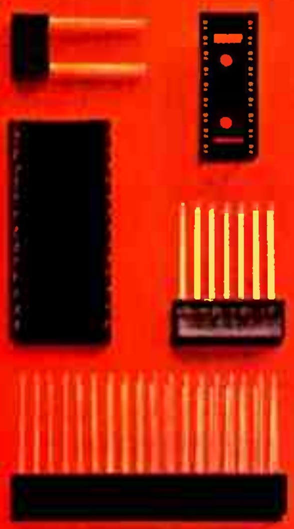


Open entry wire wrap sockets

Series C81

Same features as closed entry sockets, except has no cover. Redundant pre-loaded contact accepts round, square or rectangular leads, up to .024".

Pin Nos.: 8, 14, 16, 18, 24, 28

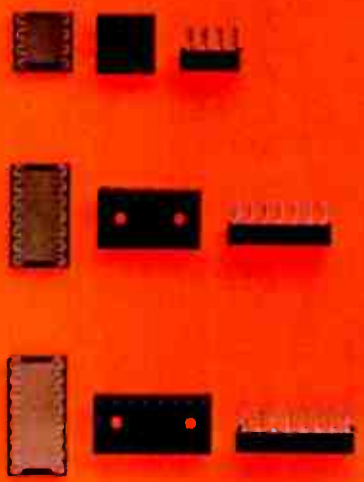


Low profile solder tail sockets

Series 93

With standoff, only .150" above board. Same features as sockets above, except has optional screw-down or epoxy mounting, built-in barrier to prevent IC contact with board.

Pin Nos.: 8, 14, 16, 18, 24

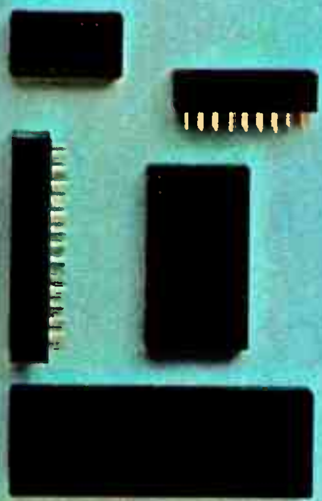


Standard profile solder tail sockets

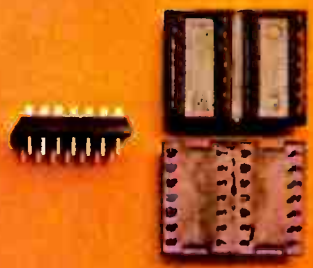
Series 82

Same features as open entry wire wrap sockets, except standard contacts are tin-plated phosphor bronze, with gold platings available.

Pin Nos.: 14, 16, 18, 24, 28, 36, 40



Accessories and special products



Discrete Component Platform

Pluggable platforms for production and prototype packaging of selected discrete components. Available in single platform for miniature discretes, double platform for larger discretes, and dual platform for multiple packaging of miniature discretes.

Cable Plugs

A 14-pin or 16-pin adapter plug for terminating inter-connection wiring, or component mounting in prototype.

Edgemount Connectors (for ceramic substrates)

Single-in-line edgemount connector has 40 positions. Unique alignment spring for precise contact mating. Gold bonded nickel silver contacts.

Cables

Single-or-double-ended, 26 to 30 gauge, 8 to 40 pin termination, single-or-multi-conductor ribbon cable, choice of length.

TI announces the industry's broadest line of off-the-shelf IC sockets.

Meet Texas Instruments family of IC sockets. Closed and open entry wire wrap sockets. Standard and low profile solder tail sockets. Not just a collection of prototypes. But truly off-the-shelf sockets with many unique design features.

Like gold stripe nickel silver contacts, for example. Contacts metallurgically bonded, not plated, with a thick stripe of gold to give you better electrical integrity at the contact point, and superior wear resistance.

Like redundant contact construction and special contact orientation. Both of which increase contact pressure. Offer lower contact and constriction resistance. And increase contact reliability.

Like individually replaceable contacts. Which means you can pull out a damaged contact without a special tool and snap in a new one. All without removing the socket body from the board.

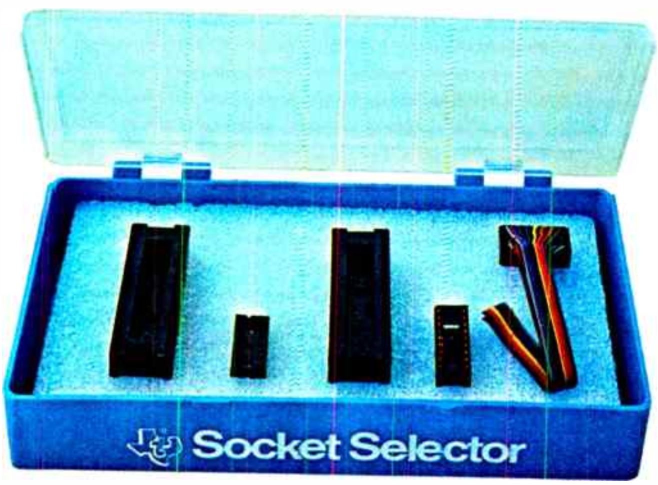
We could go on and on about our family's attributes. Like preloaded contacts to assist you when inserting the IC device. Or the arrowhead design that locks the contact in the body.

But the best way for you to appreciate our family is to test and evaluate our IC sockets yourself. That's why we've developed the TI Socket Selector. So you can send for samples of our sockets. Free.

How to assemble your own free TI Socket Selector.

If you're a qualified engineer, select the socket category (or accessory) you want from the opposite page. Mark the appropriate color-coded box in the following coupon. Then fill in the rest and mail. It's that simple.

If you're interested in a custom-design socket, tell us.



TI also offers a selection of panel systems: standard off-the-shelf panels, standard pin panels, Select-A-Wrap® prototype panels and custom-designed panels. You can specify any of these on the coupon.

One more thing. Don't despair if someone's clipped the coupon ahead of you. Just send us your request on your letterhead. After all, it's all in the family. Write Texas Instruments, Inc., Connector Products, Attleboro, Massachusetts 02703.

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Please send the free sockets (accessories, panels) checked below for evaluation.

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C

TEXAS INSTRUMENTS
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Circle 23 on reader service card

"Why did NATIONAL SEMICONDUCTOR buy Macrodata's 'FEDIS' LSI design system?"

National Semiconductor Inc., one of the acknowledged leaders in the design and production of complex LSI devices chose Macrodata's "FEDIS" turn-key LSI design system for their own in-house use in designing RAMS, ROMS, Shift Registers and complex random logic devices.

National's reasons: speed, simplicity and cost effectiveness.

FEDIS is more than a simple digitizing and editing system, it includes nodal analysis and topological design rule validation to provide error-free artwork generation.

All validations and analysis are based on digital data generated by on-line digitizing of **composite layouts.** Direct entry can be made to "CADIS" software packages such as circuit transient analysis, logic equation generation, logic simulation and cross talk analysis.

National, in using Macrodata's own in-house "FEDIS" for almost one year prior to purchasing theirs, found the system throughput to be at least twice that of other competitive units they also evaluated. **The result? Ask National's competitors.**

Dr. William C. W. Mow
President
Macrodata Company

Macrodata Company
Design Systems Division
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Electronics Newsletter

November 22, 1971

H-P calculator billed as pocket slide rule

The electronic calculator field continues to draw crowds, with one of the latest entries being Hewlett-Packard. The company has developed a battery-operated pocket "electronic slide rule" that not only adds, subtracts, multiplies, and divides, **but also has extensive trigonometric functions and has a true logarithmic capability.** The machine can display, via light-emitting diodes, an answer as either a floating-point number or in scientific notation. The company is expected to introduce the machine by the first quarter of 1972; price will be about $600.

Liquid-core fiber promises low loss

A liquid-core fiber being developed at Bell Labs shows promise as a **technique for reducing attenuation in optical communications lines.** Researchers at the Holmdel, N.J., facility already have measured attenuation as low as 15 decibels per kilometer. The best previous attenuation performance was 20 dB/km, reported by Corning Glass Works.

The liquid-core fiber's core diameter of a few mils permits multimode propagation. Wavelength used in the Corning test was 6,328 angstroms, but **Bell researchers say that 10,800Å light was used to test their fiber.**

Read head uses Hall-effect device

Pioneer Electronic Corp. of Japan has developed a read-after-write tape head for digital cassette recorders **that employs a Hall-effect device for the read head.** The read-after-write mode permits digital data to be checked for errors after recording.

Use of the Hall-effect read head allows a packing density of up to 800 flux reversals per inch, independent of tape speed. Previously, the read-after-write operation could not be performed economically at a packing density this high because of the characteristics of the normally used induction (coil) type read head. **This is also believed to be the first application of a Hall-effect device in a recording head.**

Nixon's Phase 2 leans to Univac . . .

Phase 2 of President Nixon's economic stabilization program will require at least one computer, possibly two, for the Cost of Living Council, **and early indications are that the hardware will be Univac 1108s.** But potential of the Phase 2 EDP business falls in the trickier area of enhancing the supplier's corporate image, rather than the bankroll.

The apparent advantage for Univac lies with the Office of Emergency Preparedness, whose 1108 program (called Emisari, for Emergency Management Information System and Reference Index) is being proposed to manage and distribute data flow in the council's system. That system embraces the Price Commission, its counterpart Pay Board, and their surveillance arm, the Internal Revenue Service. Though officials concede that Emisari could be adapted to other business machines, **betting is that Phase 2 managers will turn to Univac.**

. . . as House doubles computer staff

The House of Representatives is moving to develop its own computer system design capability and is doubling its staff of systems analysts and computer programers to 32. Automation of the Congress, seen by some in the computer industry as an impossible mission, **now will be explored in-house.**

National to offer 54/74 C/MOS series

National Semiconductor is set to enter the C/MOS marketplace before the year is up by second-sourcing several RCA gate functions. The big push into C/MOS, however, will come early next year with a family called **54C/74C that's designed to be power-supply-compatible with, and pin-for-pin replacements for, 54/74 series TTL.** Thus, rather than introduce a new separate logic family, **National will offer the TTL user the ability to update his circuit cards with C/MOS** where, for example, lower power may be needed and without redsign.

Computer delivered, says Marchuk

The first of the highly touted laser computers built by Laser Computer Corp. of Irvine, Calif., has been delivered, says the firm's president, Frank Marchuk, who won't say who got the machine. It's said to have a main memory capacity of 10 trillion bits and a read-write cycle time of 20 nanoseconds [*Electronics*, June 21, p. 36; March 29, p. 81]. **Nor will Marchuk say who is to get the second LC-100, scheduled for December delivery**, heightening the mystery that has surrounded the firm and its supercomputer from the outset.

Laser Computer Corp. is to complete its move to a new facility in Irvine soon, and promises to exhibit the machine in a new showroom. Meanwhile, magazine and business publication ads announcing the machine's availability—along with more technical details—are scheduled for December, January, and February. **A spokesman says the firm has also developed a mini-version** of its larger LC-100 and LC-500 machines, designated the LC-10.

JPL overcoming Mariner 9 glitches, expects success

Mariner 9 scientists at the Jet Propulsion Laboratory in Pasadena, Calif., overseeing the first orbit of a manmade spacecraft around Mars, say they **are optimistic about the chances for a successful mapping mission lasting the scheduled 90 days.** What's more, a spokesman at JPL says the spacecraft could remain active for up to a year if its batteries hold out.

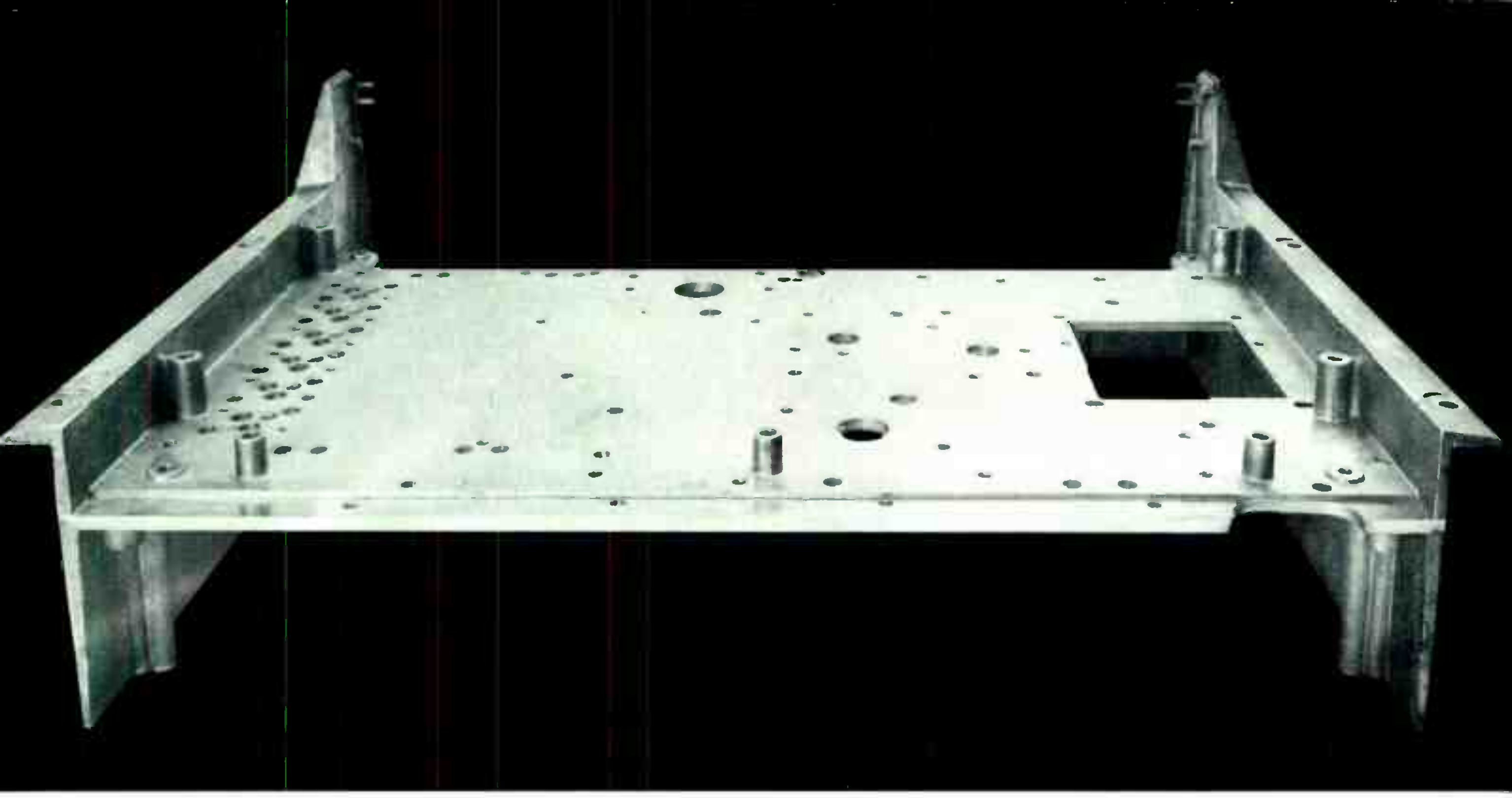
The optimism comes in the face of slight difficulties during Mariner 9's close approach and when it first went into its elliptical Martian orbit. **It's thought that a speck of dust interfered with the spacecraft's star-tracking sensor,** but that problem was corrected within a few hours. Then the initial closeup photos relayed to earth from the wide-angle television camera **showed a residual image of the earlier approach shots.** Mariner officials think the problem may have been caused by overexposing the camera's vidicon.

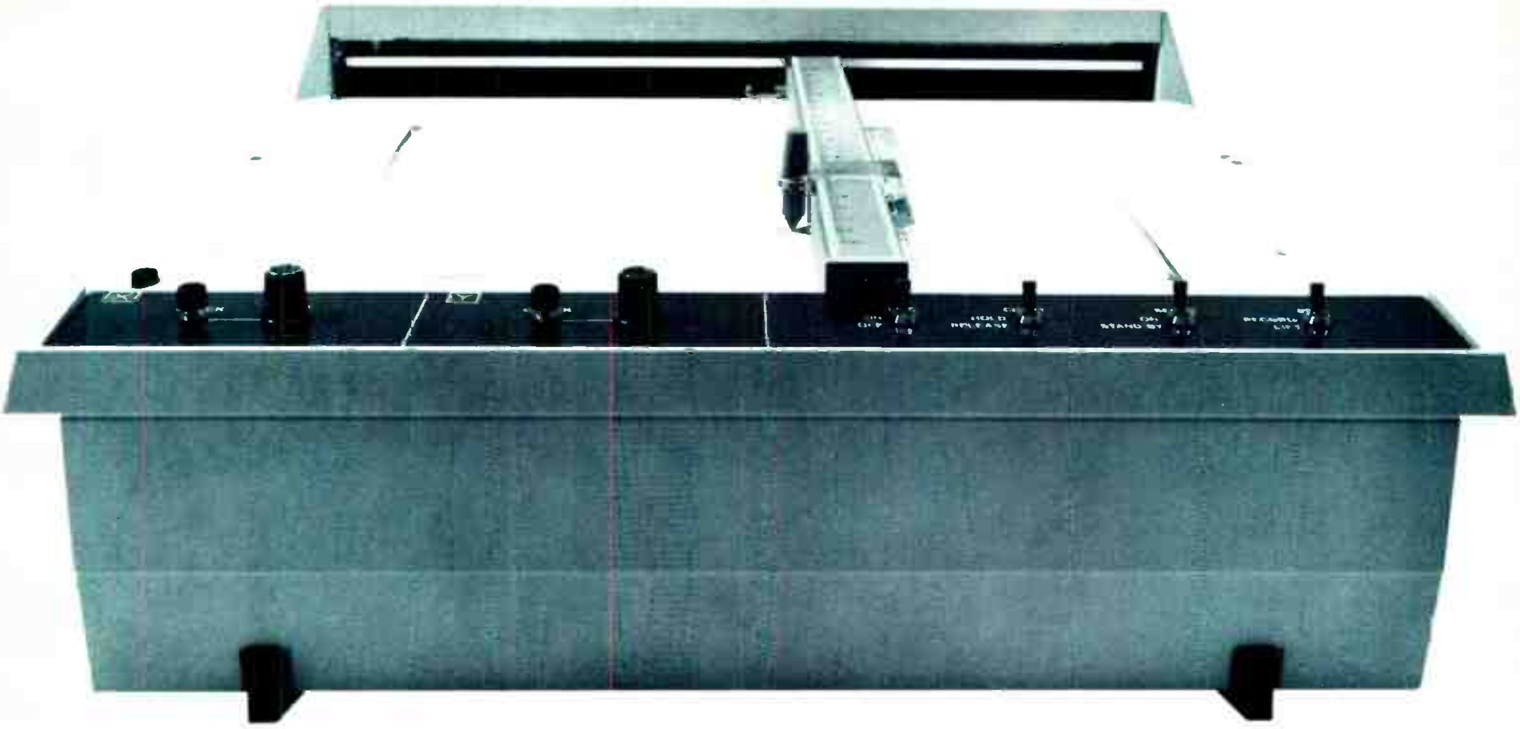
DEC adds 3-inch 11/03 to PDP line

Digital Equipment Corp., which recently has been busily extending its line of computers upward and outward, took another step at the Fall Joint Computer Conference with its PDP-11/03—the sixth in the PDP-11 family.

It is a 16-bit, fully parallel machine with a 1.2-microsecond-cycle memory coming in 4,096-, 8,192-, or 16,384-byte sizes, all in a box 3½ inches high. It sells for $3,995 singly or $2,560 in quantity. Eventually, says DEC, a terminal will be introduced for the new computer.

The new DEC machine will compete with Data General's just-unveiled trio of additions to its Nova line [see p. 109], each with 4,096 words of core. The smallest of the three machines, the Nova 1210, reaches a height of 5¼ inches.





Introducing the little counter that can.

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

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

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

10 MHz frequency module. Model 5301A, $125.

50 MHz all-purpose module includes period, time interval. Model 5302A, $250.

500 MHz module with both 50Ω and 1 MΩ inputs. Model 5303A, $750.

100 ns time interval module with: unique "time holdoff" feature, dc coupling, slope and trigger level controls, and period and frequency measurements to 10 MHz. All the functions you'd pay $1200 for in a universal counter. Model 5304A, $300.

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

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

Counters that promise a lot and deliver it all.

02109

HEWLETT hp PACKARD

ELECTRONIC COUNTERS

ICMS could be a Tri-Tac in Air Force blue

Triservice switch system, closely watched by industry as Phase 2 nears, parallels triservice network concept

What the Air Force calls its ICMS (Integrated Circuit and Message Switch) could one day become the Defense Department's triservice computerized communications switching system, the much discussed Tri-Tac. ICMS has a potential for 30 switches at roughly $1 million each exclusive of R&D. But even if it doesn't evolve into Tri-Tac—with its projected $10 billion potential over the next decade—the ICMS effort is sure to influence the evolution of Tri-Tac specifications [*Electronics*, June 21, p. 31].

"The two programs are not competitive," contends David Solomon, head of the Pentagon's telecommunications operation. "You could say they are parallel efforts." Nevertheless, the Defense Department makes clear it is keeping a close rein on Air Force ICMS spending, limiting funding to studies of concept, feasibility, and initial specs.

Interested. The Defense Department's caveats did nothing to deter 24 manufacturers of communications gear from sending 32 representatives to an ICMS briefing last month. They heard the ICMS project office spell out the system's specifications and proposed timetable. This includes plans to issue momentarily requests for proposals for the second-study phase in the four-phase program. The first conceptual phase called for a feasibility model of a transportable ICMS, with an upper limit of 3,000 switch matrix terminations for voice and data, and 150 automatic store-and-forward message switches. It was completed in May by RCA, and that could give the company a leg up in subsequent competitions.

Award of the second phase, now forecast for June 1972, will begin a 15-month "validation" of major program characteristics, including an ongoing update of system requirements. Full-scale development (Phase 3) "should be awarded in December 1973, and completed in March 1975," says the Air Force's Electronic Systems Division. "After satisfactory demonstration of development models, production of switches will begin, with incremental acceptance to May 1978 and options for additional switches."

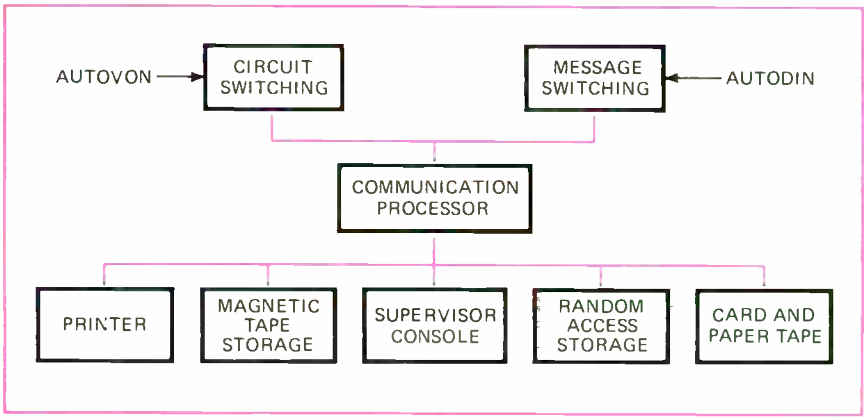
The Air Force says its ICMS engineering group—which includes support from Rome Air Development Center and the not-for-profit Mitre Corp., Bedord, Mass.—"also participated in the writing of the Tri-Tac Model 'A' specification to make sure than an interface with the TTC-39 Tri-Tac switch would be accomplished." But industry sources strongly suspect that the ICMS effort is sufficiently far along that it could well be adopted for the Tri-Tac role.

The big difference between the two concepts at this point is that the tactical applications of ICMS would call for more rugged "shake, rattle, and roll hardware," as one industry bidder puts it, while Tri-Tac's theoretically less vulnerable installations could be less rugged.

Versatility. It is evident that the Air Force is contemplating many in-house applications for ICMS apart from the switch's potential as a Tri-Tac system. And the ICMS concept of expandable modules is rationalized this way by an Air Force source: "The more Air Force programs we can satisfy, obviously, the less R&D dollar spent, and the lower per-unit cost of acquisition." From industry's viewpoint, the ICMS could satisfy every Air Force program now on paper and more.

The Electronic Systems Division

Into the sky? Air Force's Integrated Circuit and Message Switch could find its way into Army and Navy as the computerized communications switching system known as Tri-Tac.



identifies 11 of them, including Bare Base, the 407L Tactical Air Control System, the 485L Emergency Mission Support System, Overseas Autovon, Autodin Replacement, the Local-Digital Message Exchange, the Military Airlift Command Information Management System, 427M with its special-purpose data requirements, plus the Air Force communications service ICCMs, and Fifth Air Force command control and communications net.

As to the argument that telephone and message switch requirements could be better served by separate hardware packages, the Air Force rebuttal is that cost savings can be achieved in using a central processor when both circuit and message switching are required. And when the requirement calls for only one kind of switching, there is a "very small penalty in cost," since the outlay for a processor is only about 10% of the total price for the switch.

Avionics

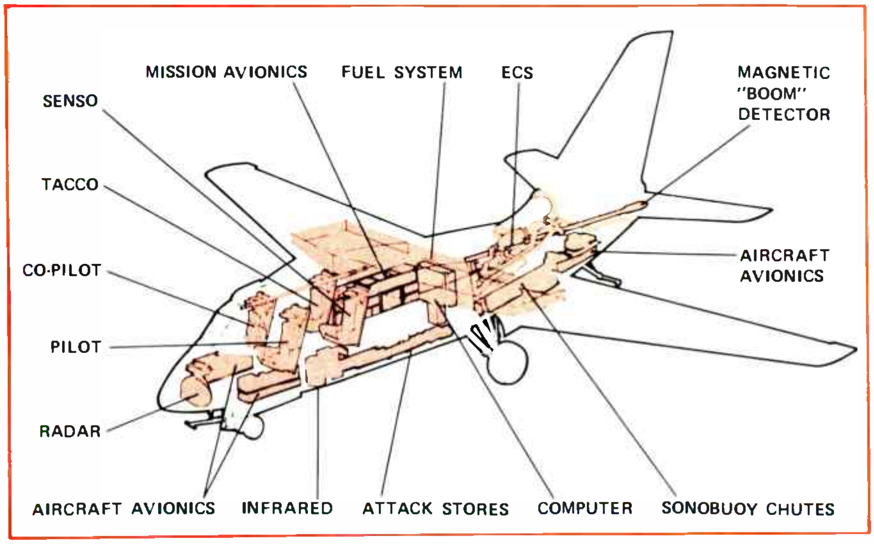
Lockheed getting ahead of itself with S-3A

After the financial furor over Lockheed-California Co.'s L-1011 TriStar commercial airliner program, as well as huge cost overruns on the Lockheed-Georgia Co.'s C-5A transport for the Air Force, the California division undoubtedly has more incentive than ever to meet the major milestones in the development of the Navy's twin-jet S-3A carrier-based antisubmarine aircraft. In "trying to track well ahead on all milestones," as one Lockheed-California source put it, the S-3A was rolled out publicly for the first time this month, slightly ahead of the Navy's schedule.

January target. But rollouts are only ceremonial events, and the firm is hustling to be 60 to 90 days ahead of the more critical milestones. Lockheed is still aiming for an initial flight in January. The formal laboratory demonstration of the plane's integrated avionics system (some 50% of the aircraft's cost will go for avionics) also is targeted for January or February—two to three months ahead of the April 1, 1972, contract requirement.

All avionics systems, including the Univac general-purpose digital computer and Loral Corp. tactical displays, have been integrated and their interfaces checked out at Lockheed's Rye Canyon, Calif., test facility. As the interfaces are worked out, key portions of the avionics are being transferred to a P-3 avionics testbed, which has been flying since late August. Eventually, the P-3 will carry a duplicate of the avionics, which then will be put in the third development craft; flight testing begins next July.

Lockheed-California's development contract, covering eight development aircraft, has a ceiling of $494 million to be parceled out over five years. That contract gives the Navy the option of buying a planned 191 production models if the development program goes well. Since no technological breakthroughs are required for the avionics package—and because Lockheed-California wants to prove it can come in within budget and ahead of schedule—there's a mood of determined optimism.



Big avionics package. That's the Navy's S-3A, which Lockheed sees as a way to save face after the L-1011 and C-5A problems. The antisub craft will begin flight testing next July.

Companies

RCA, CBS set to lock horns over quadraphonic approach

The entertainment Goliaths are at it again. RCA and CBS, veterans of battles over color television and long-playing records, are preparing to fight it out over a potentially lucrative new market: quadraphonic sound. And here the issue is matrixed vs. discrete sound.

RCA is putting its money on the discrete technique and has teamed up with Japan Victor Corp., a pioneer in discrete four-channel sound, to produce the disks; Matsushita (Panasonic) and JVC, putting their own rivalry aside, will make the hardware. Meanwhile, the CBS-Sony matrixed system is due to appear at the end of this month.

Matrix leads. So far, matrixing appears to be the more popular approach, with ElectroVoice (and its licensees) and Sansui making encoder/decoders, and many turning out hardware. Discrete is available now only on eight-track tapes and in the Dorren broadcast system. However, the RCA team hopes to head off a repetition of the monaural-to-stereo conversion confusion. "Matrixing does seem to be farther along at this point," says Jerry Orbach, marketing manager at JVC America Inc. "But discrete is true four-channel sound; matrixing only simulates it. There's no question in my mind that anyone who hears the two will go with discrete."

Togetherness. The goal for RCA is complete compatibility with two-channel equipment; the target date is next summer. Partial compatibility is available now, with no deterioration of the carrier signal in the track after many plays on stereo equipment. Frequency response, says the firm, is comparable to stereo, and four-channel playback on two-channel equipment offers better separation. Also, signals are not reduced or eliminated as with matrix disks, and disk life is equal to that of stereo records played on two-channel equipment.

But there's a hitch: since production requires laying two channels in each groove, getting the same amount of program on the record in the same space is a problem. Hardware also will be two-channel compatible.

Commercial electronics

Microwave system fights shoplifters

Shoplifting is a worsening headache and rising expense to stores of all sizes—hence to everyone who must pay more for a product when the cost is passed on. Several electronic protection systems have been developed to help counteract this pilferage; one of the most interesting is a microwave tagging system developed by Sensormatic Electronics in Hollywood, Fla.

Sensormatic's system, which uses small tags that are, in effect, microwave repeaters, work with a transmitter and receiver that scan store exits.

It has been on the market about two years, and now about 600 are installed. Among the users, say Sensormatic officials, are 25 of the top 100 department stores in the country. The setup consists of two or more unobtrusive pillars about three feet high at exits, an alarm unit, and the merchandise tags.

Doubler. Each pillar contains a transmitter operating in the 915 megahertz industrial, scientific, and medical band, a receiver for twice that frequency, plus small dish antennas, control circuitry, and power supplies. Each plastic tag, which measures about 1 by 3 inches, and 3/16 inch thick, contains a printed receiving antenna, a small, apparently beam-lead diode used as a doubler, and a transmitting antenna/tank circuit. The alarm can be audible, visual, or both.

The tag is applied to the merchandise with a special clamp that makes the unit very difficult to remove inconspicuously.

A signal is transmitted in the area of the exit. If it is received by the tag, it is doubled, retransmitted, then picked up by the microwave receiver, where it sets off an alarm. Range of the system, according to Kenneth M. Lowe of Sensormatic, is about eight feet.

The fixed transmitter and receiver are both crystal controlled, but Sensormatic is working on a less expensive system. A typical setup rents for $180 per month. The tags are also rented, at 1.5 cents apiece per month. Typical cost to a small store is about $3,000 for the first year, says Lowe. The system is most valuable with soft goods, records, and tapes. Metal items are hard to tag, but Sensormatic is introucing a configuration for expensive office equipment.

Gotcha! Shoplifting-detection system uses a tag that must be removed from article when purchase is made. If it isn't, passage between two pillars sets off audio or visual alarm.

Computers

Univac's 9700 attacks IBM with emulation

Univac has taken dead aim with its new 9700 computer at a large chunk of the market now occupied almost exclusively by IBM. The means, Univac hopes, is to incorporate a facility for emulating the old IBM 1400 series computers.

With the capability, users can load a program written in the 1400-style language into a new machine and run it—in some cases better than the old machine could. Perhaps as many as 50% of present-day IBM installations are running all or most of the time in emulation mode, and Univac sees many of these as ripe for conversion to 9700s.

In the machine. To nail these customers, Univac has included in the 9700 a microprogramed control section. Like microprograms in other machines, it is the principal control logic for the machine. It also contains the emulator, which handles the most time-consuming instructions for the 1400 line, leaving the rest to software simulation.

The control section uses read-only

Emulation is the key. Univac's 9700 computer contains microprogramed control section that holds emulator. It's with emulation that Univac hopes to grab piece of IBM's market.

and read-write memories—both bipolar semiconductor arrays. The read-only section contains the critical part of the new system's microprogram, which must be maintained at all times, even through power failures. The read-write section of the 9700 contains other parts that are not in constant use and can be reloaded as needed.

The fact that Univac is now making emulation available on its machines is of considerable significance. It's another step along the road to computers that, while perhaps technically incompatible, nevertheless can run one another's programs easily.

Surprise. IBM introduced the concept in its 360 computers back in 1964, as a stopgap measure to permit its customers to convert their programs from older languages into 360 language at their leisure. To IBM's surprise, many customers never got around to the conversion. They found it easier to live with emulation indefinitely, even at a small degradation in machine performance, than to convert their programs.

This reluctance was the impetus for IBM's integrated emulation in the 370 line, which permits old-language programs to run concurrently with new-language programs in multiprogramed mode. The 360 could run only with one language or the other.

Only one other company presently makes computers with emulation—Standard Computer Corp., of Santa Ana, Calif. Its IC-7000 has the capability of emulating any other computer, but has no identity of its own. Standard's resources have been somewhat limited; it has built only about 20 of these machines. Its emphasis now is on time-sharing services, which it operates through subsidiaries in various parts of the country.

Two sales paths. Univac expects to sell the 9700 not only to customers now using IBM's System 360 models 30, 40, and 50, but also to upgrade its own customers' existing installations of earlier machines in the 9000 line—the 9200, 9300, and 9400. All the machines use nonvolatile plated-wire memory capable of nondestructive readout. Like Univac's larger 1100 and 490 series machines, the 9700 has a dedicated storage unit for its operating system software, which permits sections of this software to be removed from the main memory, yet doesn't compete with the conventional input/output channels. The computer has an optional channel for communications-oriented processing, up to four high-speed selector channels, and one multiplexer channel.

Communications

Agreement disappointing to CATV expansionists

It looks as though hopes of cable television operators wanting to expand into auxiliary services in the major cities are going to be partially disappointed. With the Office of Telecommunications Policy prodding, cablecasters and over-the-air broadcasters have come to an agreement that will put cable into large cities, but will also serve to slow penetration of the 50 largest centers by imposing copyright restrictions on programing.

The main issue has been importing distant signals into the video-glutted metropolitan areas. As it stands now, cable companies will be able to bring in two nonlocal channels, but will have to pay for movie rights in the 50 top television markets in the country.

Not enough. This plan is less liberal than the distant signal formula proposed by the FCC last summer and later studied by the Rand Corp.—before the agreement—to analyze its impact on the cable industry. The Rand report points out that imported channels will contribute to cable's penetration of the big cities. But that penetration alone will not be enough to support auxiliary activities such as community services, education programing, and local shows.

"The rules by themselves are probably not sufficient to make cable profitable in most of the 100 largest markets," says Rand analyst Rolla E. Park. "To succeed in these cities, cable must attract customers with new services, in addition to the traditional package of better reception plus distant signals."

Signals needed. Without the FCC's provisions for distant signals, expected penetration would be 5 to 10 percentage points lower than the 20% to 35% of all households predicted for the center of the market. There are slightly more subscribers at the edges of the market, estimates Park, "but if some of the affiliates

are low-powered uhf stations, poor over-the-air reception at the edges of the market can push expected penetration over 60%."

Park warns of what he calls cream-skimming due to high penetration where over-the-air reception is bad. "If cable is allowed to grow in an uncoordinated way, cable operators may well wire up communities on the fringes of the markets, where higher penetration is expected, and leave the central cities unserved—or at best served by their own separate, impoverished systems." He adds that increasing use of color TV receivers, which demand a higher quality signal, will boost penetration.

Using a statistical model based on a survey of operations in 63 representative markets, Park quantifies expected increases in penetration due to other sources. For example, a 2% annual increase in real income would add 6% to penetration over the next 10 years. And reducing the subscription cost from the average of $63 a year to $36 could mean a substantial increase in penetration.

"This suggests that one way out may be new kinds of ownership agreements," Park says, such as "cable systems owned by entities that are not much interested in near-term profits."

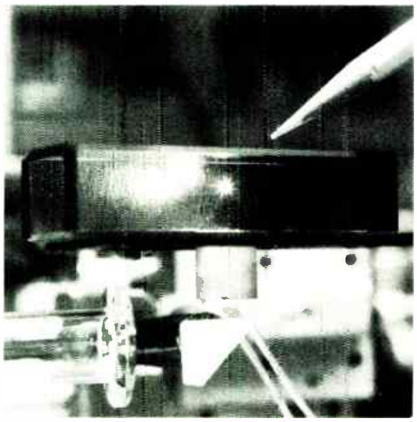
Lasers

Material suspended in light beam

A pair of Bell Laboratories researchers has come up with a potentially valuable communications research tool by suspending a particle in a laser beam and keeping it stable. Since minute bits of material could be manipulated without support, the technique "could be useful to measure scattering loss caused by particles," says Arthur Ashkin, who worked with Joseph Dziedzic on the project at Bell's Holmdel, N.J., facility.

Presently, scattering cannot be measured in real time because of interference from any support used.

Hangup. Twenty-micron particle suspended in laser beam by Bell Labs researchers.



And in designing microwave communications systems, it's important to know just how much scattering will be caused by rain, fog, or other natural conditions that can wreak havoc with transmissions.

What's more, "When used in an evacuated environment, where damping effects on the particle are negligible, optical levitation may also have applications in inertial devices such as gyroscopes and accelerometers," adds Ashkin.

It's radiation. Ashkin and Dziedzic have suspended a 20-micron glass sphere supported by a vertical light beam. The sphere comes to rest about 1 millimeter above the point where the beam is focused. Radiation pressure from the light not only counteracts gravity and raises the particle, but also traps the sphere in the beam and prevents it from slipping sideways, out of the beam.

The sphere is launched by lifting it off a transparent glass plate. Initially, the molecular attraction between sphere and glass plate is broken acoustically by vibrating a ceramic cylinder attached to the plate.

Then, the sphere rises in the light beam and comes to rest where the upward pressure caused by the laser is balanced by gravity.

The particle is enclosed in a glass box to reduce air-draft effects. Two surfaces of the glass box are painted black to show the right-angle interference patterns due to scattering.

In the Bell experiment, the trapping forces holding the sphere within the beam also were studied. A second laser was focused on the particle from the side; as its power was increased, the particle being suspended was displaced within the first beam until it was finally driven out and fell.

"Using this method," says Ashkin, "we found that the force that centers the particle in the verticle beam is about a good 0.5 G, or about half the force holding the particle aloft."

Coherent light does not have to be used to suspend the glass particle. But with coherent laser light, say Bell's Ashkin and Dziedzic, "we have a means of focusing the light beam to a flux concentration suitable to that required to lift the particle."

Consumer electronics

NRMEC chips to go into cash register

By early next summer, an electronic cash register will be on the market using the basic MOS/LSI building blocks that have been evolving at North American Rockwell Microelectronics Co. These first went into Sharp Corp.'s Micro-Compet desktop calculator more than two years ago.

Officials at NRMEC, in Anaheim, Calif., won't name their customer, but they're basing their predictions of increased growth in MOS/LSI sales heavily on the programable calculator processing unit that now goes into both Sharp and Victor Comptometer Corp. calculators. There are four such chips in the Sharp and Victor machines on the market.

Michel Ebertin, NRMEC's new director of business machines development [*Electronics*, Oct. 25, p. 26], says it's no great chore to change the processing unit over from calculator to cash register applications. What he describes as a simple cash register also would have four of NRMEC's chips, plus a programable read-only memory chip and an interface chip

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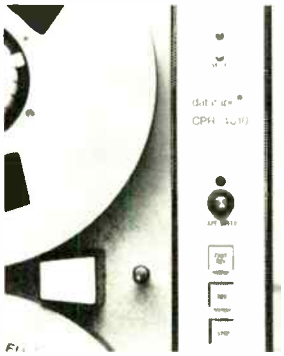
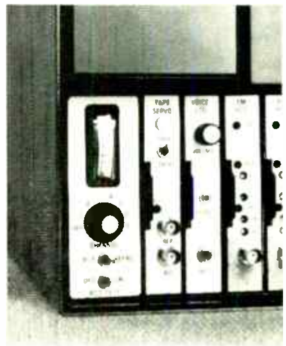
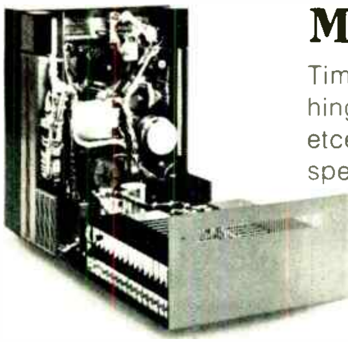




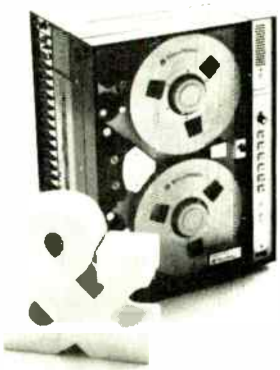


Maintenance and Servicing

Time for the annual P.M.? It's no big deal. The back panel's hinged. Just flip it down. All motors, power supplies, electronics, etcetera, are right there. (It even runs in this position.) Nothing special needed. How's that for simplicity?

Performance

Briefly, from the top: 7 speed transport, 15/16 to 60 ips; 7 speed direct, all automatically switched, 300 kHz at 60 ips; 7 speed FM record; 40/20 kHz, automatically switched. Any 2 speeds of FM reproduce; low tape flutter and TBE; isolation from reel perturbation via dual capstans and tension sensors. Low mass, closed loop IRIG servo system. The same electronics design as our top-of-the-line VR-3700B.



Bell & Howell & the CPR 4010

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to drive a display that would probably be implemented with liquid crystals, which NRMEC also makes.

Four-phase. The four chips are control, arithmetic, timing, and a steering circuit. These four, plus the programable ROM for the various cash register function keys, and the interface chips, are all fabricated with NRMEC's four-phase MOS process.

The programable ROM will handle a wide range of function keys. They are an item key that, for example, could indicate whether the purchase article is meat or produce (in a supermarket application); a refund key; a discount key; a key that calculates how many trading stamps the total transaction is worth; a key to calculate sales tax that can be locally programmed; and a key to indicate the sale is complete readying the cash registed for cash input. Other functions include a "for" key to accommodate sales of multiple items of the same kind at a sale price; an "at" key that's used to help calculate the price of several of the same items at the same price; and a key that opens the cash drawer.

There will be a keyboard with numerals from 0 to 9. In a representative transaction, the clerk would punch the numeral 5, the "at" key, and the item key to indicate five cans of soup at 27 cents each. The machine's logic and registers will multiply and accumulate the total so that the price key doesn't have to be punched more than once. And if the customer also has a taxable item such as detergent or a skillet, the clerk would enter the price with the keyboard, punch the item key and tax key and the ROM would calculate the tax on local basis in much the same way as a calculator accumulates and totals.

Locked. If the clerk punched the "end sale" key the total would be calculated, and he or she would activate the cash drawer key after entering the precise amount of cash or check the customer has given. If that number were less than the transaction total, the drawer wouldn't open; if it were equal to or more than the purchase toal, the drawer would open and the customer's change, if any, would be displayed.

Ebertin says a single ROM can handle all the listed function keys "and not come close to taxing the processor and ROM capability." NRMEC officials say the electronic cash register will cost only a tenth as much to manufacture as its electromechanical counterpart, and could sell for about half the price of today's $1,500 to $3,000 machines.

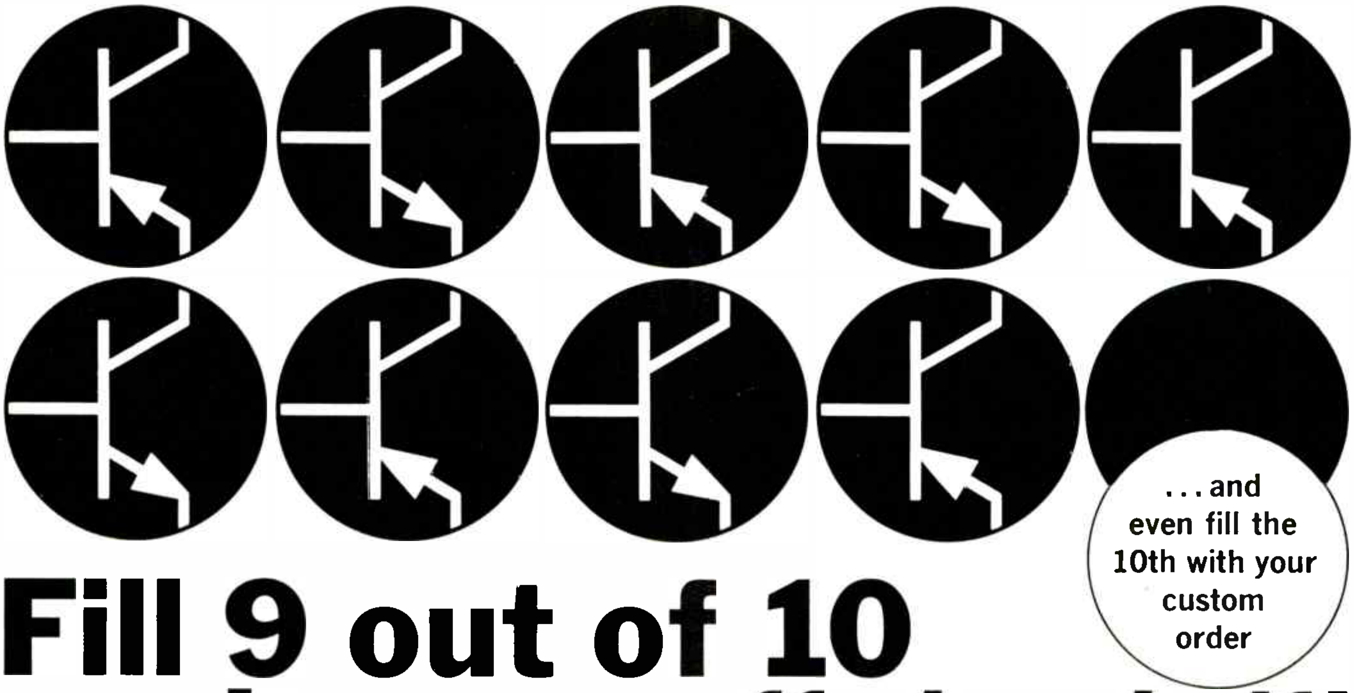
One-chip design aimed at under-$100 calculator . . .

Chalk up another entry in the single-chip, under-$100 calculator sweepstakes, and the name of the firm may surprise many people—Garrett Micro-Circuits Corp. of Rahcho Bernardo, Calif., a subsidiary of the Garrett Corp. [*Electronics*, Nov. 8, p. 26]. When the parent firm sold Garrett Micro-Circuits' assets to the Burroughs Corp. last August it retained the corporate name as well as a team that was working on proprietary developments. The one-chip calculator is the first product to result from these efforts.

Garrett Micro-Circuits has built a prototype, but does not plan to manufacturer either the chip or the calculator itself; the company will supply mask and engineering know-how to semiconductor firms, which will custom-bond the chips. "We have firm quotes on the chips and it's just a matter of placing the orders," says George Cone, director of operations for Garrett Micro-Circuits. "Production should start in January."

Smaller chip. The calculator will be produced in the U.S., and because the chip is small and the labor in assembling the calculator is minimal, it should sell comfortably for less than $100, says Cone. The chip measures 150 by 170 mils against 230 by 230 mils for the Texas Instruments calculator chip and 220 by 220 mils for the two chips used in the Ragen under-$100 calculator [*Electronics*, Oct. 25, p. 32].

Cone concedes that the TI chip has wider applications than Garrett's. However, he also points out



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that Garrett has some "design tricks" for which it is seeking patents, and adds that the clock is included in the Garrett chip, whereas TI's requires 13 external components for a clock. The company is also applying for patents on some techniques used for the keyboard input logic and for segment blanking to avoid crosstalk between the calculator digits.

Dense. "We have achieved high density without violating good practices, reliability, and yield," he claims. "We have close to 4,500 gates, whereas a typical industry figure would be 1,000 gates."

Garrett uses a standard process for its chip, a p-channel, high voltage (4.5 to 5.5 v) unit. The calculator uses 18 discrete transistors for drive circuitry and the Digitron-type display tubes. The prototype unit operates from an ac power source, but Garrett has designed an ac/dc unit which will run for five or six hours on rechargeable batteries.

The calculator performs all four arithmetic functions, including chain-type problems, and also can handle negative figures. It has eight digits with full floating point and zero suppression, and will calculate up to 16 digits internally.

. . . as new firm designs machines for others

Still another firm has found a path into the broadening calculator business without making or selling the machines. Optimized Technology Inc., Santa Clara, Calif. a company formed a few months ago, is designing calculators with half a dozen companies.

All of the chief design engineers at Optimized Technology, including its president, Lloyd Taylor, made up the customer engineering center at American Micro-systems Inc. in Santa Clara. There they were responsible for interfacing AMI's sales and engineering divisions and were involved in applications engineering on many projects, including electronic calculators.

Taylor describes his new operation as "Putting together packages. We work with a customer who wants to apply MOS/LSI to his system and we are not limited to calculators," though they are the focus of some of Optimized Technology's first projects. Taylor says that in working with a customer the firm either designs the logic or specifies one of the logic sets already available. "Then we marry a display and keyboard to it and specify a power supply and a case. We then send it out to a manufacturer (an assembler) and have it built for our customer." One such customer is Commodore Business Machines [Electronics, Nov. 8, p. 41].

Lower cost. While this approach may seem complicated, Taylor says "actually there are less parties involved with this setup than you might find in normal channels within one company that does it all itself." The result, he says, is a lower manufacturing cost for the product. For calculators, this means that machines can be built in the U.S. more cheaply than in Japan. "We can easily compete with the Japanese," he says. "A machine that costs them $80 can be done in the U.S. for $47 factory cost."

That is why he says the calculator industry has done a complete about face. "It used to be that people would consider a machine on its application, quality of the service available, appearance, and finally cost. But now it's cost first and then appearance," says Taylor. "The calculator is now a consumer product."

Integrated electronics

Solid state Loran-C on Coast Guard horizon

The Coast Guard may be able to get a solid state Loran-C yet. This appeared unlikely when projected cost overruns forced a halt to Sylvania's development of Transloc (transportable Loran-C), because there was no apparent successor. But Symbionics Inc., a spinoff of Sylvania's own Advanced Research Laboratories, was soon proposing what it hoped was a better method of doing the job.

The Coast Guard was interested enough to fund $70,000 worth of initial development. Symbionics, in turn, formed Megapulse Inc. in Waltham, Mass., to develop a semi-proprietary rf power generation scheme called the Megatron [*Electronics*, Oct. 11, p. 26]. The first model only filled a relay rack, but generated 30 kilowatts effective radiated power.

Now the service has an $840,000 contract with Megapulse for a solid state, computer-controlled transmitter module. It would be capable of more than 200 kilowatts ERP—and also capable of being paralleled with other modules to reach the megawatt power levels the Coast Guard requires. Though the contract reads "engineering model," Megapulse is trying hard to come up with the equivalent of a preproduction prototype, according to S. C. Bigelow, systems manager.

The rf portion of the 200-kw module is to be tested before spring 1972, and a version using a computer to control several of the critical parameters of the complex sinusoid that make up a Loran-C signal are to be delivered by October.

Package. The Megatron is a combination of a power supply and storage capacitors, coupled with solid state and saturable inductive switching elements. The solid state switches are off the shelf, 1,000 V, 110 ampere silicon-controlled rectifiers, and there are six for each switching function—three paralleled stacks of two SCRs each. Thus, while the transmitter emits peak outputs of 520 A, individual SCRs draw only about 40 A rms. Part of this is due to use of a nonlinear inductor in the megatron's output stage; with it in the loop, the system achieves a pulse compression effect.

Timing is overwhelmingly important in Loran; pulse timing decides navigational accuracy. Thus, the Megatron module will be built with an analog-digital servo loop around it to aid timing control. One figure of merit for a Loran signal is the tightness with which the sinusoid's zero amplitude crossings are controlled. Megapulse is shooting for a Coast Guard-specified ±10 nanoseconds. After tests of the rf system, a computer will be added in an attempt to improve control of pulse shape, amplitude, and zero crossing.

Although the Coast Guard is far from writing purchase orders for Megatrons, engineers at Megapulse look toward a hypothetical system comprised of paralleled Megatrons as a Loran station, with each module under the control of a central computer; DEC's PDP-11 would be their choice.

Industrial electronics

Word-processing market drawing more entries

Business machine makers are getting the message: the newest hot market is word processing, or automatic typewriting. Such equipment, using cassettes, paper tape, or cards, is being sold as the last link in the automated information-processing chain by more and more companies out to cut into a market virtually owned by IBM.

The market already includes at least one other business-machine giant, Remington Rand, and a host of more specialized firms, such as Quindata Inc. of New York, Information Control Systems of Ann Arbor, Mich., and Spiras Systems of Waltham, Mass., and among the latest entries is Wang Laboratories [*Electronics*, Nov. 8, p. 41.]

Word-processing gear is either a typewriter/terminal, or typewriter and separate terminal connected to a logic console. Information is keyed in, stored, and printed out. Mistakes are corrected in the console by pushing a button and typing over the error. Revisions can be localized and retyped the same way, since the units have edit capability. Training can take as little as a few hours.

Various versions. Remington and Quindata build single-station systems. On the other hand, Spiras' Accutext, also a single-station arrangement, has a CRT display. And, Information Control's Astrocomp 8

links from two to eight typewriters to a minicomputer.

Accutext, according to product manager Edward Devin, is "the only word processor using a CRT display." Information is keyed in on the terminal and simultaneously displayed: the operator doesn't have to wait for typewriter printout to catch errors or revisions. The tape accepts and transfers copy at 300 characters per second and each cassette stores 100,000 characters.

Taking the single-station concept further is Wang's system 1200: it works with an IBM computer or 1200s.

IBM's entry also offers computer hookup and point-to-point operation. Moreover, individual dictating machines can be replaced by PBX telephone or remote microphone systems, permitting feed into one or more central recorders-transcribers at a word-processing center.

For the record

Good count. Nerem is estimated to have drawn about 12,000 attendees this year, only 3,000 fewer than in 1970, and not nearly as poor a crowd as was feared. Exhibits at the Boston meeting also were better than expected, though fewer and smaller than last year.

Down. Varian Associates of Palo Alto, Calif., has experienced the most significant loss in its 23 years in operation. In the fiscal year ended in September, Varian reported a net loss of $6.7 million or 94 cents per common share. In fiscal 1970, Varian had a profit of $4.7 million.

Ampex change. Arthur H. Hausman has been elected president of Ampex Corp., Redwood City, Calif., following the resignation of William E. Roberts. Roberts will continue as chairman. While the company says that Roberts resigned because of health, financial analysts and company watchers note that Ampex has been losing money—$12 million for fiscal 1971. Hausman, 47, was formerly chief operating officer and executive vice president.

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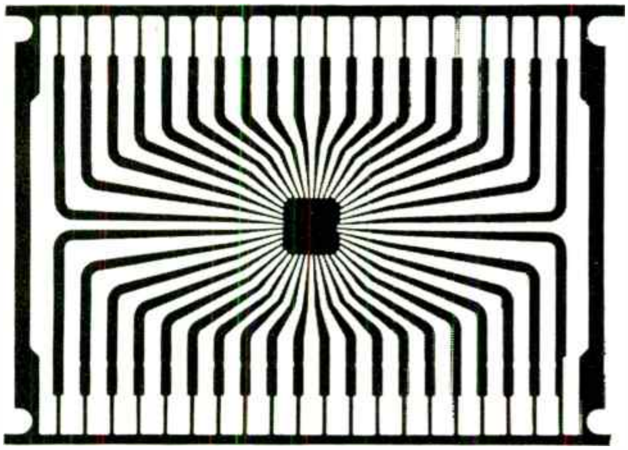

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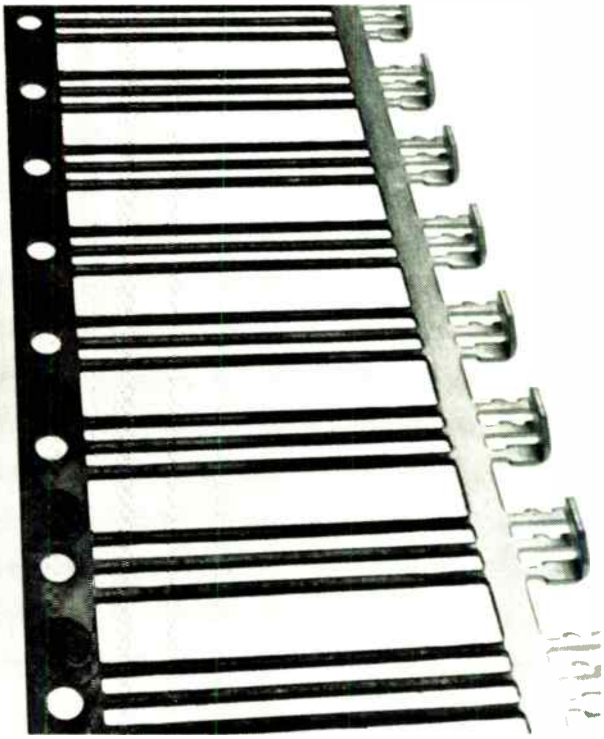

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GTE SYLVANIA

Washington Newsletter

November 22, 1971

EIA trade policy seen doomed by split in membership . . .

Fearful of a split that could result in a loss of member companies, the Electronic Industries Association appears ready to let its draft "white paper" on international trade policy die a quiet death. This is the private estimate of two EIA executive committee members, who contend that the association's first effort at establishing an industry-wide policy foundered on the opposition of the Consumer Electronics Group.

Group members, it is said, found that the draft presented to member companies at a recent meeting in Los Angeles "tended to be protectionist even though it wasn't far right of center." The draft reputedly called for free trade insofar as it did not affect U.S. industry jobs, and also for U.S. retaliation against nations raising artificial nontariff trade barriers against American exports.

. . . but no one seems too sorry

One consumer group member argues that opposition also exists among companies with multinational interests outside the consumer area, and faulted EIA staff work that had the draft document still in preparation as the Los Angeles meeting began—a situation that precluded circulation of the text among members prior to the meeting. However, a spokesman for the traditionally protectionist Parts Division termed the document "innocuous," and Government Products Division sources expressed similar feelings, adding that "three-quarters of the association is for it." EIA's top Washington executive Jim Adduci also said he has "no concern about losing members" over the nine-point position paper.

Nevertheless, most sources suspect it is a dead issue. If so, EIA will remain one of the few major trade organizations without a position on foreign trade, apart from its recent resolution urging increased trade with East European nations.

DOD pressured on prototyping by Congress . . .

Because of Congressional criticisms that Deputy Defense Secretary David Packard is not putting his money where his mouth is when it comes to competitive hardware prototyping, the Pentagon is leaning on the three services to give the program stronger support in fiscal 1973 and provide funds for competition in some major projects. The House Appropriations Committee delivered a critique along these lines to the full House recently, along with its fiscal 1972 defense spending bill.

While expressing enthusiasm for the Packard plan [*Electronics*, Aug. 30, p. 65], the HAC was also irritated that DOD wanted an additional $67.5 million to carry it out instead of reprograming existing funds. Moreover, the committee said it was disappointed that the concept "was not applied to some higher-priority existing development," and hinted that the services were exploiting the Packard plan merely to get fresh money for "low-priority programs similar to other programs that have been discussed for some years but have not received funding."

. . . but still may get more $$ than last year

The total $71 billion appropriation recommended by the House Appropriations Committee cut nearly $2.5 billion from the DOD request, but generally pleased the Department—it was still left with more than $1.4 billion above the figure it finally received last fiscal year.

Areas containing money for electronics—procurement, research and development, operations and maintenance—were all higher than fiscal 1971 funds. Procurement increased by $2.15 billion to nearly $18.2 billion, research and development by $507 million to $7.5 billion, and operations and maintenance by $313 million to $20.4 billion.

Air Force STOL, fighter win praise, but not sensor group

The only good things the House Appropriations Committee could find in the three services' competitive prototyping plans were the Air Force proposals for a short takeoff and landing transport and a lightweight fighter. In fact, the HAC didn't just recommend, it directed that the entire $12 million approved for that service's prototyping be spent on those two programs. Even so, the bill warns that preliminary Air Force plans for the STOL should get a hard second look since "it would be unfortunate to have goldplating doom this program effort." As for the fighter, it appeals to Congress because of the trend to planes costing "$15 million a copy" and the concern that the U.S. have small, viable fighters to cope with vastly superior enemy numbers.

However, a $34 million budget request for the Defense Special Projects Group—the Pentagon's heavyweights in sensor technology, who achieved fame with their Southeast Asia efforts—was chopped to $7 million. The appropriations body noted that the group's continuation is another "classic example of the bureaucratic tendency never to end an organization" even after its job is done.

HEW to unveil device bill, finally

The long-awaited Administration medical device bill, now being circulated in final draft form among Government groups outside the Department of Health, Education, and Welfare, will surface by the end of the year, say HEW officials. In the bill, the burden of clearing products for the market—the provision that the $400 million medical electronics industry opposes most strenuously—falls on advisory panels drawn from industry, Government, and scientific experts. Essentially, the details parallel last fall's recommendations by a special HEW committee on medical devices and the proposals introduced earlier this year by Paul G. Rogers (D., Fla.) in the House and Gaylord Nelson (D., Wis.) in the Senate.

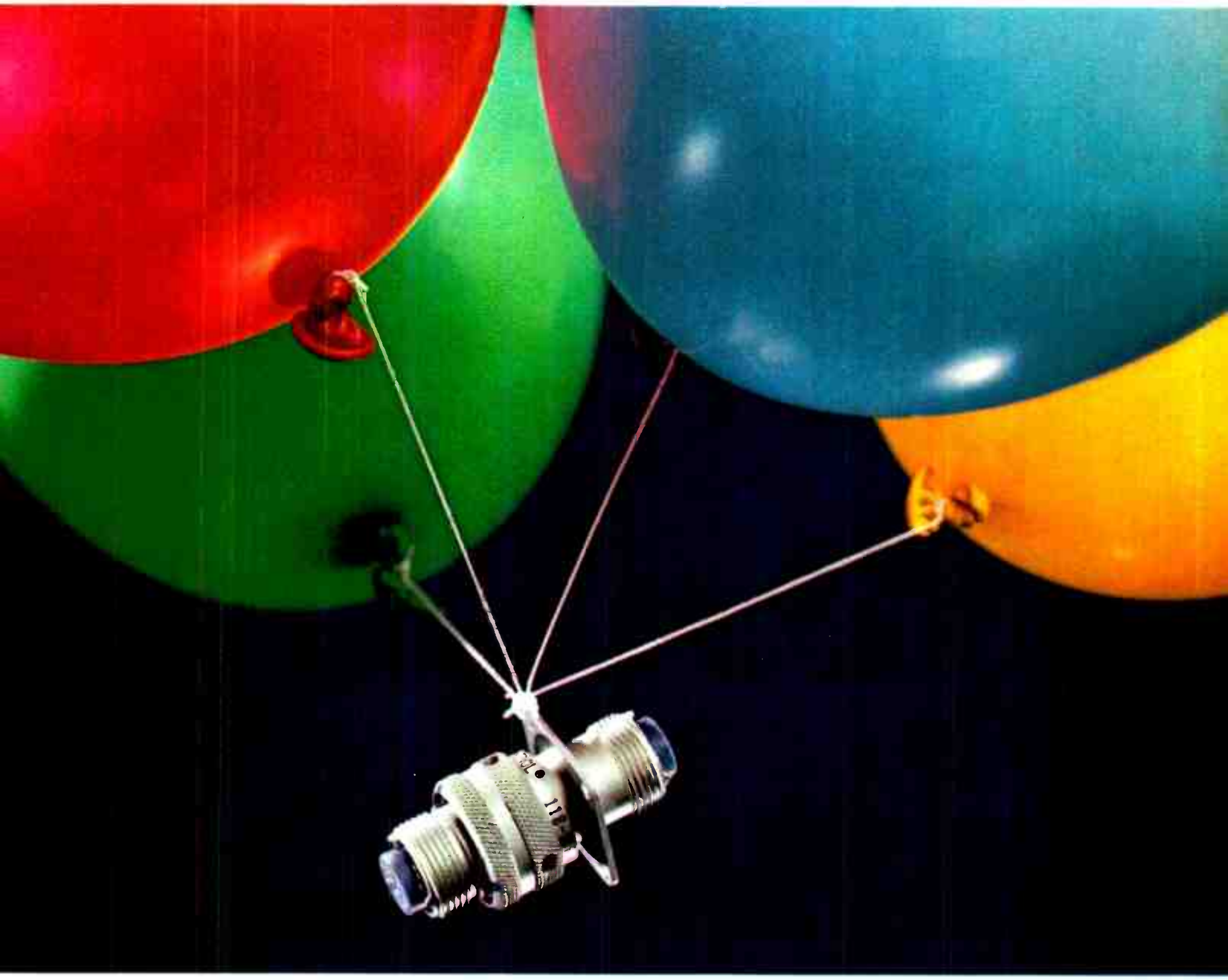
The Food and Drug Administration would have three years from the date of passage to review those devices currently on the market and subject to clearance. For devices subject to standards but not clearance, design and performance requirements would go into effect immediately. The FDA would also be allowed to inspect factories, to require manufacturer registration and record keeping, and to order repair, replacement, or refunds for faulty or ineffective medical devices.

Microwave Landing System award slips to next year

Awards for the contract definition phase of the potentially lucrative Microwave Landing System, originally intended for December, will not be made until next year. But that may still mean January, if the Federal Aviation Administration's evaluation committee can complete the unexpectedly prolonged selection process by the end of the year and if the FAA's topside concurs.

Up to six companies may be selected for the $3 million contract definition phase, which is the first in a three-phase, five-year development program to produce prototype ground, shipboard and airborne hardware for both civilian and military uses. The FAA plans to buy 454 ground units for about $100 million and to start installing them in 1978.

The new Merlin 1® connector.



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Circle 47 on reader service card

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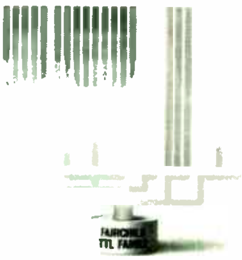

Four new high quality members have been added to the Fairchild family of 96 TTL/MSI circuits. Each can be used in a variety of designs—alone, or combined with other members of our TTL and/or MOS families—for simple solutions to complex systems problems: For example:

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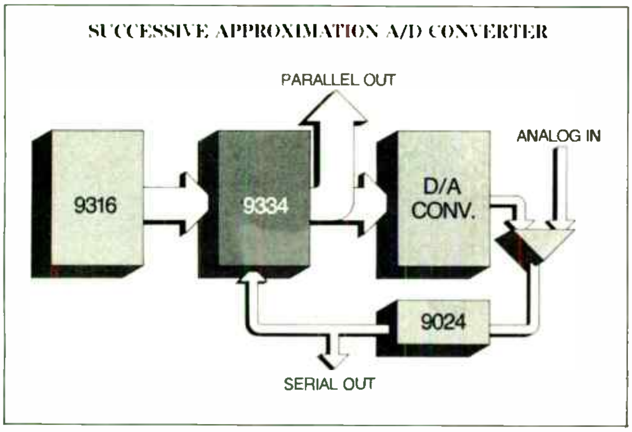
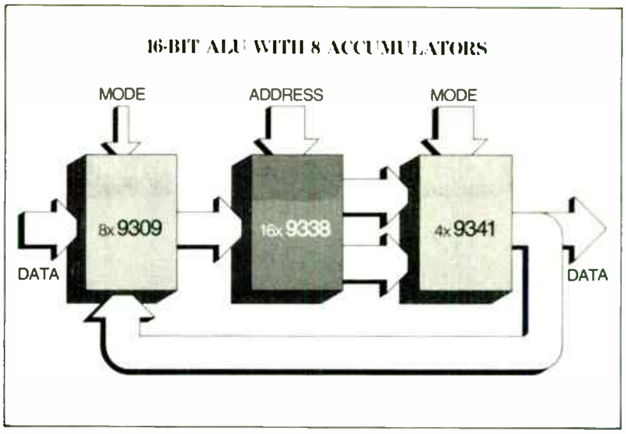


In an A/D Converter, the 9334, combined with a 9316 Binary Counter and standard linear devices, provides a successive approximation analog-to-digital conversion. Send for our Appl. Note 294.

9338 8-Bit Multiple Port Register for high speed storage in an arithmetic logic unit is probably the most significant new function yet designed for minicomputer memories. Uniquely, it eliminates any addressing restrictions by permitting simultaneous read/write without race problems and by allowing data to be written into any one of the 8 storage locations and read out of any two of the locations *simultaneously.*



Used as a one-bit slice of eight registers/accumulators, it combines with either the 9340 or 9341/74181 ALU device to become the powerful heart of a minicomputer central processing unit. It's equivalent to a 9301 decoder, a 9308 latch, two 9312 multiplexers and a dual flip-flop. Send for our Appl. Note 220.

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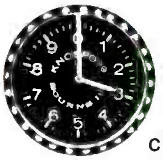

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DTS 411	300V	3.5A	300V	100W	Voltage regulator, switching regulator, DC to DC converter, class A audio amplifiers.
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DTS 423	400V	3.5A*	325V	100W	*I_C Peak = 10A High V_{CBO} and V_{CEO} ratings make it practical to operate directly from rectifier 117V or 220V AC line.
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DTS 425	700V	3.5A	400V	100W	
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DTS 723	1200V	3A	750V	50W	Very high voltage industrial and commercial switching.
DTS 801	1000V	2A	700V	100W	Color vertical magnetic CRT deflection circuits.
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2N2581	400V	10A	325V	150W	
2N2582	500V	10A	325V	150W	
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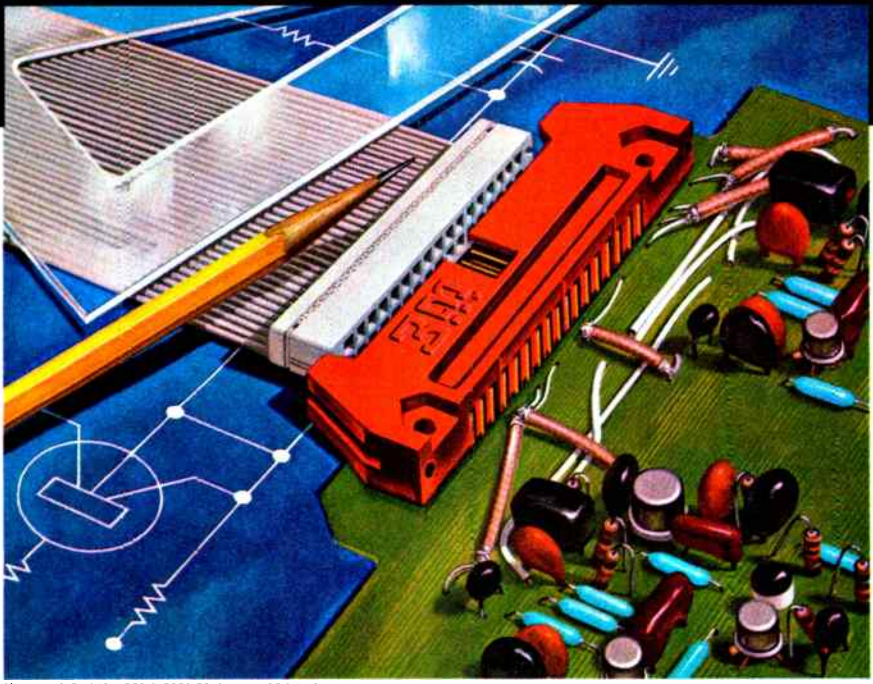

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For full information on the "Scotchflex" systems approach to circuitry, write to Dept. EAH-1, 3M Center, St. Paul, Minn. 55101.

3M COMPANY

Technical articles

Monolithic multiplier sets a fast pace for computers: p. 56

Whether it's implemented by software or hardware, multiplication is a slow process in computers, asserts author Clive Ghest. A new medium-scale IC gets the lead out by multiplying two-bit by four-bit numbers and adding the constant. Moreover, iterative arrays can multiply larger numbers and still bypass the complex designs and long sequential operations of previous hardware.

Fm stereo design made easy with a phase-lock loop IC: p. 62

The phase-lock loop lands in the consumer electronics designer's ballpark via a stereo decoder integrated circuit that provides better separation and lower harmonic distortion than conventional approaches, says author Michael Gay. And just as important, it comes in an IC package, so that assembly, alignment, and component costs can be sharply reduced.

Line eases the load for digital circuit designers: p. 70

Ask a designer of fast digital circuits about ringing and delay calculations, and he's likely to groan. But he won't buckle under the weight of load-effect dogwork, says author Laurence P. Flora, if he uses Line. It's a computer program that analyzes digital interconnections as if they were transmission lines, and computes line voltage and plots ringing characteristics as well.

How bright is bright in strobed LED displays? p. 78

With light-emitting diode displays proliferating rapidly, it's becoming easier and more economical to strobe the diodes, rather than power them individually. But what of the all-important brightness factor—will the results satisfy the viewer? Author Richard Ahrons offers a factor derived from measured data that can help determine the right point at which to strobe.

Special report: The Rising Sun isn't rising so fast: p. 119 (cover)

"Spectacular" used to be the appropriate word to describe the growth curve for the Japanese economy in general and its electronics industries in particular. "Soggy" best describes the outlook now, however. With U.S. economic policies forcing the yen's exchange rate upward, the 10% import surcharge hurting sales to Japan's number-one customer, and a mild recession to boot, Japanese electronics this year should grow only half as rapidly as last year.

The cover: The prime movers of Japan's electronics industries, as they were photographed by Arthur Erikson, Managing Editor, International, and Charles Cohen of Electronics' Tokyo bureau, during the dozens of face-to-face interviews that went into this report.

And in the next issue . . .

Optoelectronics pits lasers against air pollution . . . protecting bipolar transistors from avalanche damage . . . charge-transport devices give designers new options for memories and imaging . . . capturing and digitizing fast transients . . . getting better digital ICs for minicomputers.

Multiplying made easy for digital assemblies

New IC multiplies 2-bit by 4-bit number and adds constant; iterative arrays of the device can multiply larger numbers, yet bypass complex designs and long sequential operations of previous multipliers

by Clive Ghest, *Advanced Micro Devices Inc., Sunnyvale, Calif.*

☐ Computers have always been slow at multiplying, whether they relied on a software subroutine or on a hardware multiplier. The first requires complicated programing, and the second is generally only available as an expensive option that is wired or plugged into the basic machine. Even the large general-purpose machines that include multiplication as a standard instruction usually implement it with quite complex hardware.

Minimal hardware, however, is needed with a new, medium-scale monolithic multiplier that can be used in iterative arrays for high-speed 2s-complement multiplication. Advanced Micro Devices' Am2505 multiplies a two-bit number by a four-bit number and adds a constant to the product in a few nanoseconds. To multiply larger numbers of M and N bits requires ⅛ (M × N) of the new ICs.

Obviously, this multiplier allows direct hardware multiplication in minicomputers. Less obviously, it streamlines the design of complex special-purpose machines like fast Fourier transform processors and time-shared digital filter networks. It also completely bypasses the need for slow sequential methods in conventional arithmetic units, and for the special-purpose control and shifting logic that some processors use to speed up the multiplication process.

Basically, binary multiplication is a series of additions and single-bit shifts. Generally, a multiplier requires one fewer shifts than it has bits. Following each shift, a decision is made either to add the other factor—the multiplicand—to the partial product, or to add 0, depending on whether the digit for that bit position of the multiplying number is 1 or 0. Then the multiplicand is shifted one place relative to the partial product, or vice versa, and another similar decision is made.

The new multiplier is fast because, instead of proceeding one bit at a time, it inspects several bits simultaneously in one of the two factors to be multiplied.

No step-by-step shifting

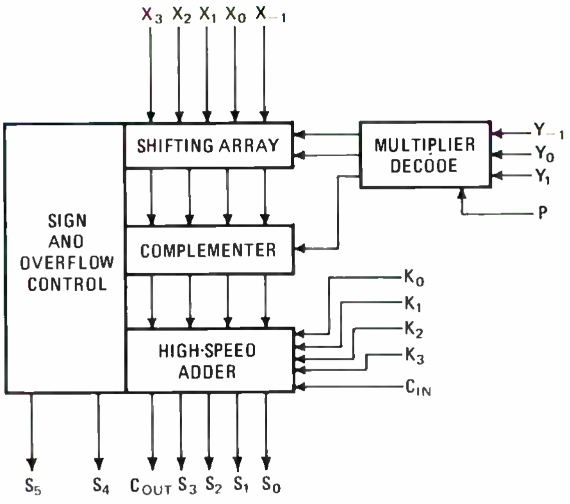
It derives from one almost obvious method of speeding up multiplication—which is to shift past all consecutive 0s in the multiplying factor in a single operation. For instance, a row of four 0s in a factor can be made to trigger a four-position shift. This is clearly quicker than alternately shifting one position and deciding not to add, four times over.

The new unit extends this technique by also shifting past strings of 1s in one go. For example, the decimal number 127 corresponds to the binary number 1111111. Straightforward multiplication by this number would require seven additions and six shifts, or 13 separate operations. But

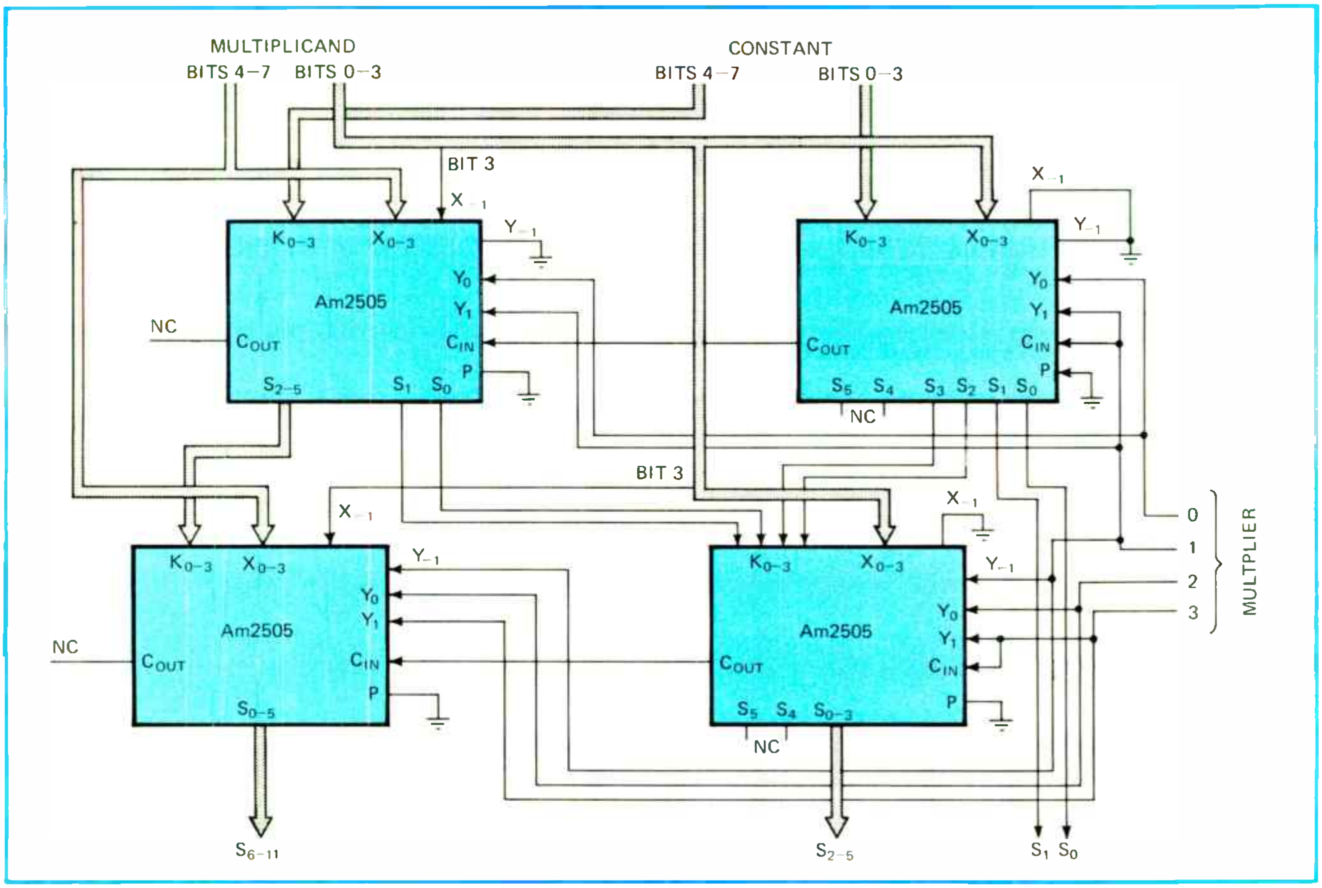
$$127 = 128 - 1 \text{ (decimal notation)}$$
$$= 2^7 - 2^0$$
$$= 10000000 - 1 \text{ (binary notation).}$$

This corresponds to a subtraction of the multiplicand in its right-most position, a single shift of seven places, and one addition with the multiplicand one place to the left of the most significant bit. In this way, the product is found with only three operations instead of 13.

Most numbers, of course, comprise several alternating strings of 1s and 0s, with a few individual bits scattered here and there. In such numbers, each string of 1s would cause the multiplicand to be subtracted once, shifted the necessary number of places, and added once, just as in the previous example. An isolated 1 in a binary number would cause a subtraction, a one-place shift, and addition. In binary notation this pair of oper-



1. Multiplier. These five sections multiply a four-bit number, x, by a two-bit number, y, and add another four-bit number, k, to the product. Inputs x_{-1} and y_{-1} are among connections used when several devices multiply longer numbers. Pin P determines logic convention; it's grounded for positive logic, unconnected for negative logic.



2. Iterative connection. Four multipliers can produce a 12-bit product from eight-bit and four-bit inputs. Successive rows are staggered; four K inputs to multiplier at lower right are connected to S outputs of multiplier immediately above and of multiplier at top left.

ations is the same as subtracting the multiplicand from twice its value. This, of course, is equivalent to adding the multiplicand once—which is exactly what the single 1 bit calls for.

This subtract-shift-add sequence is the basis for an algorithm for multiplication:

- Throughout the process, the multiplicand shifts from right to left, or from the least significant to the most significant digit of the multiplier.
- It is subtracted from the partial product at the beginning of every sequence of 1s in the multiplier.
- It is added to the partial product at the beginning of every sequence of 0s.

(The word "multiplier" in this context refers to the factor by which the multiplicand is multiplied. It is not to be confused with the main subject of this article, a device that multiplies).

Lookahead is faster

This algorithm applies even to single digits. Thus a multiplier (a device) built according to this rule would not have to look ahead as it shifted along the multiplier (the factor), but would respond to each bit immediately, adding or subtracting whenever it found two adjacent bits that differed.

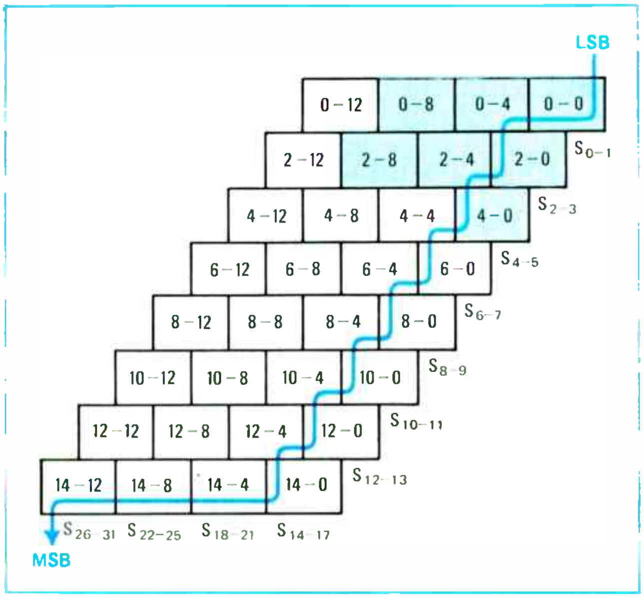
Following this rule, the worst possible sequence in a multiplying factor would be a series of alternating bits (101010 . . .). This would require an addition or subtraction for every bit position—clearly a slower operation than straightforward multiplication. But a substantial speed-up can be attained, at the expense of a little more hardware, if the multiplier (the device) is enable to look ahead and allowed to follow the consecutive string rule only for strings of two or more bits. Isolated 1s in the multiplier then cause simple additions, just as in the straightforward operation. With this modification of the rule, the worst case is again when the bits alternate; the speed then is equal to that of straightforward multiplication.

The basic rule and its modification can be summarized by writing a multiplying factor in its original form and in modified forms that indicate the operation to be performed. To take a typical 16-bit multiplier,

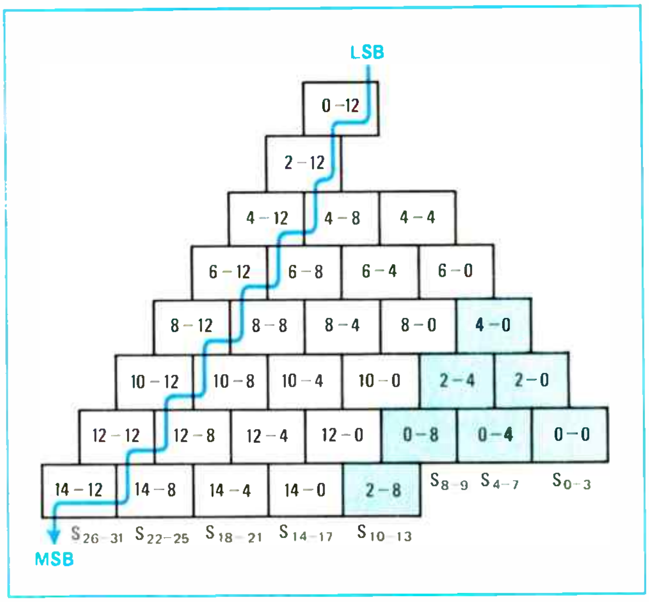
$$\begin{array}{cccccccccccccccccc} & 0 & 1 & 0 & 0 & 1 & 1 & 1 & 0 & 1 & 0 & 0 & 0 & 0 & 1 & 1 & 1 \\ = & \overset{+}{1} & 1 & 0 & \overset{+}{1} & 0 & 0 & 1 & \overset{+}{1} & 1 & 0 & 0 & 0 & \overset{+}{1} & 0 & 0 & \overset{-}{1} \\ = & 0 & \overset{+}{1} & 0 & \overset{+}{1} & 0 & 0 & 1 & 0 & \overset{+}{1} & 0 & 0 & 0 & \overset{+}{1} & 0 & 0 & 1 \end{array}$$

In both algorithms, either the shifting takes place one position at a time, or additional logic is required to count the number of bits in a string and to shift the multiplier a corresponding number of positions. But if the number of shift positions is made constant and greater than 1, this logic is eliminated without serious degradation of the speed. Furthermore, a constant shift makes it possible to build an iterative array for multiplying longer numbers than a single array can handle.

In the previous example, in the first equality, the operation to be performed is alternately addition and subtraction. If the shifting is always done two places at a time, then the multiplier bits must be paired, and sign



3. Larger array. For longer words, iterative connection can be extended indefinitely. Block labels identify bits connected to that block; for example, 6-12 refers to multiplier bits y_6 and y_7, and multiplicand bits x_{12} through x_{15}. Solid color line shows path of longest delay through this array; tinted multipliers are the ones rearranged in Fig. 4 to reduce this propagation time.



4. Faster array. Moving the tinted blocks down from their location in Fig. 3 without changing their horizontal position relative to each other decreases longest propagation path from 335 ns to 290.

Table I
Two-place shift algorithm

x_{i+1}	x_i	x_{i-1}	Operation in position i
0	0 ,	0	Add 0
0	0 ,	1	Add multiplicand
0	1 ,	0	Add multiplicand
0	1 ,	1	Add 2x multiplicand
1	0 ,	0	Subtract 2x multiplicand
1	0 ,	1	Subtract multiplicand
1	1 ,	0	Subtract multiplicand
1	1 ,	1	Subtract 0

combinations can occur only in the two bits in a pair. In this way the preceding example becomes

$$\begin{aligned} & 0\ 1,\ 0\ 0,\ 1\ 1,\ 1\ 0,\ 1\ 0,\ 0\ 0,\ 0\ 1,\ 1\ 1 \\ = & \overset{+}{1}\ 1,\ 0\ \overset{+}{1},\ 0\ 0,\ 1\ \overset{+}{1},\ \overset{-}{1}\ 0,\ 0\ 0,\ \overset{+}{1}\ 0,\ 0\ \overset{-}{1} \\ = & 0\ \overset{+}{1},\ 0\ \overset{+}{1},\ 0\ 0,\ 0\ \overset{-}{1},\ \overset{-}{1}\ 0,\ 0\ 0,\ \overset{+}{1}\ 0,\ 0\ \overset{-}{1} \end{aligned}$$

In the first equality the algorithm is the same as when the bits were considered singly, but certain simplifications become immediately obvious. Two pairs of 1 bits with opposite signs are present. Both can be combined by changing the more significant bit to a 0 and altering the sign on the less significant bit. This changes the second equality, but the result of the entire multiplication operation is unchanged.

The algorithm for multiplication with paired bits is summarized in Table 1. This algorithm calls for two-position shifts. After each shift the more significant bit is compared with the less significant bit of the same pair and with the less significant bit of the next pair to the left. As a result of this comparison the multiplicand or twice the multiplicand is added or subtracted from the partial product, in the position corresponding to the more significant bit of the pair. Commas in the table correspond to commas in the example above.

That example is contrived to contain all eight combinations of three bits. For example, the combination 00,0 occurs as the third pair from the right end, and part of the second pair. The table says that this combination calls for a 0 to be added to the partial product; and a 0 appears in the third bit pair of the second equality. Again, the combination 00,1 appears as the second pair from the left, calling for the multiplicand to be added directly; and a +1 appears in bit position 12 of the second equality. Finally, the combination 10,0 appears as the fourth pair from the right, calling for twice the multiplicand to be subtracted; and a −1 appears in the higher-order bit position, which has twice the weight of the other bit, the x_i of the table. The combination 11,0 is the right-most pair; the 0 is understood.

Functions and complements

Several characteristics of the algorithm are evident from the table. The $x_i\Omega_i$ bit indicates whether an addition or a subtraction is to occur. The exclusive-OR of x_{i-1} and x_i indicates that the necessary operation is to be performed on the multiplicand directly. The function $(x_{i-1})(x_i)(\overline{x_i\Omega_i}) + (\bar{x}_{i-1})(\bar{x}_i)(x_i\Omega_i)$ indicates that the operation is to be performed on twice the multiplicand.

Besides, this algorithm can produce a 2s-complement product when the multiplier or multiplicand are represented in 2s-complement form. A 2s-complement is a representation of negative numbers obtained from the positive number of the same absolute value by replacing every 0 with a 1, every 1 with a 0, and adding 1 to the result. In a preceding example, unsigned number 1111111 as a multiplier was shown to be equivalent to $10000000 - 1 = 2^7 - 2^0$. In a 2s-complement form, however, it represents $-1 = -2^0$ (the addition is omitted in the (n + 1)th position of the n-bit number). In 2s-complement notation, if the number is negative, the most significant digit is always 1, so that a subtraction always occurs at the last bit position, as in table 1.

Logic designs can work with this algorithm, whether they use positive or negative logic. In positive logic, a binary 1 is represented by the more positive signal level. In negative logic it is represented by the more negative level. The only other requirement is the need to interchange addition and subtraction in the algorithm when negative logic is used.

Parts of the multiplier

As its block diagram (Fig. 1) shows, the Am2505 consists of five parts: a multiplier decoder, a shifting array, a complementer, a high-speed adder, and an overflow and sign control. All are contained in a single 100-by-100-mil chip in a 24-pin dual-in-line package.

The multiplier decoder's inputs are the two bits of the multiplier, the high-order bit of the next lower pair when the unit is part of an iterative array, and a signal, P, that defines whether positive or negative logic is being used (either ground or open-circuit). It implements the two logic functions mentioned previously and the exclusive-OR of $x_i \Omega_i$ and P.

These three outputs indicate whether the next operation involves the multiplicand itself or twice the multiplicand, and whether the operation is an addition or a subtraction. When twice the multiplicand is involved, the shifting array moves it over by one bit position, and transmits the result to the complementer. Here the 2s-complement is determined, if a subtraction is called for. The output of the complementer goes to the adder, where the modified multiplicand is added to the previously determined partial product, which appears at the K inputs. The adder produces a four-bit sum plus a carry output, and also has a carry input that can accept the carry output from another device.

From time to time the operations of these four parts of the multiplication unit may cause an overflow, or a carry out of the most significant bit position. To take care of this overflow, and to generate the necessary sign bit, usually shown at the left of the most significant bit of the result, a small fast logic array is appended at the high-order end of the adder. This array also has inputs from the complementer and shifting array.

If the multiplication units were used alone, the product of a two-bit and a four-bit number would require six bit positions, which would appear at the output of the adder and the output of the sign and overflow control in about 45 nanoseconds. Most of the delay occurs in the multiplier decoder, the shifter, and the complementer.

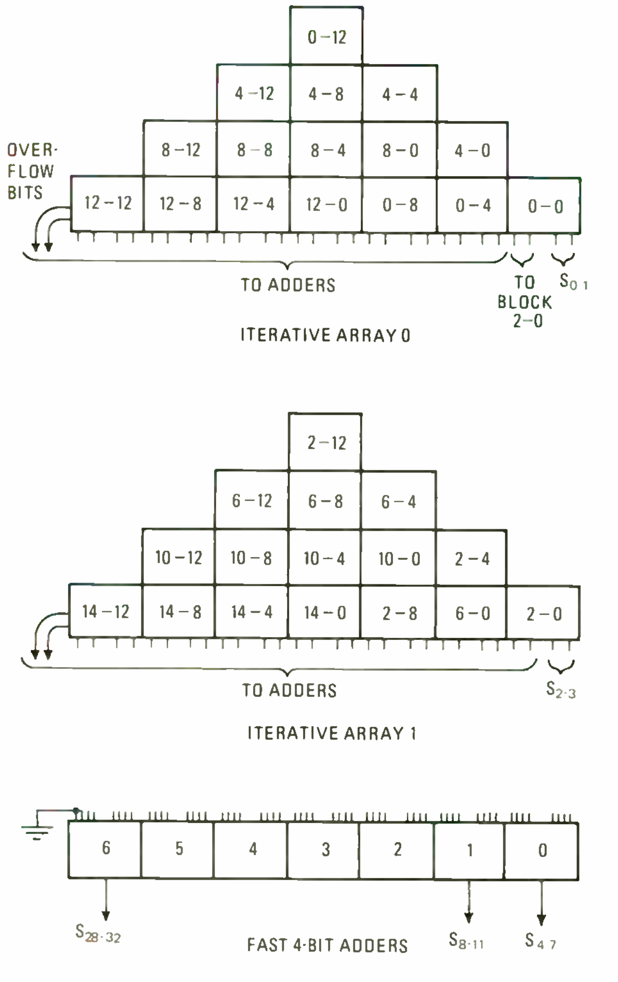
But when the multiplicand has more than four bits, or the multiplier has more than two bits, an iterative array must be laid out. In such an array all the subsections mentioned operate in parallel, and the limiting factor per multiplier is the adder time, which is about 20 ns. Furthermore, the sign and overflow control outputs of only the most significant bit positions are used.

The basis of the iterative connection for multiplying longer words is shown in Fig. 2, where four Am2505s multiply an eight-bit multiplicand by a four-bit multiplier. It uses as many units in a horizontal row as the

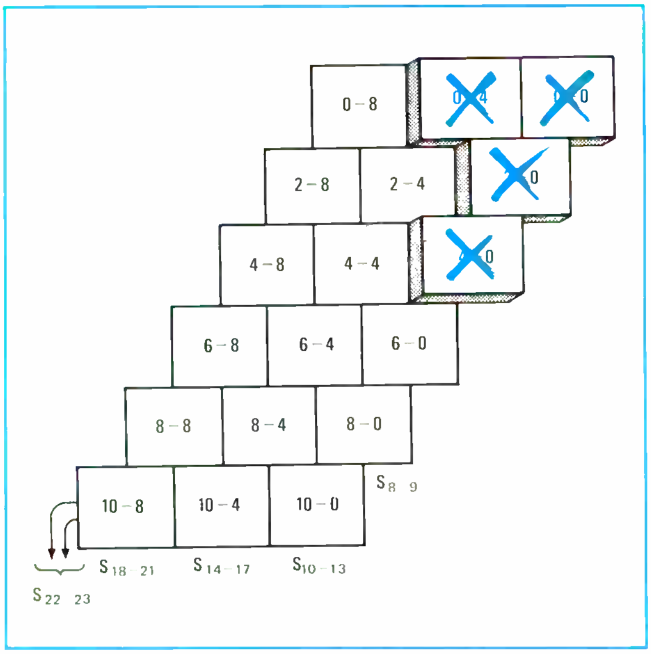
Other ways to speed

Various other schemes for speeding up multiplication are in use, but they suffer from several disadvantages. For example, straightforward multiplication takes a long time largely because of the carries that arise as a multiplier adds successive partial products. So one speed-up technique bypasses the carry propagation time by using a carry-save adder to accumulate the carries and restore them in a single step at the end. Unfortunately, this technique requires a great deal of hardware, and the final full-parallel addition itself imposes a significant carry propagation time.

A fast technique for medium-sized systems employs read-only memories for multiplication. Essentially the memory is a look-up table containing all possible products of words of a limited number of bits. These memories can multiply longer words if they are combined to form partial products that are added together. But the approach has four major disadvantages: custom masks are required for the read-only memory; a lot of hardware is necessary; the ROM cannot be built into an iterative structure, unlike the Am2505 described in this article; nor can it perform 2s-complement arithmetic directly.



5. Divided for speed. Separating the iterative array into two or more parts and then adding the results produced by the parts decreases the propagation time even more—in this case to 185 ns.



6. Truncation cuts cost. Dropping the least significant half of the full product without rounding gives a product with an error at most equal to the value of the least significant remaining digit, and permits omission of some of the multipliers.

number of multiplicand bits requires, and successive rows staggered by two bit positions as determined by the number of multiplier bits. In the figure, multiplicand bits are numbered x_0 through x_7; the connection for bit x_{-1} is ground; bit 3 is connected both to the highest-order multiplicand input of one unit and to the x_{-1} input of the next unit to the left. Similar remarks apply to the multiplier inputs. Positive logic is assumed (pin P grounded). In the case of negative logic, P would be left unconnected.

Partial products accumulate through the array via the K inputs. These inputs can be connected to ground at the top of the array, or a separate number can be added through them, to appear at the least significant end of the product.

The input carry of the multiplication units in the least significant positions is connected directly to the higher-order multiplier bit. According to the algorithm of Table 1, when this multiplier bit is 1, the multiplicand is subtracted from the partial product. To subtract a number, its 2s-complement is formed, which requires adding 1 to the least significant bit position. This 1 is most easily added by using the multiplier bit directly.

More speed . . .

Though this is the most straightforward, it's not the fastest way to multiply two numbers of more than four and two bits respectively. Speed is limited by the maximum number of multiplication units through which a particular bit must propagate in forming a product. This number can be reduced by rearranging the iterative array so that some multiplication units change their relative vertical positions but not their horizontal positions.

Figures 3 and 4 show how this rearrangement can be made in an array that multiplies two 16-bit numbers. In Fig. 3 there are four units in each horizontal row, and eight rows. The units are identified by the designations of the least significant bits of the multiplier and multiplicand, respectively, that are connected to their inputs. Thus unit 2-4 is connected to multiplier bits y_2 and y_3 and to multiplicand bits x_4 through x_7. The solid color line shows the path of longest propagation time through the array.

When the position of a particular unit is changed so as to shorten the propagation path, the unit retains all its original multiplier and multiplicand inputs, and acquires new constant inputs and internal carry lines. To insure that the product has the proper sign, the S_4 and S_5 outputs of the units at the most significant edge of the array must be connected to the appropriate K_2 and K_3 inputs in the next row, following the arrangement detailed in Fig. 2.

When the units shown with a color tint in Fig. 3 are moved downward to the position tinted in Fig. 4, the path of longest propagation shortens from 18 units to 15, or from 335 nanoseconds to 275.

. . . and still more

For still faster multiplication, the iterative array can be split into several parts, and the respective products added, as shown in Fig. 5. Here the array is divided into two parts. Their respective partial products are combined in a row of seven external four-bit adders chosen for their speed (Advanced Micro Devices' Am9340 would be suitable, for example). The least significant four bits of the product come directly from units 0-0 and 2-0. The other 28 bits are generated by the adders.

The interconnections between the multiplication unit arrays and the adders are rather complex. Their details are not important here, but, before the two partial products are added, one is skewed to one side by two bits

Table II
Delays and package count

Word length	Number of Am2505s	Number of adders	Typical delay times* (ns at 25°C) Adder levels 0	1	2
8 x 8	8	0	135		
12 x 12	18	0	205		
	18	5		155	
16 x 16	32	0	275		
	32	7		185	
	32	16			180
20 x 20	50	0	345		
	50	9		220	
24 x 24	72	0	415		
	72	11		255	
	72	24			215
28 x 28	98	0	485		
	98	13		290	
32 x 32	128	0	555		
	128	15		325	
	128	32			250

* Maximum delays at 25°C are approximately 40% longer than typical delays

relative to the other. This two-bit skewing is analogous to the skewing that occurs between successive rows in the basic iterative array.

This arrangement can complete the 16-by-16 multiplication in about 185 ns—almost a third faster than with the single array of Fig. 5. The time can be decreased even further if the iterative array is broken into four parts, and three rows of adders are used.

The number of packages required to multiply various word lengths, and the length of time they require to generate a product, are shown in Table 2.

Integers and fractions

The Am2505 can multiply numbers in either integral or fractional form. Either way, if the multiplier and multiplicand have n bits each, the product has 2n bits. The only caution when numbers are in fractional form is that, if the bit at the left end of the factors is a sign bit, then the binary point is between the first two bits, not at the left of the sign bit. It is analogous to the situation in decimal notation, where the decimal point does not precede but follows the sign, and a negative fraction is properly –.142857, not .–142857. Since the Am2505 can't distinguish between numbers with and without signs, the 2n-bit product can have two bits to the left of the binary point, if an overflow occurs.

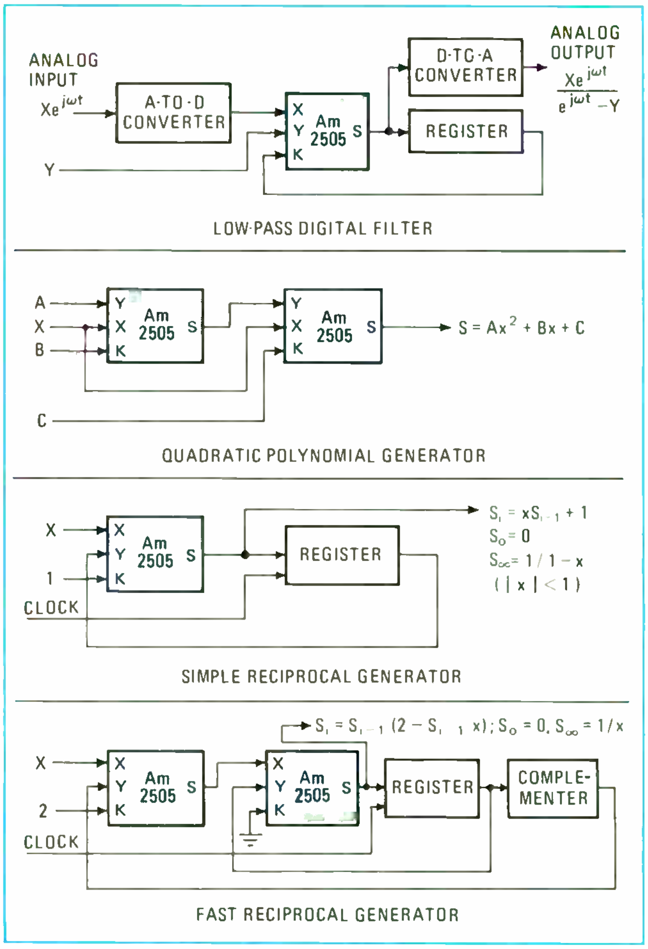
Often only the n most significant bits of a 2n-bit product are desired. These are obtained by either truncation or rounding.

Rounding is more accurate. The easiest way to do it is to add a 1 to the most significant dropped bit—that is, to the nth bit, counting from the right-hand end and beginning with 0. If this nth bit is itself a 1, the dropped portion of the result is equal to or greater than ½, and the least significant bit of the rounded number should be increased by 1. Rounding requires a binary 1 to be connected to the K input in the nth position, but unfortunately it offers no saving in hardware in the multiplication array itself.

In truncation the least significant n bits are simply dropped, and the result may be incorrect by the value of the least significant remaining digit. When truncation is designed into a system, some of the multiplication units in an iterative array can be omitted, because they contribute nothing to the truncated result. For example, in a 12-by-12 multiplier, shown in Fig. 6, full-length products would require 18 Am2505s; but if truncated results are satisfactory, four of these 18 are unnecessary. The bottom row of this array yields the 14 most significant bits of the result, numbered 10 through 23. Inputs to unit 10-0 come from unit 8-0, whose least significant digit is bit 8. Those multipliers whose outputs are less significant than bit 8—namely, units 0-0, 0-4, 2-0, and 4-0—can be removed (see also Table 3). But this truncation does not increase speed, because the removed multipliers are not in the critical propagation path.

Table III
Truncation savings

Array size	Number of packages	
	Untruncated	Truncated
8 × 8	8	7
12 × 12	18	14
16 × 16	32	23
20 × 20	50	35
24 × 24	72	50
28 × 28	98	66
32 × 32	128	84



7. Other applications. Principal applications of new multiplier are in digital function generators, fast Fourier transform processors, and arithmetic function generators, which will be able to use configurations like these to expand their capabilities.

Although the Am2505 multiplier can be applied to general-purpose and special-purpose computers, it is more useful in digital filter circuits, fast Fourier transform processors, and arithmetic function generators, all of which are components in digital assemblies that are usually less sophisticated or more limited in application than computers. Four such applications are shown in Figure 7. The quadratic polynomial generator, and by extension polynomial generators of higher degree, simply pass the inputs through a series of multiplication units; the desired quantity appears at the output directly. In the digital low-pass filter and the reciprocal evaluators, the output is fed back to the input through a register, whose contents converge to the desired result after a number of time iterations. Of the two reciprocal evaluators shown, the one with two multiplication units uses Newton's approximation method and converges more quickly. □

Phase-lock loop comes to fm stereo wrapped in an IC package

Now consumer electronics designers can obtain better separation and lower distortion with a phase-lock loop stereo decoder; because it's in IC form, assembly, alignment, component costs are cut

by Michael Gay, *Motorola Semiconductor Products division, Mesa, Ariz.*

☐ The virtues of the phase-lock loop principle are well known to communications engineers. Now they're available to help out the consumer electronics designer in a monolithic stereo decoder circuit that requires no tuned circuits.

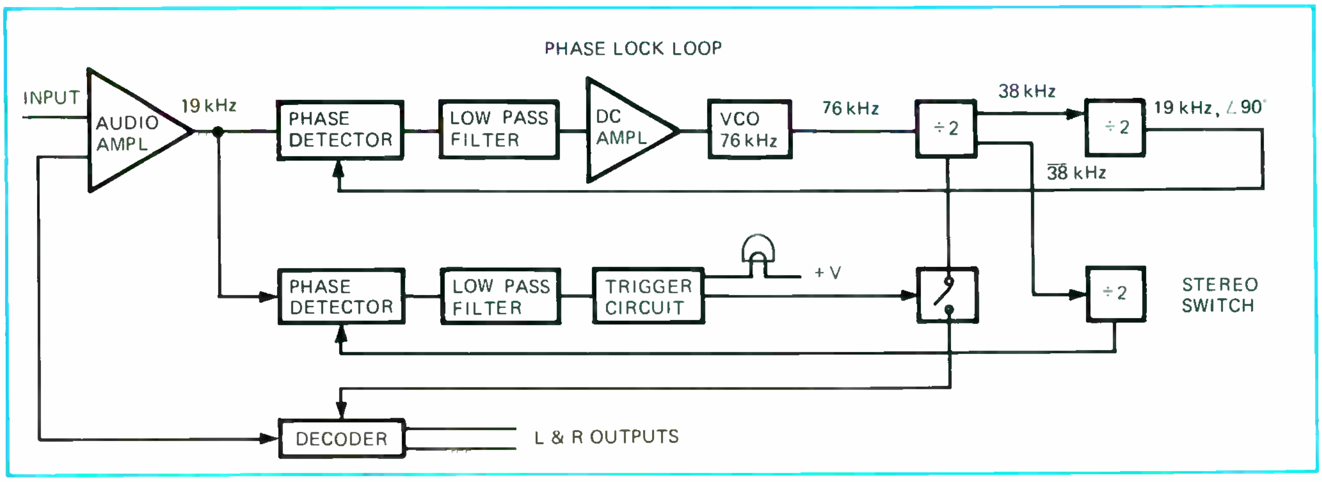
The IC yields impressive performance benefits over conventional discrete circuits—harmonic distortion is lower, channel separation is better over the frequency range, and long-term stability is improved. But equally important, this decoder chip requires a less complex factory alignment procedure and fewer external components. In fact, if this phase-lock loop stereo IC is used in conjunction with ceramic filters replacing i-f transformers, the alignment process for the complete receiver is reduced to just adjusting the discriminator transformer, front-end trimmer capacitor, and the free-running decoder frequency.

Most stereo decoders used in fm stereo receivers use a frequency-doubler circuit to convert the 19-kilohertz carrier into the required 38-kHz subcarrier frequency. Three external tuned circuits usually are required. These must be adjusted after assembly and can degrade performance if they become misaligned due to vibration, mechanical shock, or component aging. In addition to increasing alignment costs, the coils also drive up overall component costs. The new XC1310 IC, however, uses the phase-lock loop (PLL) to regenerate the 38-kHz subcarrier and manages to avoid these disadvantages.

Figure 1 shows the system block diagram. The PLL which regenerates the 38-kHz subcarrier comprises a phase detector, low-pass filter, dc error amplifier, voltage-controlled oscillator, and a divide-by-four module. The internal VCO runs at 76 kHz. This signal, which passes through two divider stages, returns as a 19-kHz signal to the input modulator, or phase detector. It is there that the returned signal is multiplied by the incoming signal so that when a 19-kHz pilot tone is present in the received signal a dc component is produced. The dc component is extracted by the low-pass filter and used to control the frequency of the internal oscillator. Consequently, the VCO becomes phase-locked to the pilot tone. This insures that the 38-kHz output from the first divider has the correct phase for decoding a stereo signal.

It's beneficial to run the VCO at 76 kHz and derive the 38-kHz signal to use as the regenerated subcarrier using a single divider stage. That way, the 38-kHz waveform has a precise 50% duty cycle regardless of the 76-kHz waveform. A 50% duty cycle, in turn, is essential in obtaining good channel separation and excluding any second-harmonic component that could demodulate unwanted Subscription Carrier Authorization signals in the 60-to-74-kHz band.

The regenerated 38-kHz subcarrier is fed to the stereo



1. Stereo demodulator. Three functions—a phase-lock regeneration loop, a stereo switch, and a decoder section—are combined in a single integrated circuit to form a complete fm stereo demodulation system. A regenerated pilot tone, which is obtained from the phase-lock loop, is modulated with the composite input in the switch section to determine whether the input signal is in stereo or is monaural.

decoder module when an internal stereo switch is closed. The decoder essentially is a modulator that multiplies the incoming signal by the regenerated 38-kHz subcarrier. Since this process degrades the signal-to-noise ratio, it must be muted if the received signal is not stereophonic or of adequate strength. The procedure is to allow the stereo switch to close only when a 19-kHz pilot tone of sufficient amplitude is received.

Here's how the pilot tone level is detected and the switch is operated by the stereo switch section of the circuit. The 19-kHz signal returned to the PLL phase detector is in quadrature with the 19-kHz pilot tone when the loop is locked. A third divider stage is connected so that a 19-kHz signal, in phase with the pilot tone, is generated. This signal then is multiplied with the incoming signal in the stereo-switch phase detector, producing a dc component proportional to the pilot tone amplitude. This dc component is passed through a low-pass filter and drives the trigger circuit, which activates both the stereo switch and a stereo-signal indicator lamp.

On the chip

The complete circuit is shown in Fig. 2. The audio amplifier Q_1 through Q_3 provides a high input impedance and boosts the input signal to provide optimum performance from the phase detectors in the 38-kHz regeneration loop and the stereo switch section. The decoder is driven with an audio signal at the incoming amplitude, but to reduce distortion the level is shifted by diode D_2 in the audio amplifier feedback network.

The amplifier is coupled to both phase detectors by an external capacitor and a series resistor (between pins 3 and 11) at 500 ohms. This provides a convenient point to add a capacitor to ground for correction, divider relays, etc.

The phase detectors are balanced chopper types combined with the filters. External components are connected to the appropriate terminals to produce the required filter characteristics. This type of phase detector was chosen over the commonly used emitter-coupled pair type because its superior dc balance minimizes phase errors.

Generating control current

In the phase-lock loop, the phase detector output (pins 12 and 13) is amplified and converted to a control current by the two-stage differential amplifier (Q_4–Q_7). This amplifier requires an input level of ±5 millivolts to produce a change of ±2 microamperes in the control current which, with typical external components, would produce a +1.2% variation in the oscillator frequency. These values allow 40 decibels of channel separation to be maintained at the mono/stereo threshold signal level, with no more than 1% error in the oscillator free-running frequency.

The oscillator is a relaxation type (Q_8–Q_{13}) that uses a specially designed trigger circuit for very good stability. The thresholds of this trigger circuit are made independent of the transistor base-to-emitter voltage. These threshold levels, which are fractions of the supply voltage, are controlled solely by the ratio of the IC's resistors. The result is that thresholds in the oscillator trigger circuit are almost independent of temperature and scale together with any change occurring in supply voltage.

The oscillator timing components are connected between a single pin (14) and ground, include an external capacitor and resistor (nominal value is 19 kilohms with a 470-picofarad capacitor). The resistor, however, is normally variable for precise frequency setting. Moreover, the capacitor's discharge through the external resistor occupies 90% of the cycle time so that any variations in the charge time, through an internal resistor, have little effect on the oscillator frequency. Both these factors contribute to the excellent frequency stability.

Because the switching threshold voltages depend only on the IC resistor ratios, their tolerances are minimized so that only a small variation in the total timing resistance is required for frequency adjustment. Since this variation in timing resistance is but a small part of the total, an inexpensive, relatively unstable potentiometer can be used for this trimming. Values of external timing components may be altered to vary the capture range of the circuit (allowable frequency error of free-running oscillator over which circuit will lock) which is ±3% with the values quoted.

The oscillator output is a fairly narrow pulse. The pulse rise times are sharpened by a buffer stage (Q_{14}) feeding the first divider. The first and second dividers are of the master-slave type. One output of the first divider drives the second divider in the PLL; the other out-

Fm stereo decoding basics

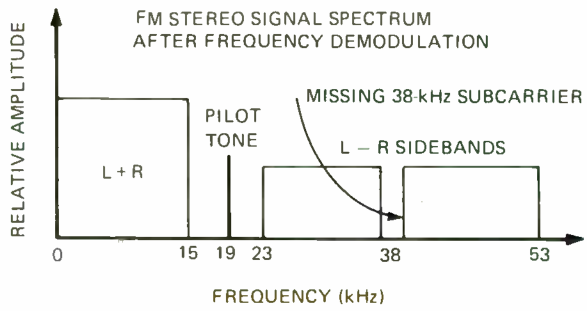
A standard fm stereo broadcast signal after frequency demodulation, comprises the sum (left plus right) and difference (left minus right) of the two channels and a 19-kilohertz pilot signal. The sum information is available directly. The difference data is in the form of a double-sideband, amplitude-modulated signal on a 38-kHz suppressed subcarrier. But since the 19-kHz pilot tone is phase-coherent with the suppressed subcarrier it can be used to regenerate the subcarrier.

The demodulated stereo signal has the form:

$$0.45\,(V_L + V_R) + 0.45\,(V_L - V_R)\sin\omega_c t + 0.1\sin(\omega_c t/2)$$

where V_L and V_R are the left- and right-channel instantaneous signal levels normalized to unity; ω_c is the subcarrier frequency, and $\omega_c t/2$ is the pilot tone.

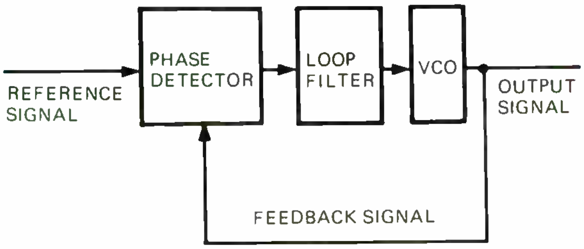
Thus, a stereo decoder circuit must perform four basic tasks: it must select the pilot tone from the composite signal; regenerate the subcarrier from the pilot tone; demodulate the channel difference signal using the regenerated sub carrier; and add and subtract the sum and difference signals (matrixing) to separate left and right channel information.



Phase-lock loop basics

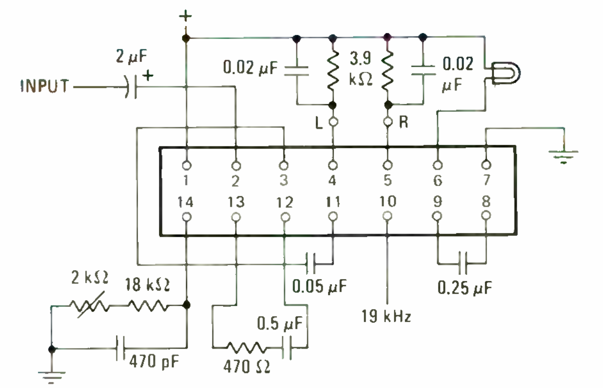
The phase-lock loop is a closed-loop electronic servo that provides an output frequency which locks onto and exactly tracks the phase of a reference signal. This is done by comparing the phases between two signals and using the resulting difference to correct the voltage-controlled oscillator's frequency. If either the output of the VCO or the reference signal changes phase, the phase detector and filter produce a dc error voltage whose magnitude and polarity depend on the phase change. This error voltage changes the oscillator frequency until phase coherence of both signals is regained.

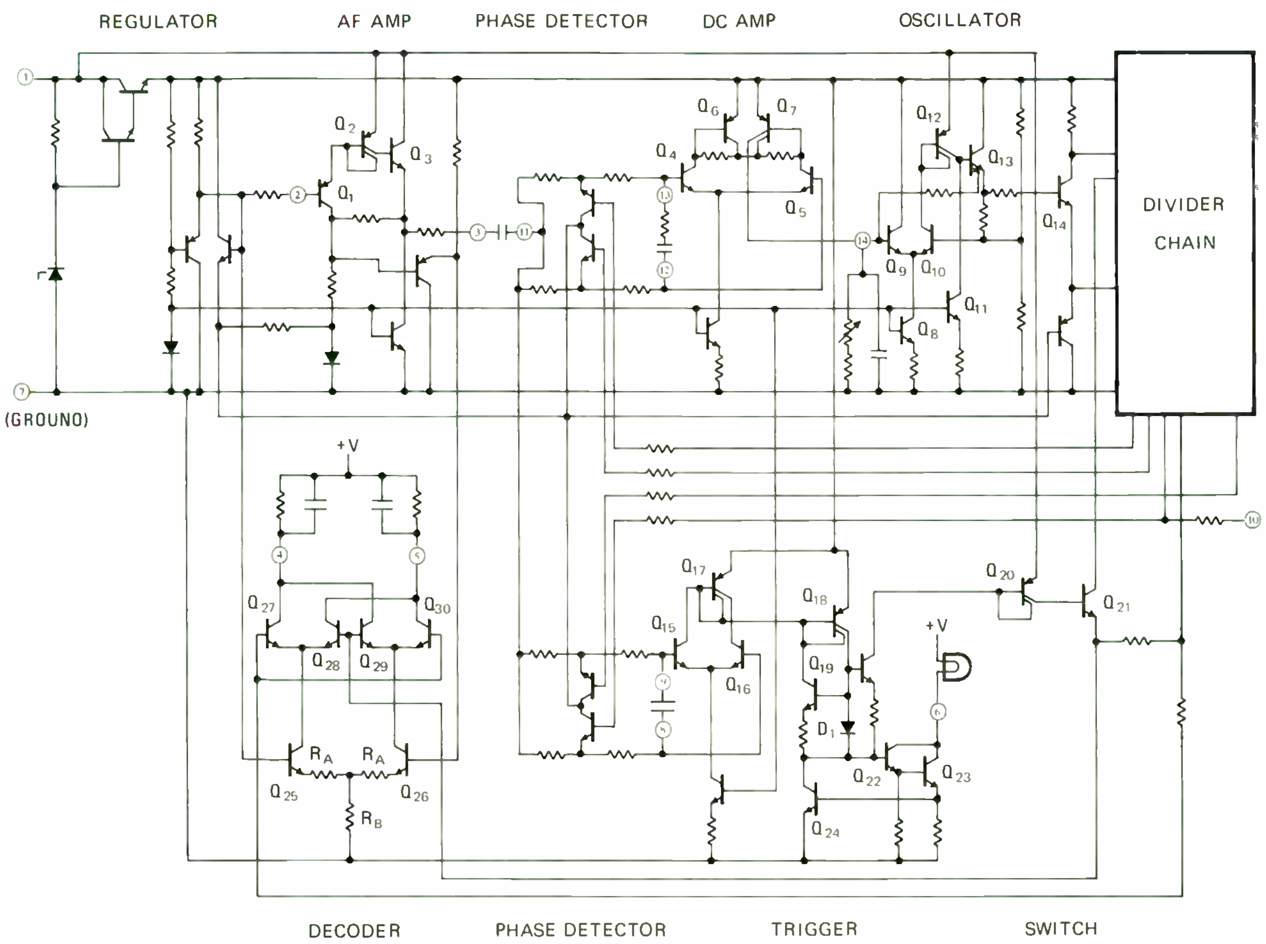
Implementing this concept is quite simple. All that's needed is a phase detector (modulator), a loop filter, and a voltage- or current-controlled oscillator. However, if an output which is a multiple of the input reference signal, but still phase-locked to it, is desired, a frequency divider may be inserted into the feedback loop.

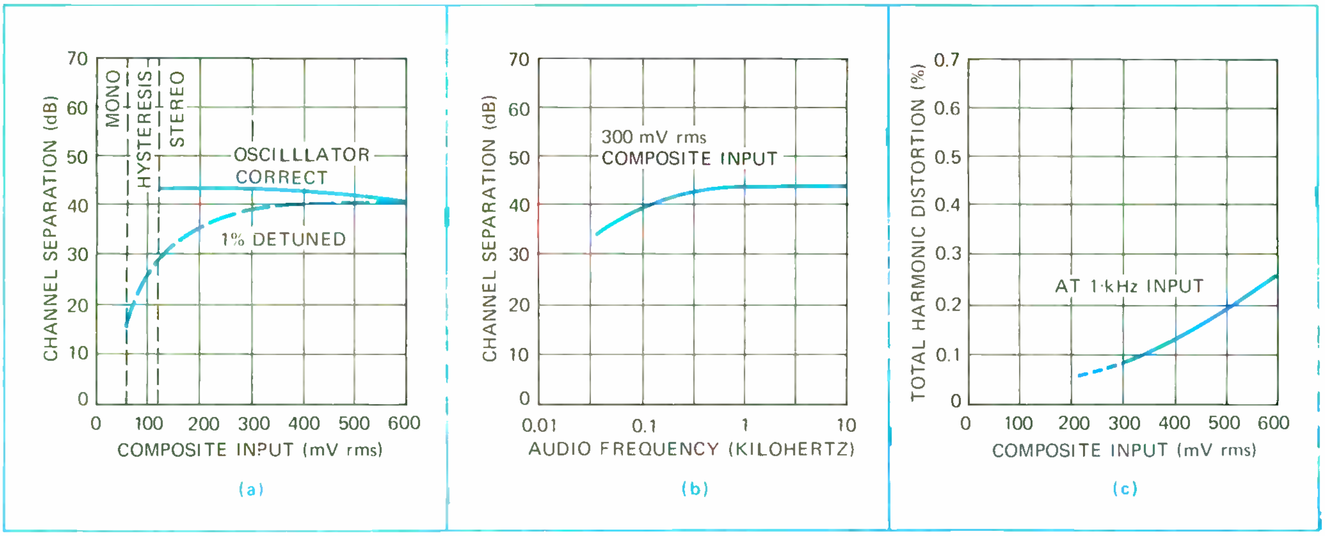


put feeds the third divider. The latter is a conventional bistable that generates the 19-kHz waveform for the stereo switch section. The input to this divider is steered by the state of the second divider. This arrangement generates a 19-kHz waveform in quadrature with the regeneration-loop waveform and of unambiguous phase. The dc level in the second and third dividers are

Manageable. Although the phase-lock loop and its divider chain make the XC-1310 rather complex for a linear IC, producibility is expedited by stage designs tolerant of process and operating variables. Typical network includes filter, timing, de-emphasis, and coupling components, and oscillator-trimmer potentiometer.







Choice characteristics. Because of the oscillator's excellent temperature stability, overall channel separation remains good even during detuning (a). When the oscillator is correctly tuned. channel separation is impressively high over the frequency range (b), and the circuit's total harmonic distortion characteristics stay at a very low level right through the range of the input signal (c).

designed for direct coupling to the appropriate phase detectors. To facilitate the adjustment of the free-running oscillator frequency, a 19-kHz output from one of the dividers is available at pin 10 to drive a frequency counter.

Since pilot-tone triggering levels from the stereo switch phase detector are quite low (36 mv for the stereo-on threshold and 18 mv for the off threshold), a very-low level trigger circuit is required. This is achieved using an input differential stage (Q_{15} through Q_{17}) in a dc amplifier, followed by a constant-current trigger circuit comprising Q_{18}, Q_{19}, and D_1. The differential input stage has a 36-mV unbalance generated by making Q_{15} four times the emitter area of Q_{16}. Thus, until an input dc level reaches 36 mv, Q_{17} is saturated and holds the trigger circuit off. But once the input level rises above that value, a current is drawn from the base of Q_{30}; it causes the trigger to switch on. To switch off the trigger, a current must then be fed to the junction of the base of Q_{18} and the collector of Q_{19}. To obtain this current, the input to the differential stage must fall substantially below the 36-mv initial triggering level providing the necessary hysteresis. Current value is determined by the relative areas of D_1, Q_{19}, and its emitter resistor.

With the trigger on, currents are drawn from the stereo switch (Q_{20} and Q_{21}) and fed to the lamp driver (Q_{22}, Q_{23}), which lights the stereo-on lamp. The lamp switch-on surge current is limited by Q_{24}.

Stereo demodulation

The decoder itself (Q_{25}–Q_{30}) is of the type used in the MC1304 fm demodulator. The incoming composite signal plus a bias voltage is applied to one side (Q_{26}) of the lower emitter-coupled pair, and the other side (Q_{25}) is returned to the same dc bias level. The regenerated 38-kHz signal from the first divider stage also is applied to that side of the stereo decoder in differential mode through the stereo/mono switch. The switch is turned on by the trigger circuit and interrupts the path from one side of the divider so that with the stereo switch off, only a common-mode 38-kHz signal is applied to the decoder, and decoding ceases.

Handling differential and common modes

When a composite stereo input signal is applied to the base of Q_{26}, currents will flow in both Q_{25} and Q_{26}. The currents can be separated into differential mode components $(i_{26}-i_{25})/2$ and common-mode components $(i_{26}+i_{25})/2$ flowing in each collector. These currents are commutated between the two outputs by the switching action of the upper emitter-coupled pairs (Q_{27} through Q_{30}) when the 38-kHz regenerated subcarrier is applied. The common-mode current components emerge unaffected at the outputs (pins 4 and 5), but the differential mode current components emerge multiplied by the 38-kHz square wave.

Multiplying the stereo signal by the decoder transfer function (output current/input voltage) and neglecting supersonic terms yields outputs of:

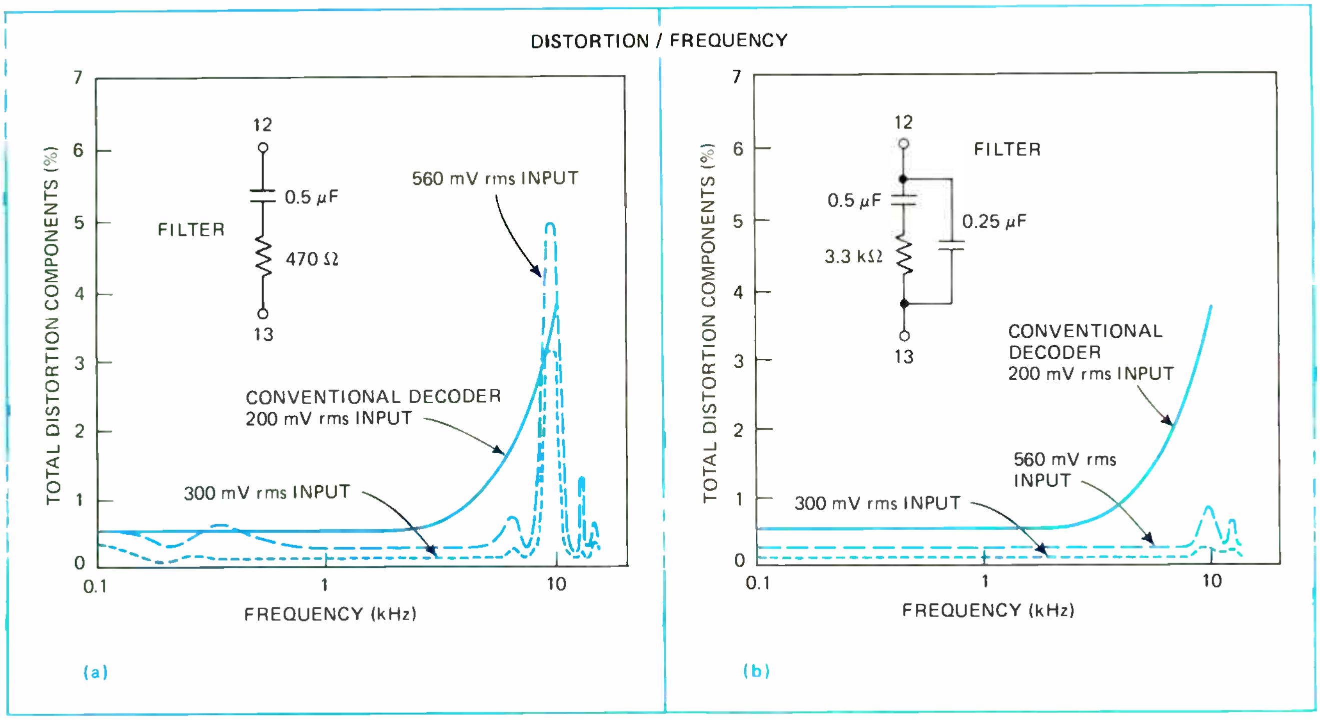
$$0.45\,A\,(V_L + V_R) \pm 0.45B/2(V_L - V_R)$$

With appropriate values for constants A and B, which depend on the resistor matrix ratio, one output will contain only V_L and the other only V_R. To accomplish this, the resistor matrix ratio, R_B/R_A, must yield $(\pi/4-\frac{1}{2})$ with appropriate modifications to compensate for the emitter resistances of Q_{25} and Q_{26}, and finite decoupling of the signal applied to the base of Q_{25}.

Typical device characteristics shown in the table and

BASIC STEREO DECODER CHARACTERISTICS

Supply voltage range	8 to 16 volts	
Temperature range	−40° C to +85° C	
Input signal range	pilot level	composite level
Stereo on threshold	16 mV rms	90 mV rms
Stereo off threshold	8 mV rms	45 mV rms
Maximum input before distortion	100 mV rms	560 mV rms
Audio output (560-m V composite input)	500 mV rms	
Stereo lamp current (nominal)	100 m A	



Compensation counts. These distortion tests were achieved with a 1-kilohertz modulation of a composite signal that was assumed to contain only right- or left-channel signals. When a bypass capacitor was added to the shunt leg of the filter (b), distortion figures were greatly reduced. The distortion peaks themselves were primarily accountable to loop resonances and phase jitter. (Equivalent distortion curves for a conventional decoder at 200-mV levels should be compared with the 300-mV curves of the IC.)

the performance curves shown in Fig. 3 and 4(a) were measured with the circuit configuration shown in Fig. 2. The curve in Fig. 4(b) was obtained from the same circuit except with a modified loop filter between pins 12 and 13. The stereo input (composite) signal is assumed to contain only left or right channel signals with 1-kHz modulation.

Figure 3(a) shows channel separation as a function of signal level at 1 kHz with the oscillator set precisely and with a 1% oscillator free-running frequency error. Figure 3(b) shows separation against frequency at 300 mv rms composite input level. Note that separation is almost independent of frequency and of signal level when the device is correctly tuned. The 1% tuning error reduces separation to about 30 dB at low signal levels but full performance still is obtained at higher levels. In a typical conventional decoder a 0.2% tuning error in any of three tuned circuits will degrade the separation to 30 dB at all signal levels.

Decreasing distortion

Figure 3(c) shows total harmonic distortion vs signal level at 1 kHz; Fig. 4 shows total distortion components against frequency at input levels of 300 mv rms and 560 mv rms with single- and double-capacitor phase-lock loop filter networks. The distortion peaks that occur at low frequency are due to loop resonance, while those at high frequency are caused principally by beat notes due to phase jitter of the oscillator.

The phase-lock loop decoder offers a significant improvement in distortion even with a single capacitor in the loop filter. And with a double capacitor filter the distortion products are about 20 dB lower than for the conventional decoder at an equivalent input level. Equivalent distortion curves for a conventional decoder are shown for comparison. These were measured at levels 200-mv rms and should be compared with the 300-mv rms curves for the phase-lock loop decoder.

In all cases, however, relatively high beat-note distortion figures are measured due to attenuation of the fundamental component in the de-emphasis network.

Odd and even harmonics

Ultrasonic outputs occur at the odd harmonics of 19 kHz (38 kHz, 57 kHz, etc.). They are inherently generated by the passage of the 19-kHz pilot tone through the decoder, while even harmonics are due to circuit imbalance. The 19-kHz output with a normal fm de-emphasis time constant of 75 microseconds is 34.4 dB below the normal recovered audio level. The 38-kHz output is typically 45 dB down.

Imbalances in the PLL circuit will also cause demodulating of SCA signals, thus giving rise to audio beat notes. However, its performance is 20–30 dB better than that of the conventional decoder. Measurements showed a beat note level of 80 dB down from the 1-kHz output level with a 67-kHz input level. Rejection of SCA signals was measured with a composite input signal containing 1-kHz modulation to which a standard 10% signal in the 60–74 kHz band was added. ☐

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Program calculates load effects of high-speed digital circuits

Digital interconnections are analyzed by program called Line as if they were transmission lines; from a minimum of input data it accurately computes line voltage, plots ringing characteristics

by Laurence P. Flora, *Burroughs Corp., Pasadena, Calif.* *

☐ High-speed digital circuitry often lands its designer with the job of analyzing the loading effects, like circuit ringing and delay, that result from line discontinuities. This analysis is highly complex, and requires a computer's speed and accuracy.

However, it has to be performed in terms of transmission line equations, and ECAP (electronic circuit analysis program) and its equivalents are really only satisfactory for standard lumped-constant circuitry. A lumped-element model doesn't fit transmission lines too accurately. Besides, the programs take an extremely long time to solve even moderately complex problems of this nature.

To help the engineer plot an accurate analysis of a high-speed transmission line, a program called Line was recently developed. It's based on a general load configuration that represents all circuits to be used in the systems under study. It also is based on what the general load effects are when a unit step or unit ramp function is transmitted down the line, and closely approximates any reflection without reference to the line's history from time zero. The program, which is written in Fortran, is conversational, and can be run on a time-shared terminal. In contrast to existing computer programs, Line can precisely analyze a transmission line problem, but it cannot handle a general circuit consisting of various lumped components.

Line makes use of the accurate, yet general, load configuration of Fig. 1. Besides being an adequate representation of the circuits used in most systems, this RC network may also model a purely resistive discontinuity (i.e., when $R_2 = \infty$) or purely capacitive discontinuity ($R_1 = \infty$, $R_2 = 0$, and $R_3 = \infty$).

Computing the reflection

To understand how Line solves for general load effects, consider the response of a line to a unit step or a unit ramp function. These two forcing functions are chosen since either provides a good approximation for most input waveforms.

For the load of Fig. 1, the reflection voltage due to a unit step function is:

$$[V_r(t)]_{step} = K_2 + (K_1 - K_2)e^{-t/r} \qquad (1)$$

while a reflection voltage due to a unit ramp function can be expressed as:

$$[V_r(t)]_{ramp} = K_2 t + r(K_1) - K_2)(1 - e^{-t/r}) \qquad (2)$$

*Now on educational leave at Massachusetts Institute of Technology, Cambridge, Mass.

where:

$$K_1 = (R_2R_3 - Z_0R_2 - Z_0R_3)/(R_2R_3 + Z_0R_2 + Z_0R_3)$$

and:

$$K_2 = (R_1R_3 + R_2R_3 - Z_0R_1 - Z_0R_2 - Z_0R_3)/(R_1R_3 + R_2R_3 + Z_0R_1 + Z_0R_2 + Z_0R_3)$$

and:

$$r = C_1(R_1R_2R_3 + Z_0R_1R_2 + Z_0R_1R_3)/(R_1R_3 + R_2R_3 + Z_0R_1 + Z_0R_2 + Z_0R_3)$$

and Z_0 is the line output impedance.

Now the solution can be generalized, and computation time minimized. Since the reflection voltage may assume an infinite number of waveforms, the final solution must be some approximation that produces accurate results from a minimum of information. With such an approximation, comparatively little need be known about the line's immediate past history, and the complexity due to multiple reflections is minimized.

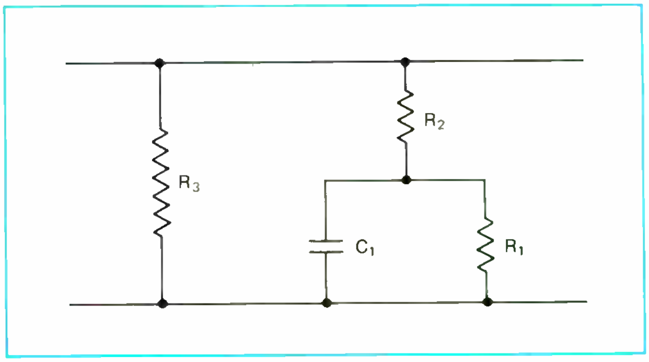
Of course, any waveform can be approximated as a series of small steps. But a better approach in this context is to use a series of small ramps, since this is nearly an exact approximation of a pulse with a finite risetime and falltime — the usual shape of waveforms transmitted over lines in high-speed digital systems.

Assume that the input waveform is a ramp with a slope of A volts per second up to time T_1. Then, at T_1, the slope increases by an amount B, which gives a new slope of A + B. By superposition, reflection voltage is:

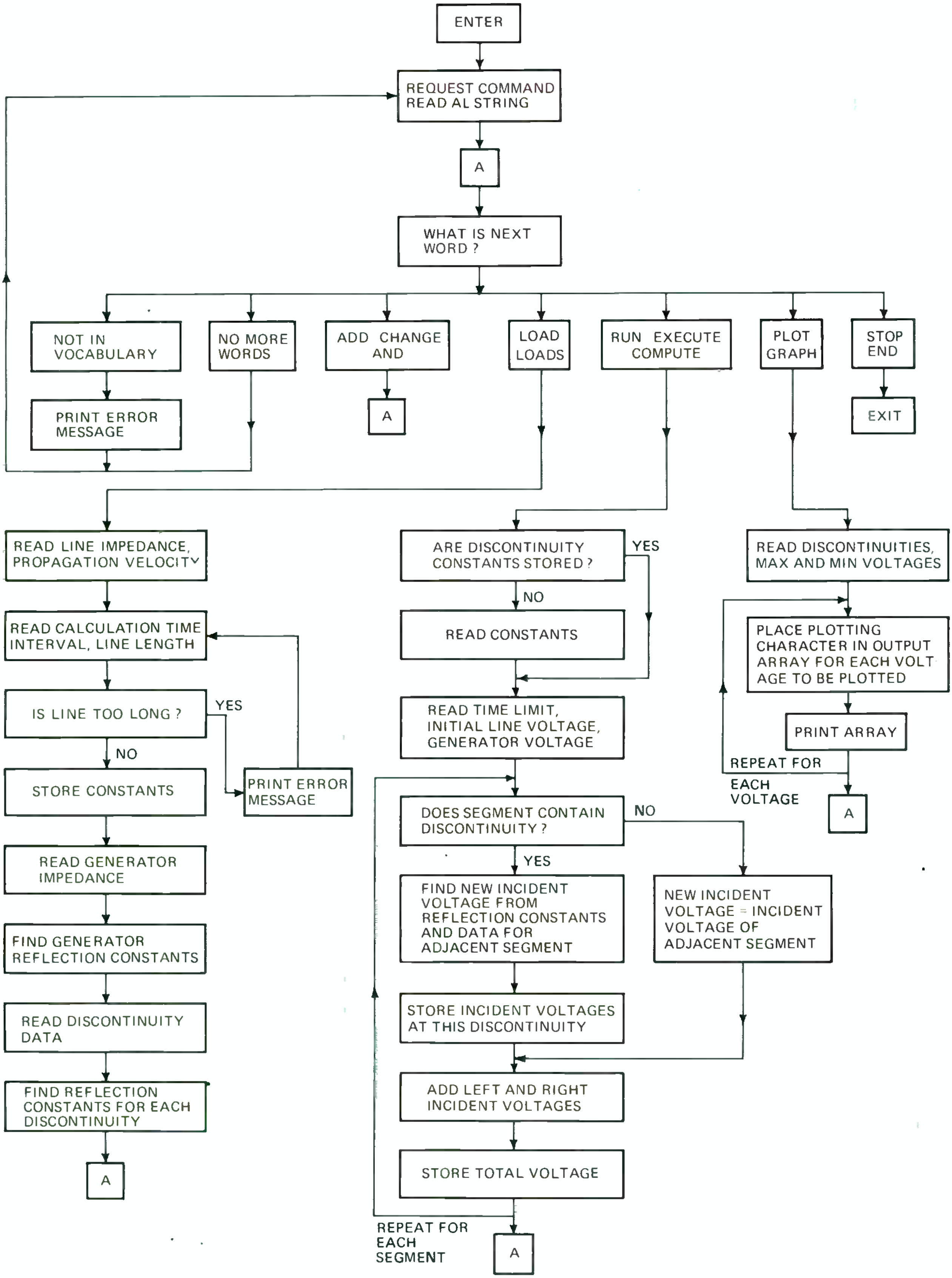
$$V_r = A[V_r(t)]_{ramp}U(t) + B[V_r(t - T_1)]_{ramp}U(t - T_1)$$

where U(t) is a unit step function, and $U(t - T_1)$ a delayed unit step.

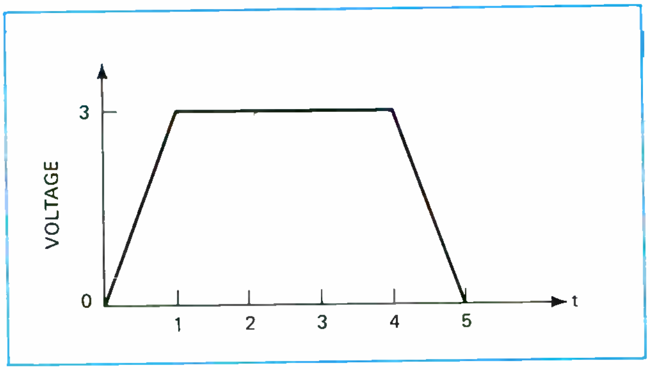
The forward voltage at time T_1, which is represented



1. General load. RC network accurately represents most loaded transmission lines in high-speed digital systems. When $R_2 = \infty$, it is resistive; when $R_1 = \infty$, $R_2 = 0$ and $R_3 = \infty$, it is capacitive.



2. Flow chart. Once initial data is entered, Line computes incident voltage and reflection constants for each line segment, storing only incident and transmitted voltages from previous adjacent segment. There are three basic instructions: LOAD (describing physical line properties), RUN (establishing initial electrical conditions), and PLOT (graphing reflection voltage at several load points).



3. Input voltage. Line accepts input waveforms as piecewise linear functions with up to 20 breakpoints. For example, the voltage waveform shown is described by an initial value (0,0) and four breakpoints with coordinate locations of (1,3), (4,3), (5,0), and (10,0).

by $V_f(T_1)$, can be expressed as:

$$V_f(T_1) = A\left[K_2T_1 + r\left(K_1 - K_2\right)\left(1 - e^{-T_1/r}\right)\right]$$

And the final equation for the reflected voltage is:

$$V_r = V_f(T_1)e^{-dt/r} + (A + B)[V_r(dt)]_{ramp} + (AT_1)[V_r(dt)]_{step} - (AT_1)(K_1 + 1)e^{-dt/r} \quad (3)$$

where:

$V_f(T_1)$ = forward voltage at the end of the last time interval

$V_r(dt)_{ramp}$ = the unit ramp reflection of Eq. 2

$A + B$ = the new ramp slope

$V_r(dt)_{step}$ = the unit step reflection of Eq. 1

AT_1 = the incident voltage at the end of the last time interval

dt = the time interval.

Note that only two pieces of information about the line's history need be saved for the next calculation—the incident voltage, AT_1, and the transmitted voltage, $V_f(T_1)$, at the end of the last time interval.

Using the results

To program Eq. 3 into a computer, the values of circuit variables R_1, R_2, R_3, and C_1, or mathematical variables K_1, K_2, and r must be stored. Also, the input waveform must be represented in memory, for example, by a table of voltages or by an equation.

The reflected and transmitted voltages are calculated at each discontinuity, but need to be stored for only one time interval. However, it is convenient to save the transmitted voltage for each interval since the instantaneous line voltage is the sum of two transmitted voltages (one for each direction). Some provision should also be made for the distance between loads so that the transmitted voltage (plus the reflected voltage due to the voltage incident in the opposite direction) reaches the next load after a suitable time delay.

The program Line reads the values of R_1, R_2, R_3, and C_1, and calculates and stores K_1, K_2, and r. The input waveform is described by a piecewise linear function that has up to 20 breakpoints. Total line voltage at each discontinuity is also stored and can be plotted. The computation interval is determined from the resolution requested by the user; it is the output time interval divided by 10. This allows a very close approximation of any waveform, including a step with a fast risetime.

The instruction sequence for Line is shown in the flow diagram of Fig. 2. To start the program, the command RUN LINE (or equivalent instruction, depending on the time-sharing system used) is used. After this, there are three operating instructions that can be repeated as many times as desired.

Operating instructions

The first of these is LOAD or LOADS, which allows the user to describe the line's physical properties. For proper operation, Line requires the line impedance, the propagation velocity on the line, how often (at what time intervals) the voltages should be computed, the total length of the line, the impedance of the driving generator, and the positions and values of loads on the line.

To describe a load for Line, load position (distance from the generator), and the values of R_1, R_2, R_3 and C_1 must be entered. Up to 19 loads can be accommodated. Constants representing the loads are saved in a disk file.

Any consistent set of units may be used. For instance, the system of ohms, feet, seconds, and farads is acceptable, and velocity would then be entered in feet per second. But this system may be cumbersome, and a more convenient set of units is kilohms, inches, nanoseconds, and picofarads. Velocity is then expressed in inches per nanosecond. (It should be noted that the unit of capacitance multiplied by the unit of resistance must be consistent with the unit of time.)

The second operating instruction describes the incident voltage waveform, and uses the command RUN, EXECUTE, R. E. or COMPUTE. For this computation, Line requests the maximum time for which the voltages are to be computed, the initial line voltage, and the breakpoints of the input voltage waveform. For instance, an input voltage like the one illustrated in Fig. 3 would be described by initial voltage (0, 0) and breakpoints (1,3), (4,3), (5,0), and (10,0).

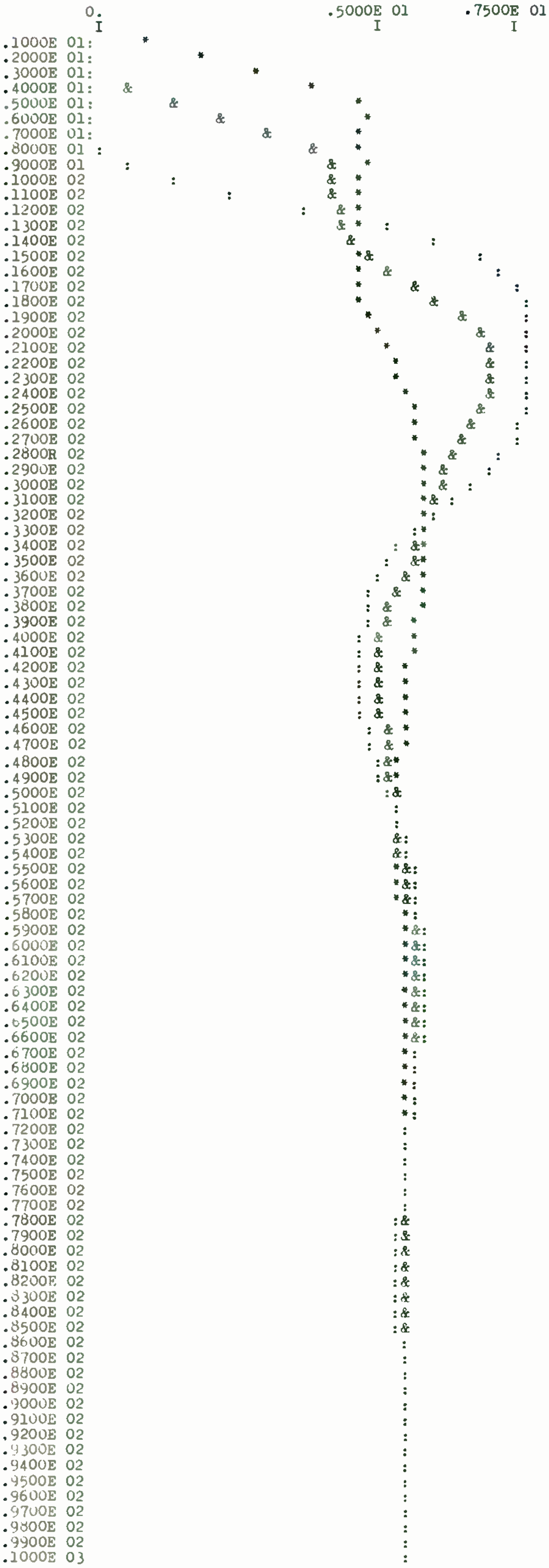
The time at which the last breakpoint occurs must be equal to or greater than the maximum time for which the voltages are computed. When this last breakpoint is entered, Line calculates the voltage waveforms at every load and writes them in a disk file.

If one of the commands describing the incident voltage is given before the physical properties of the line have been established (through a LOAD command), an error message is typed. When this occurs, the command RUN LINE must be entered again.

The third and last operating instruction, PLOT or GRAPH, causes Line to graph the voltage at one or more of the load points. If several separate plots are desired, the command must be given several times. Line prints each load's number and position, and asks for the number of waveforms the user wants plotted, plus the numbers of those loads for which plots are desired.

Along with the load numbers, Line lists load positions, and the typewriter character with which each load will be plotted. Finally, the program asks for the desired minimum and maximum voltage scale for each plot. All plots are superimposed. If either the PLOT or GRAPH command is given before the voltage waveforms have been computed, an error message is printed, and the command RUN LINE must be given again.

```
RUN LINE
 RUNNING

WHAT IS YOUR COMMAND?ADD LOADS

WHAT IS THE LINE IMPEDANCE?.100

WHAT IS THE PROPAGATION VELOCITY?8

AT WHAT TIME INTERVALS DO YOU WANT THE VOLTAGES?1

HOW LONG IS THE LINE?60

THE LINE WILL BE BROKEN INTO SEGMENTS  .800E 00 LONG.
WHAT IS THE IMPEDANCE OF THE GENERATOR?.020

DISCONTINUITIES ARE OF THE FORM R1 IN PARALLEL WITH
C, ALL IN SERIES WITH R2. ALL IN PARALLEL WITH R3.
INPUT LOAD POSITION, C, R1, R2, AND R3.
INPUT 5 ZEROS IF NO MORE DISCONTINUITIES.
?1,0,1000,1000,1000
?12,10,1000,.100,1.0
?24,5,1000,.200,2.0
?36,15,1000,.067,.667
?48,5,1000,.2,2
?60,10,1000,.1,1
?0,0,0,0,0

WHAT IS YOUR COMMAND?RUN

VOLTAGES WILL BE COMPUTED FOR EVERY
 .100E 01 INCREMENT IN TIME.
WHAT IS THE MAXIMUM TIME?100

WHAT IS THE INITIAL LINE VOLTAGE?0

INPUT WAVEFORM BREAKPOINTS BY ENTERING
TIME,VOLTAGE
?5,5
?100,5

THE VOLTAGES AT THE DISCONTINUITIES HAVE
 BEEN WRITTEN IN THE OUTPUT FILE LINEV.

WHAT IS YOUR COMMAND?PLOT AND STOP.

NUMBER          1      2      3      4      5      6
POSITION    0.80 12.00 24.00 36.00 48.00 60.00
HOW MANY VOLTAGES DO YOU WANT PLOTTED?3

INPUT THE NUMBERS OF THE DISCONTINUITIES
AT WHICH THE VOLTAGES ARE TO BE PLOTTED.
?1,3,6

  DISCONTINUITY      PLOTTING
NUMBER    POSITION    CHARACTER
    1     .800E 00        *
    3     .240E 02        &
    6     .600E 02        :
WHAT ARE THE MINIMUM AND MAXIMUM VOLTAGES?0,10
```




```
END LINE 1 MIN, 33.4 SEC.
```

4. Line example. Sample program and plot shows total line voltage versus time for three points of discontinuity along a line. Different typewriter characters represent the three ringing waveforms, which are plotted at 1-nanosecond intervals.

A RUN command may be given several times, as can the PLOT command. RUN causes Line to find the response of the loaded line to different input waveforms. Either STOP or END terminates the program.

It is also possible to obtain the voltage response at some point on the Line where there is no load, without affecting voltage at that point. The user simply inserts a load where desired by letting R_2 and R_3 be several orders of magnitude larger than the line impedance.

To make Line's commands more readable, punctuation and the words ADD, CHANGE and AND may be used. Then a simple command to completely describe a problem, compute the waveforms, obtain a plot, and stop would be: ADD LOADS, RUN, PLOT AND STOP.

Figure 4 is a sample run of the program to find the ringing characteristics of a line at three points of discontinuity for 100 nanoseconds. Total line voltage is plotted at 1-ns intervals along the line. The program restricts minimum and maximum voltage excursions to 0 and 10 volts, respectively, if the line voltage exceeds these limits. □

Printed copies of Line are available at $0.75 each from the author, Laurence P. Flora, 40 Highland Ave., Cambridge, Mass. 02139

Designer's casebook

Low-voltage regulator uses reversed error amplifier

by Claus H. Claasen
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A regulator circuit with an upside-down error amplifier can provide a regulated voltage of less than 4 volts at 2 amperes, while operating from a higher-voltage unregulated supply. Since zener diodes and IC regulators cannot supply an output at this voltage and current level, an auxiliary voltage of opposite polarity is commonly used to achieve low-voltage regulation. The voltage may be obtained from another supply or from an existing circuit voltage.

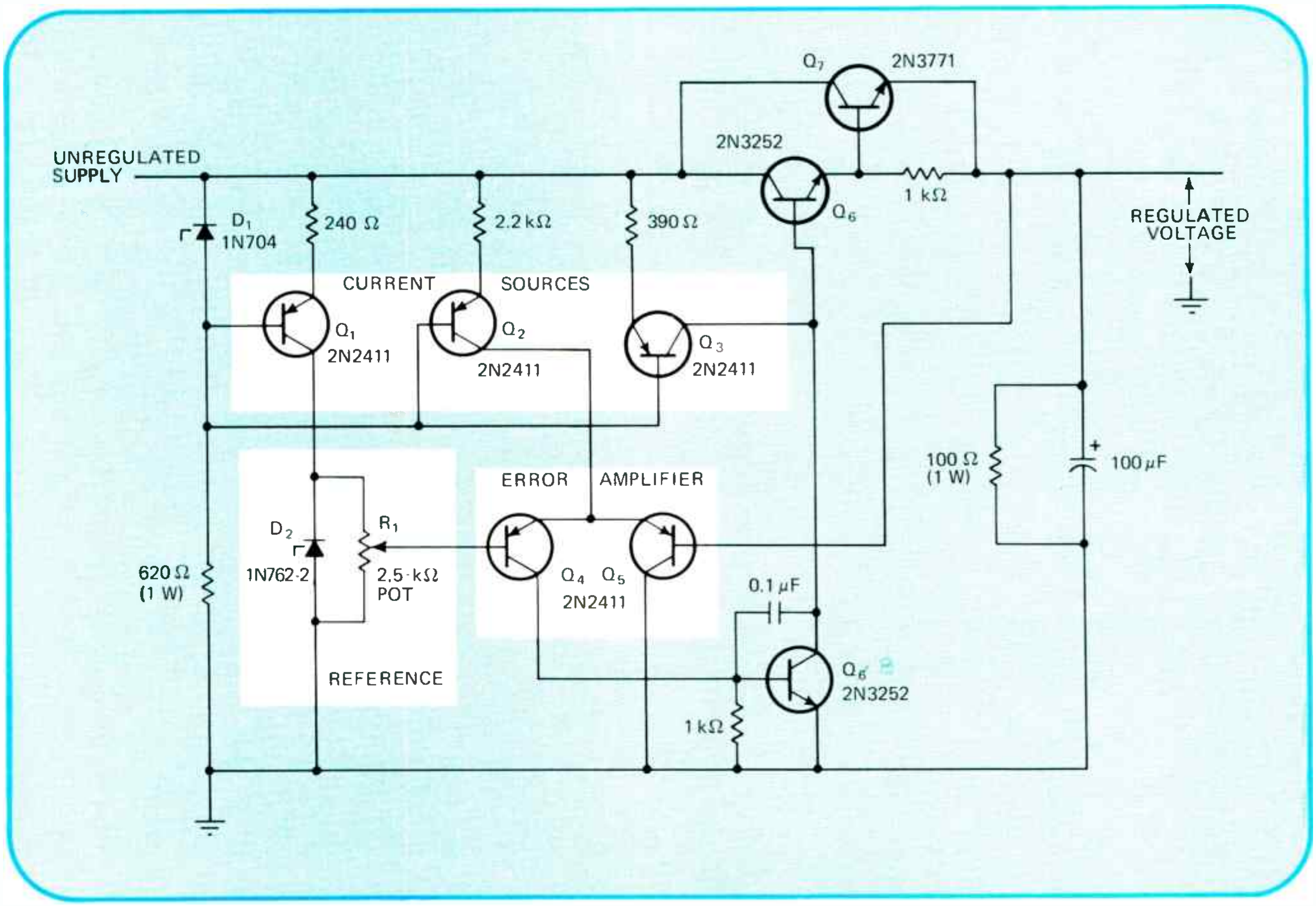
Reversing the regulator's error amplifier and inverting the amplifier's output with a current-sink transistor can result in voltages of less than 1 V and a regulation of better than 1%. The circuit shown provides a low positive voltage, but a small negative output can be obtained very simply if all diodes are reversed and all npn transistors changed to pnp types and vice-versa.

Zener diode D_1 is a common reference for current sources Q_1, Q_2, and Q_3. Transistor Q_1 feeds zener voltage reference D_2; Q_2 supplies the error amplifier, which consists of transistors Q_4 and Q_5; and Q_3 feeds a series pass element, the Darlington configuration of Q_6 and Q_7.

Under the control of the error amplifier, transistor Q_8 sinks all or part of the current coming from Q_3. The error amplifier compares the regulated voltage with a fraction of the reference voltage, as determined by potentiometer R_1.

For the components indicated, the circuit regulates 3.2 V at 2 A maximum from an unregulated supply of 14 V nominal. When unregulated supply tolerance is ±10%, circuit regulation is better than ±1% after initial adjustment. A regulated output of 1 V can be obtained from an unregulated supply of about 8 V.

Regulating small voltages. Regulator circuit supplies output voltages as low as 1 V. Current sources Q_1, Q_2, and Q_3 feed zener reference (D_2 and R_1), error amplifier (Q_4 and Q_5), and series-pass Darlington pair (Q_6 and Q_7), respectively. Error amplifier compares regulated output to zener reference, while Q_8 acts as current sink for Q_3. Circuit provides 3.2-V regulated voltage from 14-V bulk supply.



Hard-limited sinusoid eases frequency multiplication

by Donald F. Dekold
University of Florida, Gainesville, Fla

An audio-frequency multiplier achieves a multiplication factor of 40 (for a 625-hertz input) by hard-limiting a damped sine wave. The design uses a minimum of components and circumvents the problem of inherently low-Q inductors at audio frequencies.

If the input is a symmetrical square wave, the circuit performs odd multiplication; for an asymmetrical square wave, it functions as an even multiplier. A true square wave can only yield odd harmonics, but even harmonics can be introduced by varying the square wave's duty cycle. For even or odd multiplication, both tank circuits will ring at their natural frequency.

Due to L_1's normally low Q, the ringing response will be a damped sinusoid (e_a). Resistor R_1 isolates the tank circuit from a source that may have a low output impedance, which could further lower the tank's Q. Since the field effect transistor has nearly infinite input impedance, it does not load the tank circuit.

Because the input is periodic with a frequency of f_o, the ringing responses are also periodic. A source-follower stage couples these periodic ringing waveforms into an integrated circuit limiter.

Due to the high gain of the limiter, the ringing waveform is hard-limited, and the decaying sinusoid becomes a positive quasi-square wave of relatively constant amplitude at point b. The voltage, e_b, appears across load resistor R_2.

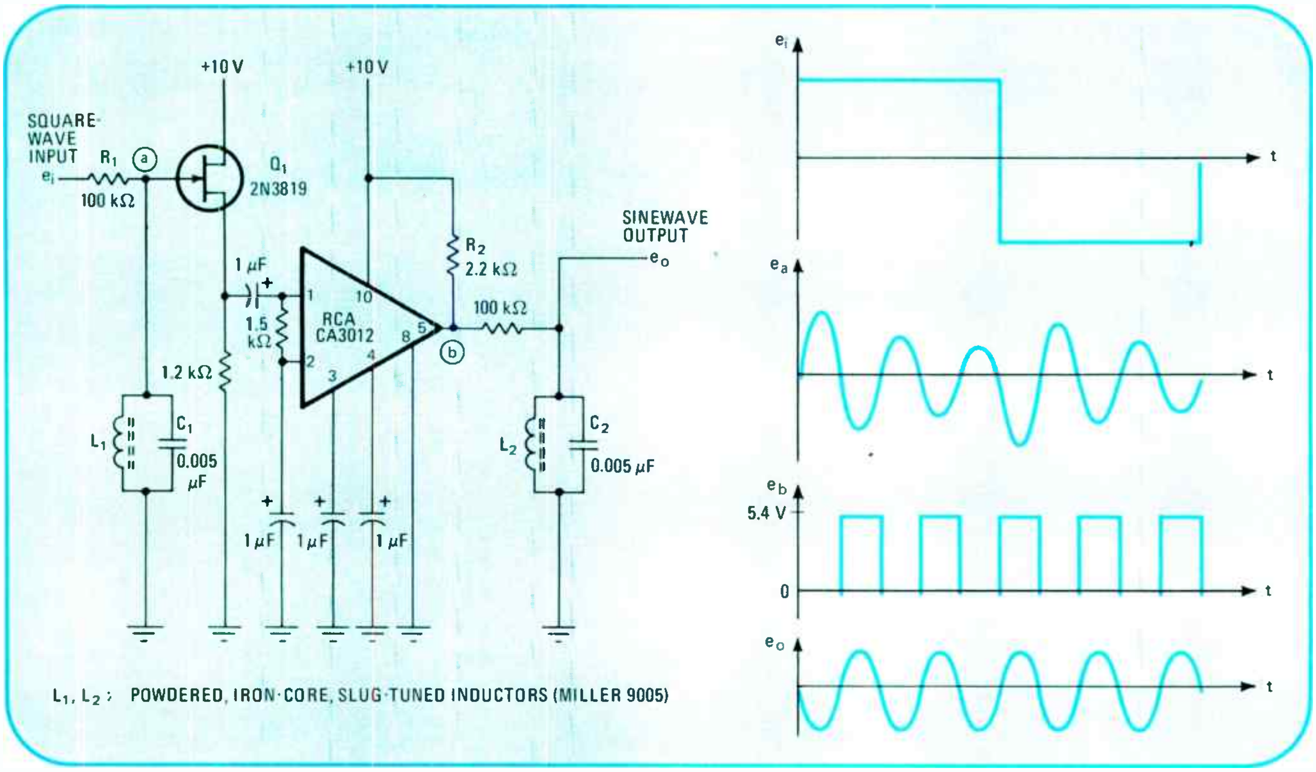
Another tuned circuit, formed by L_2 and C_2, filters the limiter's output, producing a sine wave whose frequency is nf_o. The filtering task at this point in the circuit is easy, since the limiter's constant-amplitude output primarily contains frequency component nf_o and odd multiples of nf_o. The single tank circuit is sufficient to provide sine waves with good spectral purity.

Care must be taken to adjust both tuned circuits so that their natural (ringing) frequencies are exactly the desired multiples of the input frequency. If this is not done precisely, an objectionable amount of spectral impurity appears in the output signal as amplitude modulation.

For an input frequency of 625 Hz, the multiplier produces an output frequency of 25 kilohertz, which corresponds to a period of 40 microseconds. The total period of the input square wave is, of course, 40 times the period of the output sine wave.

In addition, the duty cycle of the input square wave must be adjusted so that it can be coupled into the first tank with a phase relationship that does not destructively interfere with the tank's ringing voltage. An asymmetrical square wave of this type can be supplied by a one-shot multivibrator. For example, a standard one-shot with a variable pulse-width control can be used as the multiplier's input stage; the one-shot would be driven by a source whose frequency is f_o. The waveforms shown are for a times-five multiplier.

Multiplying audio frequencies. Either symmetrical or asymmetrical input square wave causes L_1C_1 tank circuit to ring at its natural frequency; symmetrical square waves yield odd multiplication, asymmetrical yield even. Source-follower couples ringing waveform into wide-range limiter. Resulting pulse train is filtered by second tank (L_2C_2), producing sine wave. Multiplication factor is 40 for 625-hertz input.



Flip-flop sequences conversion register

by Richard J. Mann
TRW Systems, Redondo Beach, Calif.

The conversion register for a successive-approximation analog-to-digital converter can be made to sequence automatically by adding a control flip-flop. Usually, bit time signals are used to sequence cell setting and conditional resetting in the conversion register.

If the converter is closely associated with a large digital system, these bit time signals generally are available. But if the converter is a remote self-contained unit, a counter and a decoder must be added to generate the bit-time signals. A more efficient register design eliminates this extra circuitry by adding one flip-flop.

If the register is seen as a conventional sequential machine, its operation can be represented by a state map, as illustrated in (a) for four-bit conversion. The conversion sequence begins with the most-significant bit, the 1000—0 state, which corresponds to the midscale analog value.

After a comparison between this analog value and the data value, the first cell may or may not be reset. In either case, the next cell is set. For example, the register will jump from the 1000—0 state to the 1100—0 or the 0100—0 state depending on the comparator value. This process is repeated for each less-significant bit.

Therefore, the register for an n-bit converter is sequenced from its initial 1000—0 state to one of 2^n possible final states. Since the total number of register states is $2^{n+1} - 1$, adding a flip-flop as a control bit permits each register state to have a unique value so that the register is self-controlled.

The last state always has a logic 1 as the control bit. Depending on system requirements, a 1 in the control cell permits the control bit to signal completion of a conversion cycle, to dump the register data into an external buffer, to make the converter wait for data sampling by the user, or to initiate a new conversion cycle. In any case, re-initialization occurs by forcing the 1000—0 state and clearing the control bit.

An auto-sequencing four-bit register, then, can be implemented with five flip-flops (b). The mechanization scheme, which is easily expandable to any number of bits, uses J-K flip-flops like Texas Instruments' type SN5472. Converter operation is stop-and-hold.

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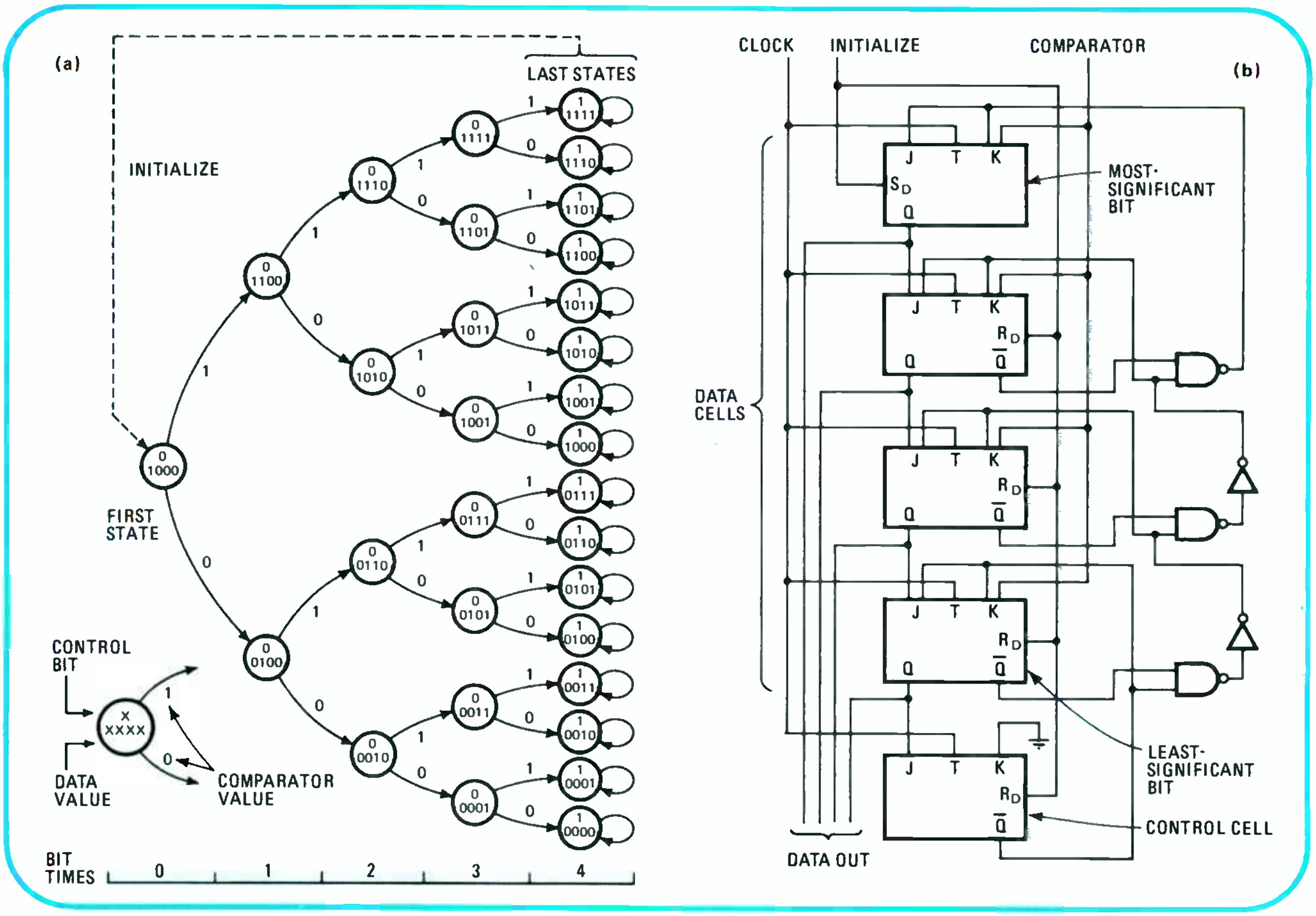
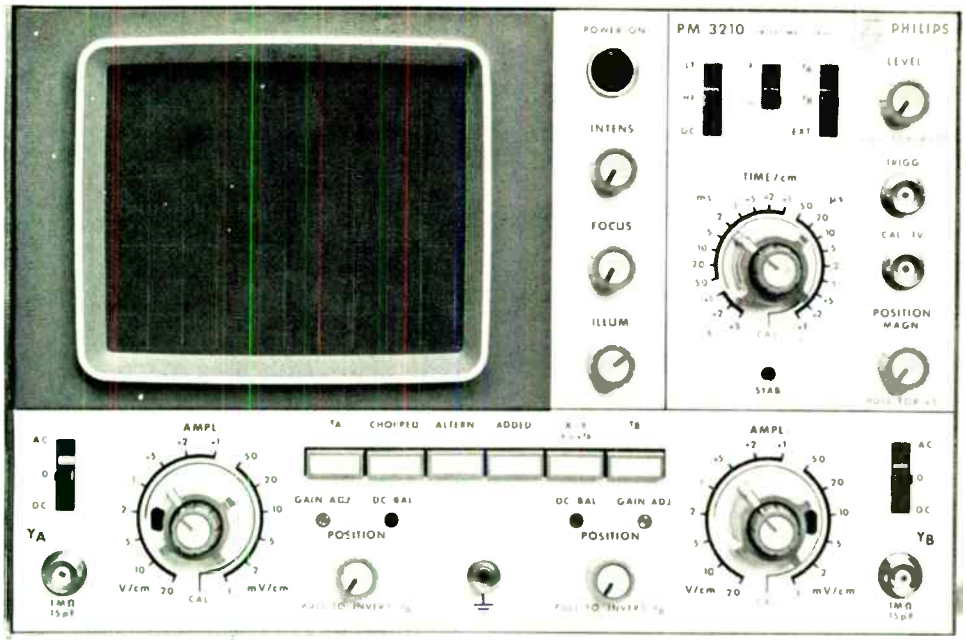
Automatic sequencing. State map of register (a) for four-bit a-d converter shows $2^5 - 1$ total states, and $2^4 - 1$ final states, indicating that self-sequenced operation can be realized with extra flip-flop. Self-controlled four-bit register (b) uses five flip-flops, instead of usual four. In general, n-bit converter has 2^n final states, $2^{n+1} - 1$ total states, and requires n + 1 flip-flops for automatic sequencing.





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In strobed LED displays, how bright is bright?

Multiplexed displays using light-emitting diodes can give circuitry economies, but will the results be satisfactory to the viewer? One aid is a strobing factor easily determined from measured data

by Richard W. Ahrons, *Opcoa Inc., Edison, N.J.*

☐ More and more designers of alphanumeric displays are considering the use of multiplexing or strobing techniques with individual light-emitting diodes. By driving these elements on a time-shared basis, the amount of decoders, drivers, and other peripheral circuitry is reduced.

The LED lends itself to use in strobed circuits because it's a rectifier, requiring no isolating elements. In addition, its fast response is compatible with pulsing and its light output increases with the drive signal's amplitude.

However, an essential but generally misunderstood aspect of strobed systems is the effective light output seen by the viewer, which is related to the peak absolute value of light output under pulse conditions, and the duty factor. In some cases, strobing results in a gain in average light output with dc operation, under the assumption that the average strobe current equals the direct current. A gain or loss depends on the slope of the light output-vs-current characteristic.

Obviously, gain or loss as defined here is only one measure in determining the performance of a display. The overall evaluation of a strobed system must be determined by the absolute value of light attained [see "A fair comparison," p. 80]. An LED yielding high gain but with a lower absolute value of light output cannot be considered superior to a device exhibiting a loss but with a higher absolute value of light output.

Fortunately, there's a method that can quickly determine the gain or loss obtained when strobing LEDs under any set of electrical conditions. The method uses one plotted curve of light emissions vs current. Circuits for measurement of this characteristic can be readily assembled in the laboratory.

Plotting the curve

For plotting meaningful curves to evaluate strobed display performance, it is convenient to define a strobe intensity factor, S, as:

$$S = \frac{\text{Light intensity per unit current at } I_{peak}}{\text{Light intensity per unit current at } I_{av}}$$

where I_{av}, the average current into the LED, equals I_{peak} times the duty cycle. This average current corresponds to the current supplied by the dc power source.

From a plot of measured points of light intensity per unit current vs current, the factor S can be derived conveniently. Since only relative values of light are required, the measurement method does not require sophisticated or expensive light-measuring equipment. All curves are normalized to the peak output per unit current. Typical curves for commercially available seven-segment displays are shown in Fig. 1.

The strobe intensity factor, S, may be found for several seven-segment displays using the curves in Fig. 1 by dividing the value of light output per unit current at the specified peak current by the value of light output per unit current at the specified average current. If the resulting value for S is larger than unity, pulsing the device to the peak current value will effectively produce more light than operating continuously at the average current level.

In the curve derived for the Monsanto MAN-3 display of Fig. 1(b), the normalized output for a peak current of 50 milliamperes is 0.94. Assuming a 2% duty cycle, an average current of 1 mA yields a relative light output of 0.2. Calculating S from this data, we get S = 4.7, a significant gain over unstrobed operation at the average current level. This value is close to the published figures of 4.4 for MAN-3 units operated at these current levels.

The curves, of course, only indicate gain or loss due to strobing. The absolute value of the light output must be included to determine the total effect of strobing.

For example, S can be calculated from the curves of Fig. 1(a) for three different types of displays, at, say, a peak of 40 mA and an average of 10 mA. For Opcoa's SLA-1, S = 0.68; for Monsanto's MAN-1 and MAN-4, S = 1.03 and 1.35, respectively. Thus, although the MAN-4 yields the best gain for strobed operation, the SLA-1, with its higher absolute output at 40 mA, will give the brightest output.

The curves in Fig. 1 also illustrate the relative quantum efficiency of the LED as a function of current; the ordinate could just as well be labeled "relative quantum efficiency." When the curves deviate from unity, there will be a decline from maximum efficiency. Most gallium-arsenide-phosphide diodes have relatively low efficiency at low current levels and thus produce a strobing gain when average current is low compared to that required for maximum efficiency. In effect, strobing at higher peak currents in this case compensates for the loss in efficiency of light emission at low currents in some diodes. Quantum efficiencies at the peak are typically 0.12% for GaAsP (emission centered at 660 nanometers) and 1.2% for gallium phosphide (emission centered at 690 nm).

In designing strobed displays, both S and system organization should be taken into account. For example, consider a large 14-digit LED display with each digit containing seven cathodes and one anode. If all 14 digits are strobed in one bank, 21 driver interconnections would be required (14 anode drivers and seven cathode drivers). Since one of 14 digits is "on" at any time, a 7% duty cycle is required.

An alternate form would be to organize the displays into two banks of seven, requiring seven anode drivers (one driver shared by one digit in each of the two banks) and 14 cathode drivers; this would still require 21 driver interconnections, and, incidentally, lower peak currents. However, the latter organization results in a 14% duty cycle; a more favorable S can result with this greater duty cycle if the LEDs are operating on the negative slope or loss portion of the curves.

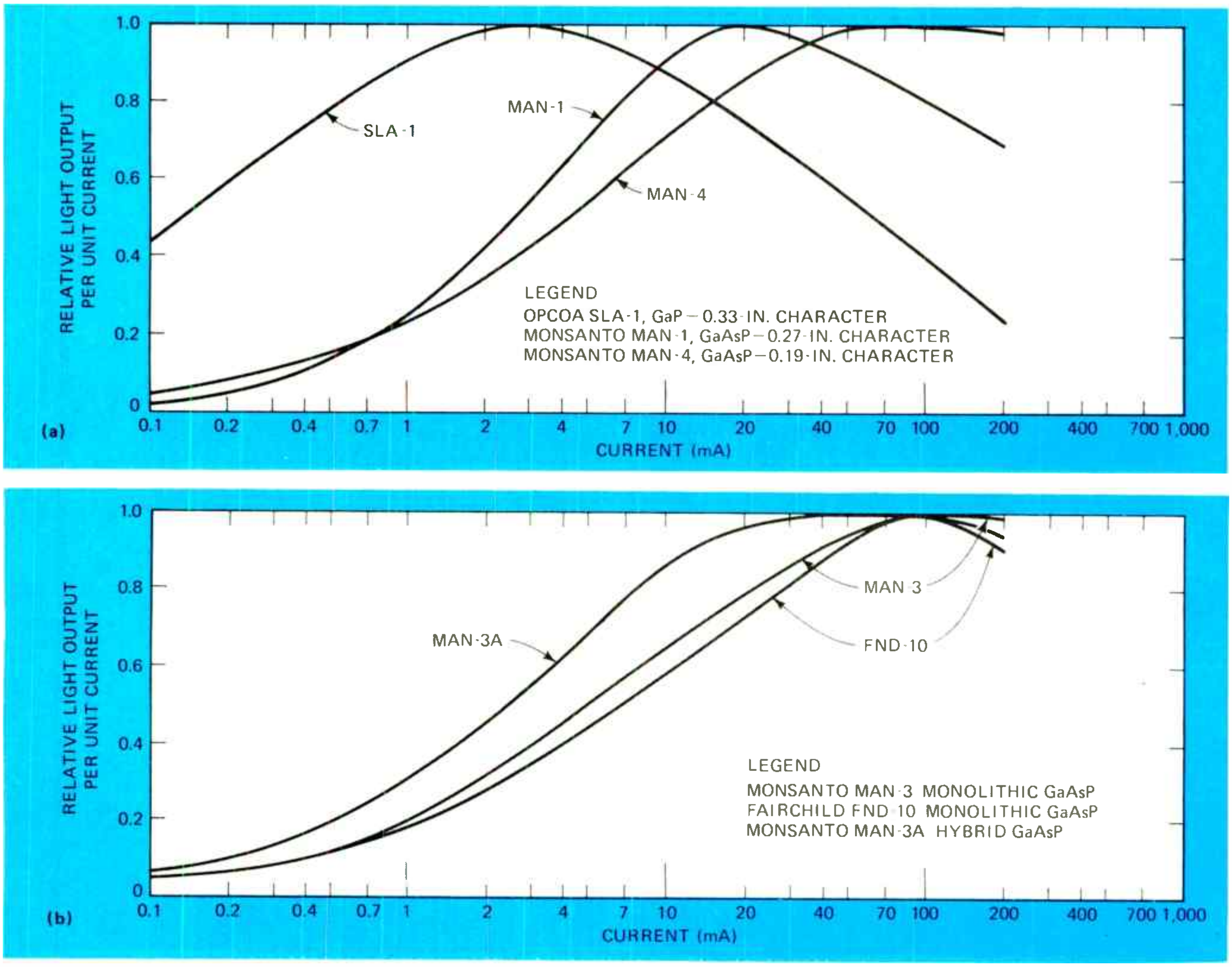
The data needed to obtain the curves of Fig. 1 does not require accurate absolute measurement of emitted light as a function of current but does call for accurate relative measurements, achievable without sophisticated equipment. A small silicon photovoltaic cell (such as Centralab Type 58C, International Rectifier Type SO505E, or Solar Systems Type S-23), with low leakage current, may be utilized as the photodetector.

To operate the LED at low currents, dc measurements are used. Either a dc light-measuring instrument or a suitable solar cell can serve as the detector in the circuit shown in Fig. 2(a). The cell should be placed directly over the segment to be measured. The operational amplifier provides the necessary gain and presents a low impedance to the solar cell. The variable resistor serves as a range adjustment.

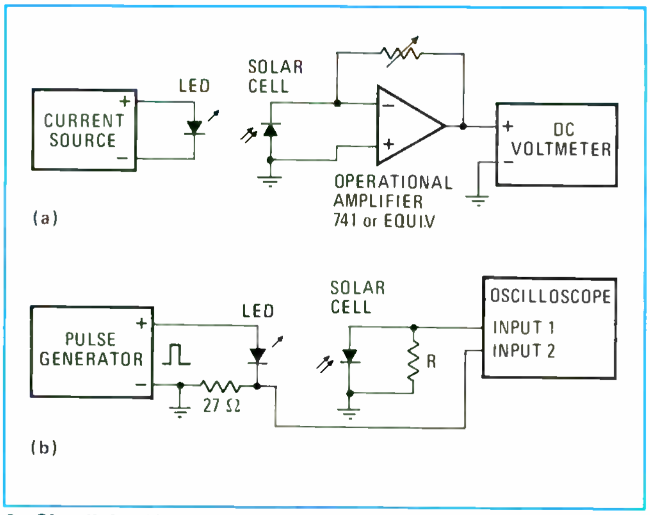
Selecting resistors

About 330 kilohms is a typically useful value when operating in the current range of 1–10 mA through the LED. When operating in the 0.1–1-mA range, the value should be increased to 3.3 megohms. In this lower current range, the dark-level reading should be recorded first and subtracted from the light output reading. The operational amplifier should not be overdriven lest linearity be affected; the input current offset also must be taken into account.

When the LED's bias conditions begin to cause appreciable heating, light output can decrease; this decrease is a function of temperature at the diode's p-n junction. A typical LED's light output will decrease about 0.5 to



1. Helpful data. These curves, plotted from measurements made on several commercially available types of seven-segment displays, are the first step in determining the factor S, a comparative measure of the gain or loss obtained under multiplexed operation. Ratio of values at specified peak current to those at specified average current yields S. Similar curves can be derived for dot-matrix-type LED displays.



2. Simplicity. Uncomplicated setups simplify measurement of data required to derive curves of Fig. 1. At lower current levels, dc measurement with arrangement (A) should be used. When current level through LED exceeds 5 mA, pulsed setup of B) is required.

A fair comparison

To compare the absolute value of light emitted by two LED displays identical in geometry (character size, area of emission, etc.), almost any standard measure of light emission can be used. However, when display geometry differs, the comparison becomes more difficult. For example, the three standard measures—luminous flux (lumens), luminous intensity (candelas or lumens per steradian), and luminance (foot-lamberts)—do not adequately allow a comparison between various seven-segment geometries.

Luminous intensity is an excellent measure for a point source; therefore, it is meaningful when applied to a single solid state indicator lamp. *Luminance*, on the other hand, is based on a *unit* area of the source and thus is more suitable for a large, flat emitter like a TV screen. It is a poor measure for comparing different types of seven-segment displays—they are highly structured and neither approximate a point source nor a large continuous flat source, but fall somewhere in between. Thus, some standard measure that is a compromise between luminous intensity and luminance appears to be desirable.

A quantity, *candelas per unit character area*, would seem to fill this requirement. (Character area is defined as the product of character height and character width.) Such a measure takes into account both the total light produced by a segmented display and the effect of the size of the display character. In that way, effective brightness of the whole display is quantified, unlike, say, the foot-lamberts measurement, which expresses the brightness of only a small area—usually measured by most manufacturers at the brightest point.

Luminous intensity, in candelas, can be determined, for example, with a calibrated, 1-in.-diameter detector placed about two feet from the display. As in all such measurements, detector response must be corrected to match the response (photopic) of the eye. For a display with a character height of ½ in. or less, the resulting candela measurement is a good engineering approximation, unless the display is highly directional. Dividing the measured value obtained this way by the product of character height and width results in the desired value of candelas per unit character area.

1.0% per °C. Thus, for higher excitation currents, pulse measurement becomes necessary. A current level of 5 mA is a good crossover between pulse and dc measurements. For pulse measurements a reasonably sensitive dual-trace oscilloscope (about 5 mv/cm) and the silicon photovoltaic cell should suffice. A pulse repetition rate of several hundred hertz and pulse width equivalent to a 2% duty cycle will give reasonably accurate results.

One scope channel is used to measure the current through the LED by displaying the voltage across the 27-ohm resistor; the other channel measures the relative output light power from the LED. The resistor, R, should be adjusted so that detector output at low LED current levels can be read conveniently, while at higher levels the voltage across the resistor shouldn't exceed .05 V.

To assure a smooth curve plot, overlap in current scale should be used in taking data for the low-power dc measurements and the higher-power pulse measurements (data should be taken for the dc case up to about 10 mA, and for the pulsed case, down to about 2 mA). In the overlap area, the two curves can be matched and an appropriate multiplier applied to yield a smooth curve. The curves can be normalized to the peak value of light output per unit current by dividing the values of light power per unit current by the maximum value.

Brightness as a function of current, as presented on many LED data sheets, cannot be used to generate the curves. This is apparent when a straight line on linear coordinates is shown on a data sheet; it obviously results in an S equal to 1 for any set of values used in strobing operation. Also, some data sheets give dc characteristics only and do not take into account the effects of heating at higher current levels.

Matrix displays

The same type of curve also can be generated for an LED element in an X-Y matrix. In this case S becomes a pulsing factor for the matrix. An X-Y matrix can be scanned line by line (line sequential), or a dot at a time (dot sequential). Dot-sequential scanning imposes a duty factor inversely proportional to the number of dots; one dot of information is presented to the display at a time. Line sequential scanning requires a duty factor inversely proportional to the number of lines, which are presented a line at a time. Assuming a constant average LED current, S can be calculated from the required duty cycle, the peak current, and the curves generated for the individual LED. Determining the S value for both scanning arrangements influences X-Y matrix display organization. Also, the decision on whether to line scan relatively to the X-axis or Y-axis can be made on the basis of the S value for either case.

The seven-segment display can be set up in an X-Y matrix layout. Thus, the seven-segment display may be analyzed as in the case of an X-Y matrix of light-emitting diodes. □

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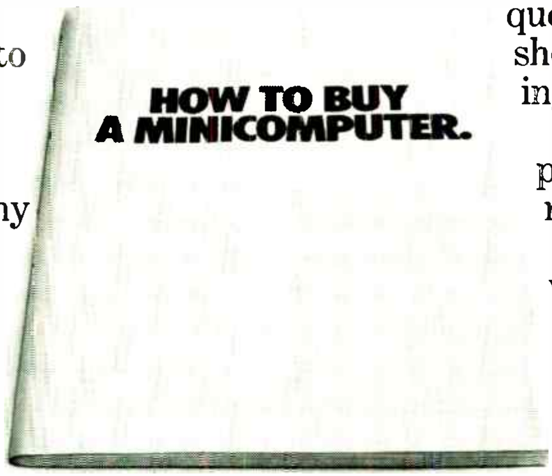

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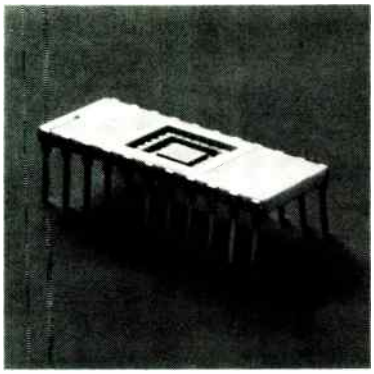

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Board testers make most-wanted list

Digital system makers, seeing how IC failure rates devastate logic board yields, are demanding—and getting—better board testers

by Stephen E. Scrupski, Packaging & Production Editor

Now that logic boards holding 100 ICs are becoming common, even a 1% failure rate in ICs can turn almost every board into a reject. This situation, which promises to get worse rather than better as digital systems increase in complexity, is creating such a demand for board testers that it could overshadow even the soaring LSI testing market. The urgent need is for automatic systems that diagnose which ICs are faulty, so that the costly board can be repaired rather than thrown out.

Robert McClure, chairman of the board of Telpar Inc., a Dallas-based company that provides test programs for logic testing, estimates that a year ago the average IC package had about eight gates, but now it's up to 16 and probably will rise to 20 or 30. Such increased complexity coupled with the decreased cost of less complex circuits has resulted in higher likelihood of circuit failures. Typically, says McClure, about 2 to 5% of the incoming ICs are bad, and if the devices are not pretested, often only about 2% of boards holding 100 ICs will completely pass the final board tests. Even if bad ICs are screened out in incoming inspection, he continues, failures of the board itself, such as open etches or solder bridges on the more dense wiring patterns can cut final board yields in half.

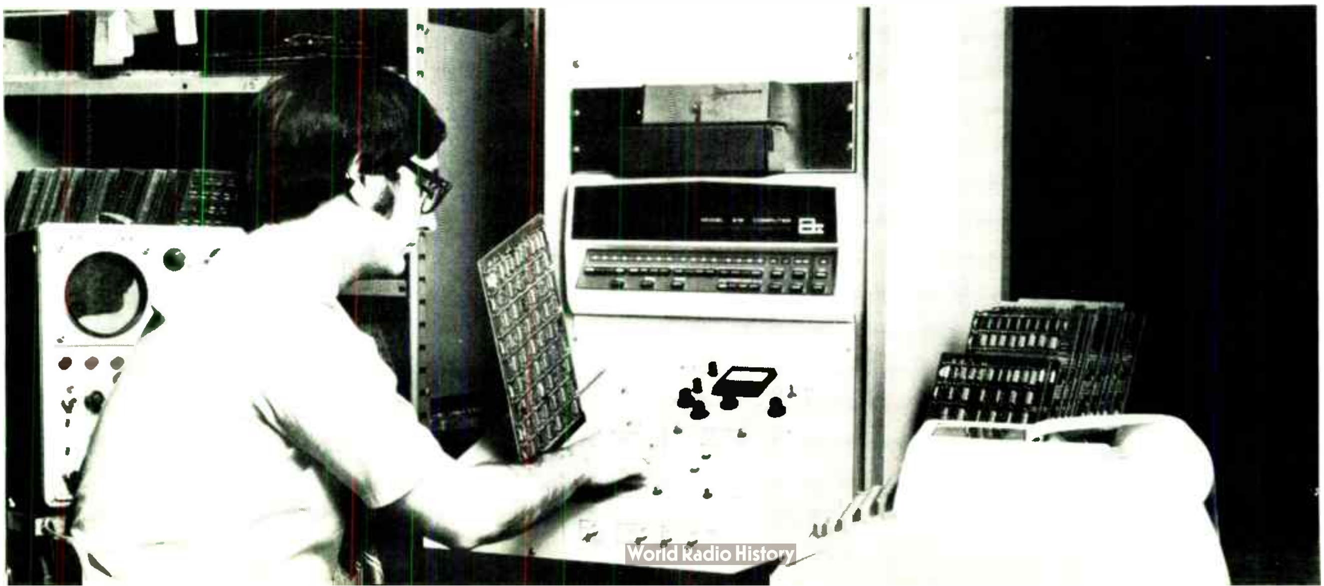
To test logic boards, "most companies have ended up with a mixed bag," says Howard Painter, marketing manager for logic circuit testers at General Radio Co., West Concord, Mass. Its Model 1790 tester, originally developed for in-house use, was introduced a couple of years ago at a base price of $30,000. The companies that have developed their own testers, says Painter, "find they've accumulated things from a scope to a tape-controlled tester; the cost has gotten out of hand, and the system isn't readily adaptable. Computer-controlled testers are more general; it's a simple matter of writing a new program."

General Radio, in fact, is getting ready to announce a new test system, the 2200, which, with modular plug-in circuits, will handle digital, analog, and passive circuits. Based on the 1790, the new system uses a PDP-8/E with a 4,000-word memory that can be supplemented in 4,000-word increments up to 32,000. It will handle boards having between 12 and 256 pins, in increments of 12.

Texas Instruments Digital Systems division, Houston, is another company that has decided to market an originally in-house system, the ATS960 tester [*Electronics*, Oct. 11, p. 117.]. Hal Phelps, test systems applications engineer, says that there's a trend away from specialized, in-house testers "because they're expensive."

Another reason for the growth of the commercial tester market is cutbacks in personnel at the systems houses, according to Sam Duran, marketing manager for Datatron, Inc., Santa Ana, Calif. He points out, "The big in-house instrumentation groups are gone, and while a company might have the technology, it doesn't have enough people to do a better job of tester

Picky, picky. Fault-finding is the virtue of the Capable logic tester made by Computer Automation. Like most logic testers, the system provides on-line capabilities for automatic fault isolation. The operator can troubleshoot at the console, or tag boards for later repair.



development." Thus, says Duran, the market for logic board testers "dwarfs" the market for LSI testers, which his company also makes.

Pinpoint logic. Testers designed for LSI are not directly useful for logic circuits, since, for LSI circuits, all the operator wants to know is whether or not the circuit is bad. But with logic boards, the operator also wants to pinpoint which particular circuit on a board is bad and should be replaced. The speed of the LSI tester also is usually far greater than is needed for logic board testing.

Ramon Alonso, president of Adar Associates, Cambridge, Mass., a maker of device testers which also are being used as board testers, confirms that "there is an obvious split between card and device testers, and it's growing." Adar's testers are in fact being aimed at memory board tests, which do need speed.

Comparison checks. The simplest test of a logic board is to operate one that's known to be good in parallel with the board under test, and then compare their outputs. The more complex the boards, the more time it takes to get each into the same logic state to begin the test.

Despite such difficulties, at least one commercial supplier is following the comparison route. Trendar Automation Corp., Mountain View, Calif., is offering a tester [*Electronics*, Aug. 16, p. 115] that automatically makes the logic states identical and then applies test inputs in three sequences—high, normal, and low voltages. Any output that fails to respond is displayed with its pin number. The system fixes the input in that state, enabling the operator to trace the source of the error.

Donald P. Allen, Trendar vice-president and director of marketing, defends the comparison method, pointing out that programed testing is not as flexible as it seems. If there is an engineering change in the pc board design, he says, a programing change is more time-consuming and more difficult than a change in the comparison system "where you might only need to add a jumper or take one way."

Program changes. Robert C. Allan of the marketing department of E-H Laboratories Inc., Oakland, Calif., sees it differently: "With the comparison method, every time you want to change the board specs you have to unwire and rewire. With minicomputers, you only have to change the program."

Hewlett-Packard also had a comparison tester, the 2060A, but the system was discontinued as a commercial product, even though the company still uses several in-house.

Most other test manufacturers, however, are following the programed tester route. William S. Routh, director of product marketing at Fairchild Systems Technology, Sunnyvale, Calif., says, "I don't like comparison testers. They're fine for simple boards, but cannot do fault isolation without operator intervention, which rules out an unskilled operator." In practice, however, most computer-controlled systems are operated by technicians who troubleshoot boards as soon as a fault is found, says Stuart Daniels, at Digital General, Cleveland, Ohio, makers of programed testers. His view gains credence from the fact that many such systems come equipped with circuit probes and scope hook-ups, which imply usage by technicians rather than unskilled operators.

The tester made by Teradyne Inc., Boston, Mass., for example, is interactive and can be interrogated when there is a failure. It can also be programed to stop at certain tests, so that the operator can "walk" the machine through the procedure, and to cycle the tests to get a continuous display, so that the user can revise the circuit board and then see the results.

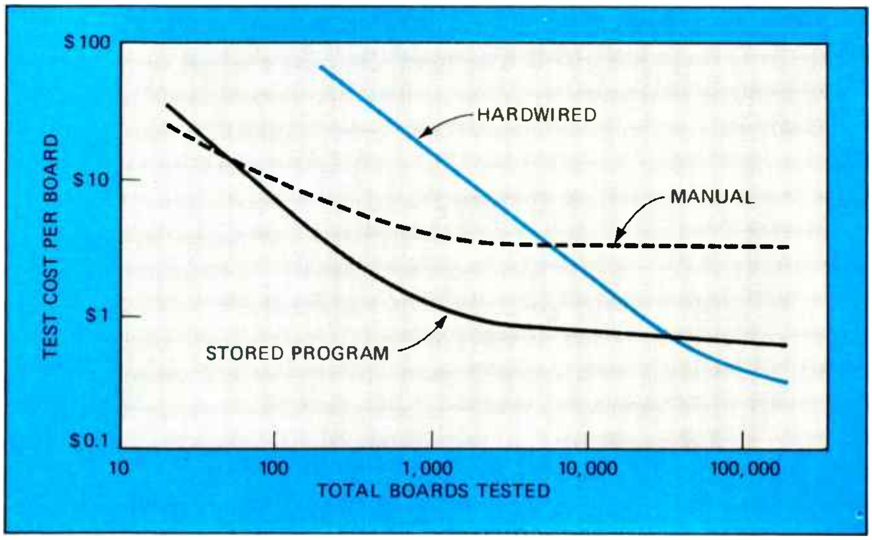
It's capable. Computer Automation Inc., Newport Beach, Calif., although better known for its computers, has been marketing a computer-controlled tester since January 1970. The tester, called Capable, includes the company's own model 216 computer. Douglas Cutsforth, production line manager for tester products, reports, "We can test about 20 boards an hour, counting fault isolation time, and so reduce the testing cost to about 30% of the board's total cost—down from more than 50%."

To make the fault isolation model, Computer Automation takes an actual circuit board, inserts failures, and stores the output patterns and corresponding inputs. A table then is printed out, showing the logical string involved in a failure.

A different method of generating a fault location table was developed by Data Test Corp., Concord, Calif. Its tester analyzes the board design and counts the number of transitions on each output line for a full range of inputs. When a board is checked, the tester simply compares the total number of transitions made in each output. □

Contributing to this article were James Brinton, Lawrence Curran, Gail Farrell, Paul Franson, Stephen Wm Fields, and Roberta Schwartz.

Tradeoffs. Testing costs vary, depending on the number of units tested. For most board lot sizes, programed testers cost least. These curves are from a Texas Instruments study.



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Data Technology

Markets

Japanese firms sprouting in U.S.

Jolted by 'Nixon shock,' Japanese electronics firms accelerate trends to set up joint ventures in U.S. with American technical, marketing aid

by Lawrence Curran, Los Angeles bureau manager

The U.S. commercial electronics sector is providing fertile soil for a new species of Japanese company: the multinational firm seeking, through joint ventures, U.S. technological and marketing help for American sales. If nourished carefully, it could bloom as handsomely as the consumer electronics planting that was accomplished so successfully back in the '60s.

At least three Japanese electronics firms are seeding ventures in California. Sharp Corp. of Japan is backing Datapet in Santa Ana; Omron Tateisi is bankrolling Omron Systems and Omron R&D in Mountain View, and Toyo Electronics Industry Corp. is investing in Exar Integrated Systems Inc., which is in Sunnyvale.

The Japanese government approved the Sharp-Datapet deal only this month; Omron, which began almost two years ago as Myko Systems, consummated the deal with Omron in Japan in September 1970; while Exar started up last April 30 after getting a satisfactory financial commitment from Toyo.

Moreover, such moves by Japanese companies are likely to be spurred by the 10% import surcharge and the upward movement of the yen caused by President Nixon's new economic policy. That game plan produced "Nixon shock" among Japan's electronics firms, (see p. 119).

James Imai, president of Imai Marketing Associates Inc., Sunnyvale, says that before the Administration's Aug. 15 move, interest in setting up in America was only moderate. "But now," he says, "the difference is like night and day. Now instead of just doing business with the U.S. it may be more reasonable to set up a company in the U.S."

What's more, he adds, the Japanese interest in overseas joint ventures may not be limited to the U.S. For calculator manufacturers, he points out, the labor content is continually decreasing while for labor-intensive operations, the advantage of offshore assembly is being offset by import tariffs. Japanese companies are realizing that the solution is to manufacture a product with labor and parts coming from the country where the end product will be sold. Thus Japanese firms will be looking for joint ventures in Europe expanding into much broader multinational companies, says Imai.

The Japanese electronics companies, he adds, can succeed in the U.S. if they make sure that Americans are actively involved in the business. Most Japanese electronics companies, says Imai, don't know how to do business in the U.S., and so when Sony and Matsushita (Panasonic) set up American sales organizations, they hired Americans to work in an American environment. Toshiba and Hitachi, however, sent Japanese nationals to run their U.S. sales offices, and it didn't work as well, as evidenced, says Imai, by comparing the U.S. market penetration of the four companies.

California, here we come. The Japanese commercial electronics activity in the U.S. centers about the three California firms. Datapet is an acronym for Data Phone Equipment and Terminals, illustrating the firm's marketing goals. William F. Sauers, a former executive at the Autonetics division of North American Rockwell Corp., Anaheim, Calif., and now Datapet's president, agrees with the adage that "you either cross another nation's borders with trade or with armies." He'd rather do it through the trade route, he says.

Omron systems is headed by Bernard Jacobs, past director of research and development at General Instrument Corp., Hicksville, N.Y., who says he predicted the trend toward multinational companies eight years ago. Omron Systems is in the calculator business, but is expanding into data processing and other digital systems. Omron R&D is the U.S. arm of Omron Tateisi, and will market such products in the U.S. as dollar-bill changers, turnstiles, and credit card, banking, and traffic control systems.

Markets. Exar makes liner integrated circuits for the speech and data communications market in this country, and is designing some devices for Toyo that will be used in Japanese home entertainment equipment. Exar's president, S. Paul Davis, comes from Signetics Corp., Sunnyvale, Calif., and characterizes himself as "mostly a manufacturing manager kind of guy."

Of the three firms, Omron is the only one that's been in business long enough to have a delivery and sales history. Last April, Jacobs says, Omron shipped "well over 100,000 calculators" from both its Japanese and Mountain View facilities, and adds that sales are running at a rate of $1 million a month now. He expects the firm to do "considerably better" next year.

Datapet's business plan calls for sales of $1 million the first year, $4 million the second, and $12 million in its third year. And for his part,

Exar's Davis says his firm's outlook is based on making linear ICs to capture an initial 5% of a potential $6 million business in speech and data communications devices. This figure was turned up in a survey of 15 companies that will use such circuits.

Better yields. "It's a hell of an asset to get Japanese labor involved with your products," says Davis. "U.S. firms may be able to meet Mil-M-38510 and Mil-Std 883, but they're still unsophisticated. Where U.S. wafer probe yields would be 20% to 30%, we're getting 50% to 70% with the circuits that are being made in Japan."

Exar's plan is to make linear-ICs for a range of speech and data communications products, ranging from modems to repeater amplifiers, as well as paging and public-address amplifiers for U.S. consumption. Also included will be the parts for home-entertainment equipment that Toyo will sell in Japan.

At Datapet, Sauers says Sharp is a "substantial" stockholder in the firm. Both companies intend to maintain their equity relationship even after Sharp begins to infuse further funds into Datapet through contracts. T. Mitsutomi, executive vice president, says Datapet's objective is to supply Sharp with a high-technology base in data communications at a low price; the vehicle will be exploitation of fast-moving technologies like MOS/LSI.

"Sharp has enormous manufacturing and design know-how in electronic calculators, scientific calculators, and terminals," says Mitsutomi, who is American. "So we want to combine the forces of the two companies in data communications systems and terminals that tie in with such systems."

Datapet will provide the prototype and low-volume production of such products where needed, and will market the products in the U.S. and Canada, but Sharp will do all of the high-volume manufacturing that's required in Japan. Sauers says Sharp wants to diversify its industrial products group beyond its calculator lines—into electronic cash registers, electronic scales, printers, copiers, and credit-authorization terminals. "They feel they need U.S. know-how and systems engineering capability," Sauers notes, "because the first big market for these products is in the U.S."

Americanization of Sharp. One of Datapet's functions will be to Americanize these products. Another will be to bid on opportunities that bring Datapet's remote terminal data communications expertise (a goodly number of the firm's 14 present employees come from Autonetics) to bear. Datapet has bid on two such jobs. One would use the Autonetics-developed embossed card reader and associated modems in a system that would provide automatic dial-in to a central computer. Still another proposal of the company, a terminal to be used in warehouse inventory and stock control, has been submitted to "one of the largest time-sharing systems," Sauers says.

Datapet also will pick another U.S. affiliate to jointly acquire a large national system and a software, marketing, and service organization to handle products that Sharp Electronics Corp. of New Jersey doesn't sell in this country. Sauers believes Datapet will need a 20% price advantage over established U.S. firms such as NCR and Sweda to successfully market Sharp's electronic cash registers in this country.

"Before the Nixon shock, it would have been fairly easy," he says, but he's not giving up on it. Because Sharp has worldwide joint ventures, notes Sauers, it will be looking for the lowest-cost manufacturing it can find.

Omron Systems' Jacobs says that Omron machines on the American market were formerly being built in Japan with Japanese parts, except for the LSI arrays, "but we are switching over to all U.S. parts and labor. For the Japanese market, we will assemble in Japan with Japanese parts and labor, and we are setting up an operation in Mexico, too." He also adds that Omron Systems is turning out 35,000 of the lower-priced ($175 to $200) calculators a month for such companies as Commodore and Unicom, among several others.

Small profile. The Japanese attitude about doing business abroad, Jacobs says, is that "you do it with direct participation of local people; you must maintain a small-business image in a foreign market." Japanese companies have tended to do business abroad as a block; Jacobs thinks this is the only way to go in a foreign market, and he says American firms will have to learn to participate in foreign markets that way. He maintains it's a trend that points very clearly toward how international business will be conducted in the future. □

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Commercial electronics

Electronics in the driver's seat

Bendix's new test track brings electronically controlled urban transport systems that much closer for the crowded cities of the U.S.

by Alfred Rosenblatt, New York bureau manager

By leaving the driving to nobody, Bendix expects to be one up on the testing of urban transit vehicles of the future under actual operating conditions. By next January, they will have completed the first full-scale, computer-run track—covering 15 acres—devoted to checking the electronic guidance and controls of urban transit systems now being developed.

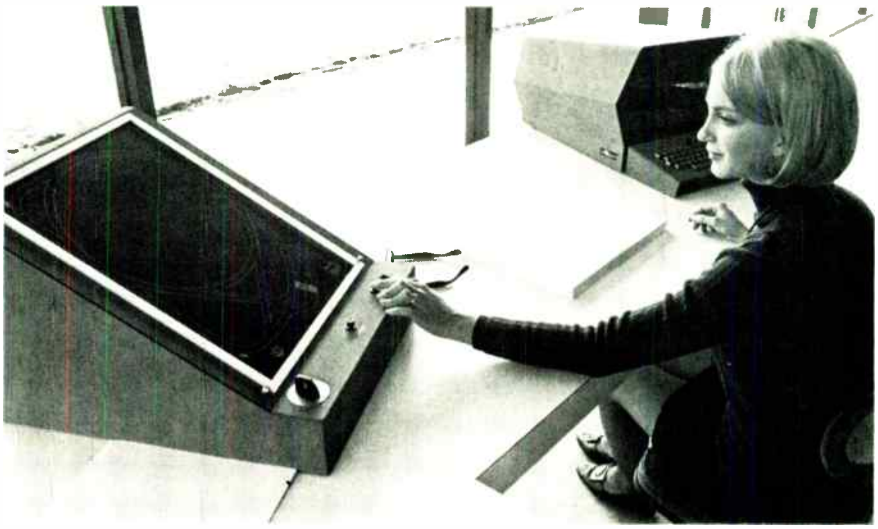
More than $10 billion over the next dozen years has been earmarked by the Federal government for urban transit. And much of the money will go for unmanned, electronically controlled cars. Until now, engineers have used computer models or model-railroad-type systems to check out electronic systems for driverless transit vehicles. But to test vehicles under the real operating conditions they will encounter, Bendix Corp.'s Aerospace division in Ann Arbor, Mich., decided to build as true-to-life a test set-up as possible.

"This is the first full-scale model that routes cars automatically through the use of a centralized computer," says Ralph Mason, marketing manager for Bendix' transportation department. The approach allows realistic examination of the problems imposed by weather, vibration, and electrical noise. Test cars can be programed to maintain a safe distance from each other and be switched on and off the track. Merging and de-merging, accelerating, braking and cruising automatically from station to station can be not only calculated but witnessed.

The test facility is not built for any particular vehicle propulsion or tracking system. When the track opens, three, small Swedish-built utility vans, with battery-powered dc motors replacing the original engines, will be used to check controls that can be applied to just about any of the wheeled, air-cushioned, and duo- and monorailed vehicles being designed for people mover, personal rapid transit, mass transit, and intercity railroad systems. Vehicles in such systems may carry as few as a half dozen passengers—as in a personal rapid transit car that moves directly to a commanded destination—or more than 100 passengers in mass transit and railroad systems serving stations on a specified route.

Underground. On the Bendix track, vehicles will move under electronic control from communications loops buried in the roadbed. The track itself consists of a main, circular guideway about 300 feet in diameter that is joined by several feeder lanes. A vehicle passing over every portion of the track once would travel about one mile. The track also has the equivalent of three "passenger stations."

Bendix's control scheme will maintain 10-second (later on, 5-second) headways, or spacing between vehicles travelling at top speed of 30 mph. Signals are fed to and from the vehicles, over a pair of parallel



Where's the bus? Two antennas on the front bumper help keep the vehicle (at right) centered on Bendix's test track. Its position is shown continuously in the central station on a mimic panel displaying the track's outline (below).

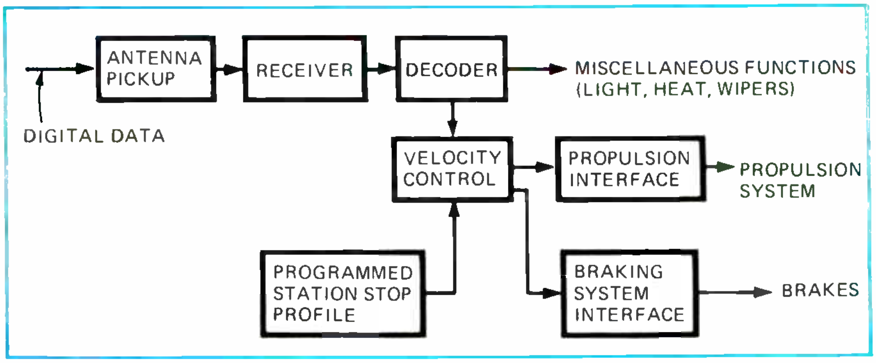
wires buried 2 feet apart in the roadbed. These wires cross over each other every 25 ft in the mainline section of the track, and every 12.5 ft in the sharper curves where the maximum speed is limited to 15 mph. By counting the crossovers, at which the magnetic field drops to zero, each vehicle monitors its position and transmits the information to the central computer over a frequency-shift-keyed 96-kilohertz carrier signal. In the reverse direction, the computer uses a similar carrier at 145 kHz.

Signals sent from the computer and from the vehicles are separated in "wayside communicators" around the track. These units amplify the signals from the vehicles and transmit the command signals into the buried communications loops.

The Bendix track also is outfitted with an independent backup that will keep the vehicles safely separated and the track operating should the primary crossover-counting system fail. This backup uses magnetometers to sense the vehicles' location. Each magnetometer—spaced in blocks 100 feet apart in the 30 mph zones and as close together as eight feet in the slower speed zones—is hardwired back to the central computer. The computer is programed to allow minimum headways of five seconds between vehicles in the backup mode, with a minimum of one open block spacing between them. If this one-block spacing requirement is violated, the FSK communications carrier going to the vehicles is removed and the vehicles are braked to a halt.

The message format consists of a 16-bit word followed by its complement and including three bits for identification. Data rate is 4,800 bits per second, and each vehicle can receive up to four commands per second. Typical commands direct a vehicle to start, brake, proceed to a particular station, maintain velocity levels at anywhere from 25% to 110% of the maximum speed, and turn its lights, air conditioning and windshield wipers on or off.

Station command. Vehicle destinations are dictated by the central computer, and the commands are stored by the cars. In a future modification, destinations may also be entered from pushbuttons on a special passenger input unit in the vehicle cabin. To prevent information blackouts as the vehicle passes over the zero-field crossovers, two pairs of receiving and transmitting coils are used—one pair mounted at the front, the other at the rear of the vehicle.



Vehicle control. Coded digital commands sent from the central computer on a 145-kHz carrier are received by the electronics on the vehicle, decoded and used to control speed

The central station computer used by Bendix is a Digital Equipment Corp. PDP-11/20, a machine "nicely adaptable to real-time control," points out Stewart McMillan, manager of the transportation laboratory. This computer also has "respectable memory storage capacity," he adds. The 12,000 words it has now can be expanded to 32,000 words.

Lateral guidance. A vehicle is kept on track and prevented from wandering from side to side by two coils that are mounted on its bumper, about 15 inches to each side of the center line. These coils sense current flowing in a third wire, also buried in the center of the roadbed. The magnetic field created by current in this wire induces a voltage in each coil. A servo system then steers the vehicle to keep these voltages equal.

To route a vehicle to various points, sections of the guidance wire are driven by one of two oscillators. At junction points, the vehicle is commanded to seek a particular frequency and, in so doing, switches off onto its new path. A slight overlap of the two frequencies insures guidance will continue smoothly after a switching command is received.

When the vehicle must stop at a station, a special tone is transmitted, and the vehicle slows down with a predetermined velocity profile. This profile is now stored in a diode matrix, but in a production system would be stored in a solid-state read-only memory, says McMillan.

During deceleration, an odometer on the vehicle produces a pulse every 9 inches. A comparison is then made between the actual velocity and that stored in the memory. By controlling the propulsion and the dynamic braking on the vehicle, the two velocity values are matched as closely as possible. The aim is for a vehicle to stop within 6 inches at a station. In a full-fledged people mover, Mason hopes passengers will be given the impression that they are riding not in cars without drivers but in horizontal elevators, because "people are used to elevators, not to driverless cars."

When a vehicle is running at its commanded speed, its velocity is always checked against the commanded velocity by counting the time intervals between the zero-magnetic-field points of the buried communications wires, McMillan explains. However, below speeds of five miles per hours, the crossover wire counting method becomes too inaccurate, and the system relies on a tachometer.

No special effort has yet been made to compress the electronics into as small a volume as possible. It presently takes up bulky racks in the front and rear seats of the vehicles. But once in production, medium-scale integrated circuitry should be sufficient to scale everything down to a reasonable size, says McMillan. Cost of production electronics is estimated at between $5,000 and $8,000 per vehicle. □

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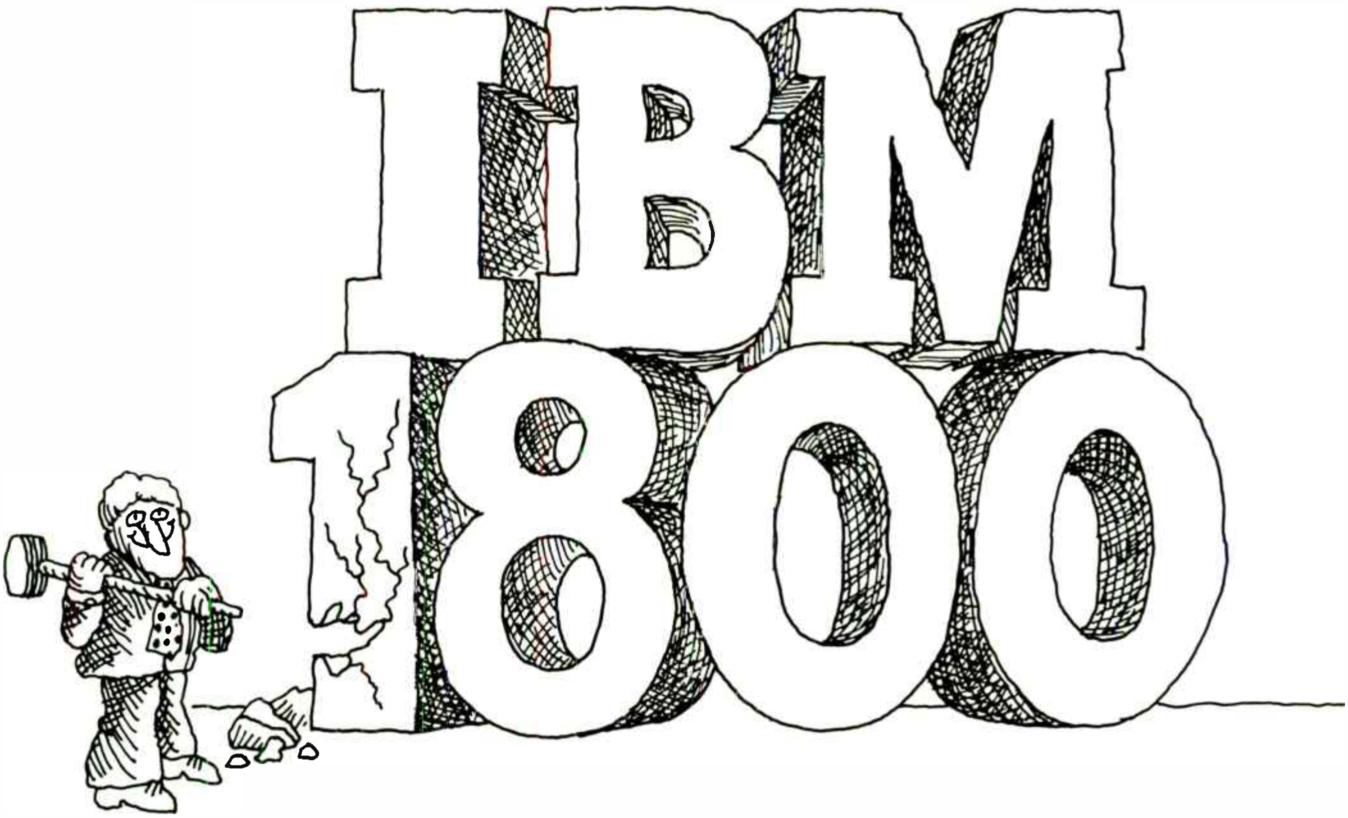

Manpower

Will it be: 'Thank God it's Thursday'?

Electronics firms are among the vanguard of companies switching over to the four-day work week; they find morale and production up, absenteeism down

by Marilyn Offenheiser, New York staff

The latest tradeoff in the electronics industries is one less workday per week in return for higher profits and productivity. That's the goal of an increasing number of electronics firms that are looking into the 10-hour-per-day, four-day week. Those that have tried it find that both the relative efficiency of their workers and their drawing power for recruitment have improved.

Electronics firms recently making the switch include Smith Kline Instruments Inc., Palo Alto, Calif.; Weinschel Engineering Co., Gaithersburg, Md.; and Hugle Industries, Sunnyvale, Calif. And according to John Morgan, labor resources consultant for General Electric Co., New York City, that company is studying 4/40 mainly with recruitment in mind.

All kinds and sizes. Kenneth Wheeler, president of Wheeler Associates, a management consulting firm in Lowell, Mass., calculates that of the 800 to 1,000 companies on 4/40, about 20 are electronics firms—from sophisticated R&D houses to assembly-line operations, and from small 40-people "shops" to those employing 400 or 500.

"It's only a question of time," says Wheeler of 4/40's prospects. "When a large company gets in, there will be a domino effect to compete for labor." And William Standring Jr., vice president at Hugle, calls it a "trend of the future."

However, the negative comments are equally emphatic, ranging from "it's a fad" to "poor economics." Doug Anderson, senior consultant at Arthur D. Little Inc., management consultants in Cambridge, Mass, says, "The system can create too much overtime which raises labor costs, making it too difficult to meet foreign competition."

Productivity is higher. Nonetheless, those electronics firms on 4/40 have found that productivity and quality sometimes increased, but never fell. And though a poll of managers indicated fatigue was a problem at first, workers quickly adjusted to the longer day and complaints stopped.

Weinschel's personnel director, Richard Hoffman, feels efficiency always tends to fall off near quitting time no matter how long the day. Adds Wheeler, "Production does tend to go down in the ninth and tenth hours, but this is more than made up for by continuity in work flow, and 20% savings on startup and shutdown time as well as coffee and lunch breaks."

Few companies approach 4/40 in exactly the same way. In some cases, employees work Monday through Thursday; in others, the days are staggered. At Hugle, workers and technicians report for 10 hours on Monday through Thursday while management and secretaries work nine hours on those days and four hours on Friday morning.

The reasons for going on 4/40—and those for not going on—vary, too. Warwick Electronics Inc., Chicago, is studying 4/40 but does not expect to convert, if at all, until after the recession is over and the labor market loosens. But at Weinschel, the switch was made at employee request; as Hoffman puts it, happy workers are productive workers.

EEs bring up the rear. In general, though, engineers are lagging behind production workers in getting on the system. At Weinschel, for example, EEs are not on 4/40, but personnel director Hoffman sees no reason why they shouldn't; their work is production-oriented anyway, he feels. At Smith Kline, assembly-line people went on the system first, and now EEs are also included. However, other managers feel engineers should not be paid by the clock.

Of course, 4/40 is not without its problems. So far, most of the companies implementing the program are small; larger firms find it difficult to coordinate 4/40. Customer requirements are also germane—Xerox Data Systems Inc., El Segundo, Calif., says it cannot make the change since it is geared to clients still on a five-day schedule.

Overtime hurts. Another significant deterrent is the Walsh-Healey Public Contracts Act, which requires time-and-a-half pay for work beyond eight hours per day if the firm has Government contracts. Some companies, such as Motorola Communications Inc., Chicago, and Microwave Associates Inc., Burlington, Mass., are holding off because these provisions would prove too costly under 4/40. But on the other hand, the premium pay situation also can cause a drop in tardiness and absenteeism. At Smith Kline, "If a worker misses a day," says personnel director Thomas Lowden, "he loses 25% of his weekly salary rather than 20%, and since the last two hours are on time and a half, a late worker misses a greater portion of pay."

Lowden says that 4/40 employees are "enthusiastic about the program." And Hugle's Standring cites "improvement of employee morale," and that's the essential first step toward greater productivity. □

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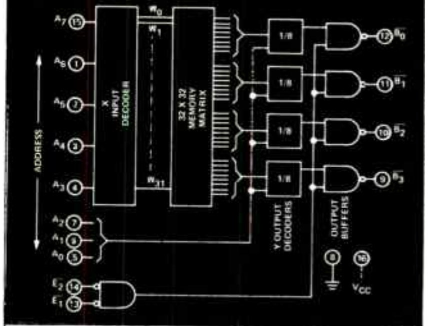

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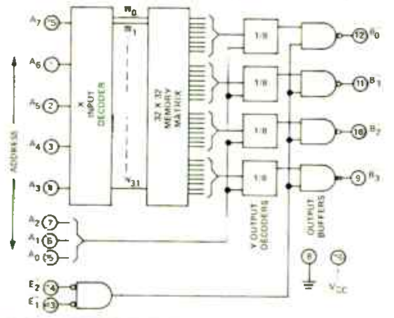

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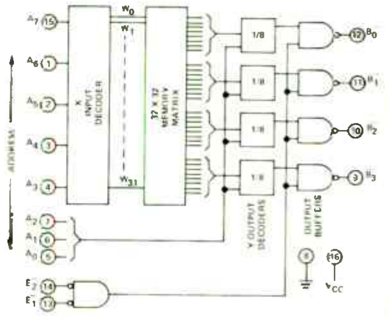

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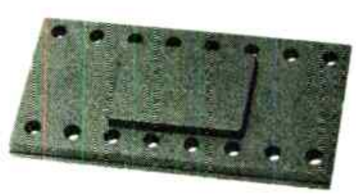

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H-P broadens its computer role with multimode machine

System/3000 runs real-time, batch, and time-shared jobs simultaneously; is aimed at school, instrument markets

A move into the small-scale computer market from a minicomputer base is a giant step. Hewlett-Packard took four years to complete that move, announced formally last week at the Fall Joint Computer Conference with the introduction of the System/3000.

H-P has two primary marketing targets in mind for the disk-based general-purpose system: automated instrumentation networks, a logical extension of the company's basic field; and computer-aided instruction, which the company sees moving into a new era of substantial Federal funding. Marketing officials expect first-year sales to be split 50-50 between education and instrument applications.

Technically, too, H-P sees the advent of the System/3000 as a giant step. "It's the first small-scale computer system with true multiprograming and multilingual capabilities," says Robert T. Bond, planning manager for the Data Products group in Cupertino, Calif.

The system, which contains new peripherals and a mainframe with a completely new architecture, can simultaneously handle real-time requirements, like those of automatic testing systems, time-shared computer terminals like those used in computer-aided instruction, and batch operations in data processing or administrative tasks.

In designing the System/3000, Bond says, "We took three hardware specialists and three software specialists, and tried to evolve a system, not just a new piece of hardware with some modified software. The result is a stack architecture similar to Burroughs but with some concessions." It allows dynamic allocation of resources and provides for concurrent input-output and CPU operation. Central processor hardware provides inherent re-entrant code, relative addressing, memory protection, and virtual memory through variable-length code segmentation. The addressing flexibility provided by the hardware stack design of the central processor makes possible a very large instruction set—170 instructions—which includes hardware floating-point operations as a standard feature.

These 170 instructions are contained in a microprocessor based on a large-scale IC read-only memory, with an instruction time of 175 nanoseconds. The ROMs are 256-by-4 Tri-state bipolar devices. The system can accommodate up to four independent main core momory modules with a combined capacity of 131,000 bytes. A high-speed data path provides for a system data rate of up to 2.85 million words per second among system modules.

Plug-in boards enable the user to expand the core memory capacity from 32,000 to 131,000 bytes in increments of 16,000 bytes. For mass storage, disk files now available

Multilingual. A new architectural approach to design of small central processors enables System/3000 to handle three modes simultaneously, each in more than one language.

from H-P range in capacity from 5 million to 50 million bytes, with data transfer rates of up to 250,000 bytes per second. On-line storage can be expanded to more than 1 billion bytes, and for greater system performance, new high speed H-P swapping disk files are available that can store up to 4 million bytes with average access time of only 8.7 milliseconds and a data transfer rate of 470,000 bytes per second.

High-level language. According to Bond, "an important key to System/3000's abilities is the H-P-developed SPL/3000, a high-level system programing language, which allows programs to be encoded three to six times faster than with traditional assembly languages." He says that H-P was able to reduce software development time by a factor of five, using SPL/3000 exclusively. The computer has a comprehensive file management system to simplify file usage.

In addition to SPL/3000, H-P will offer a new version of Fortran IV and Basic 3000, a more powerful extension of H-P Basic, now the standard of the industry. The two languages will be provided for all operating modes.

The first System/3000 machines will have folded planar core memories for main storage. The 32-kilobyte memories are expandable in 16-kilobyte increments to a maximum of 131 kilobytes. The company plans to add semiconductor memory modules next year. Among possibilities, system designers are looking at the n-channel MOS memories being made for H-P's new calculator.

Presently, System/3000 software includes text editing and formatting, statistical analysis, system diagnosis, flowcharting, and user-program diagnosis. Complete system software will be demonstrated at the factory in the spring of 1972. Deliveries are scheduled to begin in the fall of 1972.

Prices will range from about $100,000 to $300,000 depending on system configuration. Leasing prices will start at $2,000 per month.

Hewlett-Packard Co., 1501 Page Mill Road, Palo Alto, Calif. 94304 [338]

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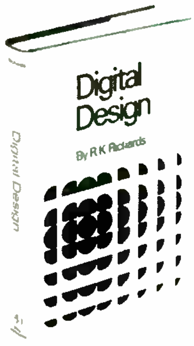

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By W. Gosling, W. G. Townsend, and J. Watson, *all of University College of Swansea, Wales*

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By Arpad Barna, *University of Hawaii*

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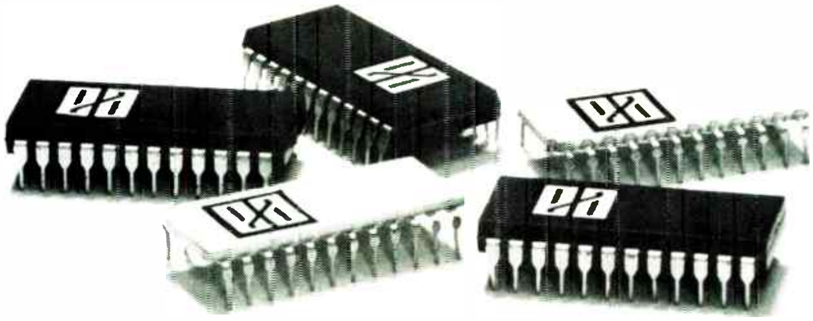

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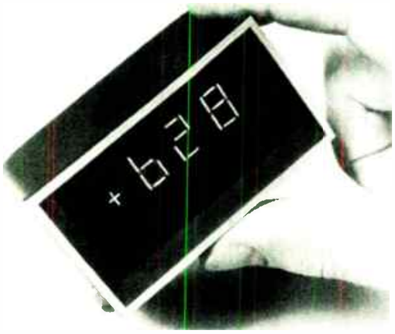
Instruments

Meter is small in size, price

Panel-type readout offers 3½ digits, 5-V operation, and accuracy of 0.05%

There are already about 30 makers of digital panel meters, but that did not stop a module supplier—Analog Devices Inc.—from moving into the business.

"We feel we have the right product at the right time," says Ray Stata, president. "Our model AD2001 is the smallest currently available digital panel meter, and it offers the best performance at the lowest price." With its latest activity, Analog hopes "to make the digital panel meter a true component, not the pseudo-instrument it is today."



The AD2001 is priced at $89 in 100-lot quantities and $135 singly. It measures a mere 1-¾ inches high by 3 in. wide by 1-½ in. deep, and needs only a 5-volt supply, such as is used to power integrated circuits. Moreover, this little 3-½-digit DPM provides an accuracy of 0.05% of reading, ± 1 digit.

Autopolarity, a BCD output that is compatible with both TTL and DTL circuits, and out-of-scale indication are standard features. The AD2001 also responds to computer commands to either take or hold a voltage reading. Full-scale range is 199.9 millivolts. And bias current is less than 1 nanoampere, with an input impedance of 1,000 megohms.

A novel circuit approach called Analok is responsible for the new DPM's high stability (50 ppm/°C) and accuracy. Analok, according to Analog Devices, locks out the sources of meter drift while locking in meter accuracy. Errors that affect resolution and accuracy are due principally to offset voltages and currents in the integrator and comparator sections of a DPM's dual-slope analog-to-digital converter.

The analog portion of the AD2001's converter includes a stabilizing network. An input signal is first filtered to improve meter normal-mode rejection. An analog switching network then accepts the filtered input as well as correction signals from the stabilization network. The correction signals are derived from offset errors at the comparator output.

Analok also allows the new DPM to handle bipolar inputs without using a dc-to-dc converter, as other meters usually do. The input reference level is removed from ground by operating with the integrator and comparator converter sections at plus and minus levels with respect to the reference. Level shift is accomplished with analog switching and stabilizing networks.

Another significant feature of the AD2001 is its very bright display (4,000 foot-lamberts); RCA Numitron tubes are used for the readout. Within a year, Analog intends to round out its new 8 DPM line with 2½-digit, 4½-digit, differential, and isolated units.

Analog says the AD2001 is suited to a wide variety of applications because of its automatic polarity indication, resolution, TTL-compatibility, and numerous control signals. Among them: voltage and current measurement, and instrumentation.

Analog Devices Inc., Route 1 Industrial Park, Norwood, Mass. 02062 [351]

Reflectometer includes high-resolution recorder

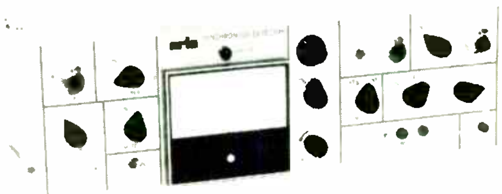
A time-domain reflectometer system that is battery or ac operated is for CATV applications. The model 1501 has a plug-in recorder; high-resolution recordings of 4 by 25 cm can be made at the touch of a button. The unit displays signals on an oscilloscope screen, or on graphs directly without an oscilloscope. The 1501 is suitable for quantitative analysis

and fault location. Its step pulse rise time is 1.3 nanoseconds, amplitude 1 volt. The 1501 can be used out to 10,000 feet. Price is $1,900 for the reflectometer alone, and $2,950 with the 323 oscilloscope.

Tektronix Inc., P.O. Box 500, Beaverton, Ore. 97005 [353]

Phase-sensitive detector's input amplifier is wideband

A digitally derived square wave reference oscillator output with a linear phase-adjustment control is provided in the model ESE3000 phase-sensitive detector. The input amplifier is wideband so that Q adjustment and frequency trim controls are not needed. All Fourier components in a square wave are



detected with their appropriate weighting.

For most operating conditions the phase-sensitive detector has a 100-dB peak noise/minimum detectable signal ratio.

The amplifier-detector unit and

oscillator are decoupled from each other and isolated from the chassis ground.

Advanced Research Instrument Systems
6500 Tracor Lane
Austin, Tex. 78721 [356]

Potentiometric recorders have 3-second response

A line of 10-inch chart recorders that provide response time of less than 0.3 second have a one-moving-element linear servo motor and a

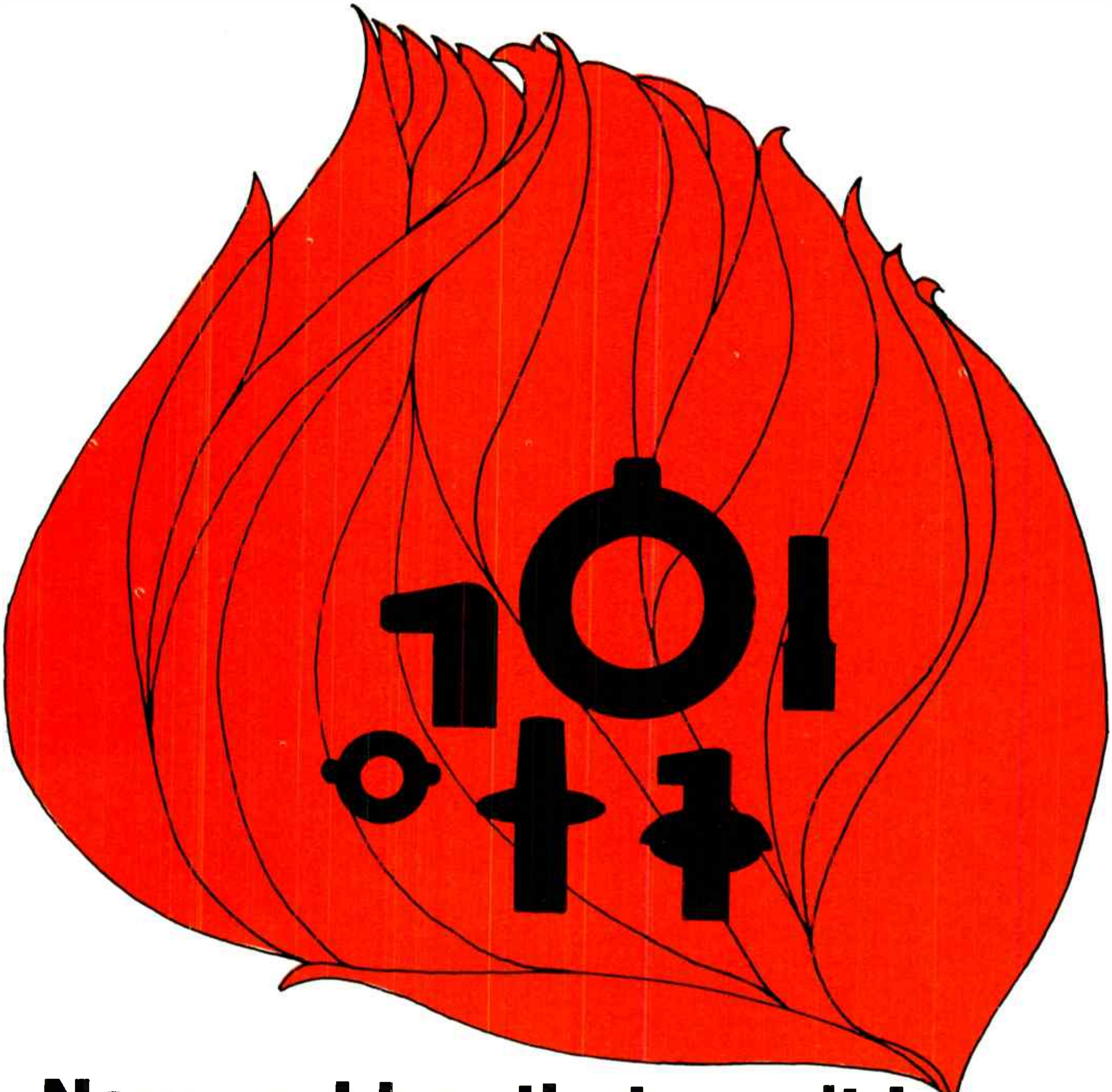
disposable unitized pen-and-ink system in single- or two-pen crossover models. Units of the Speed Servo 2 recorder line have up to 10 chart speeds, and optional metric speeds. Prices start under $1,000.

Esterline Angus Division of Esterline Corp., Box 24000, Indianapolis, Ind. 46224 [354]

Radiometer combines amplifier, electrometer

Measurement of irradiation is performed by a lock-in amplifier/dc electrometer system called the Irradiscan 900. Dial settings and readouts are directly calibrated in the

units of interest. Operation in the two basic modes is selectable by a single front panel switch. An analog recorder output and a 3½-digit bi-



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Here's news about an important break-through for designers of products in which consumer protection or industrial safety are of utmost importance: Depending upon part size and performance requirements, Stalwart now offers rubber parts that either will not support combustion at all or will self-extinguish in as little as two seconds after the source of the fire has been removed. This snuff-out rate is many times superior to other so-called fire-retardant elastomers. Stalwart fire-retardant custom rubber parts not only meet, but far exceed the fire resistance standards established by industry and underwriter groups. No, we do not use Formula X or other miracle ingredients. This unique capability is born of more than twenty years experience in laboratory and field research, with performance-proven results. Our customers simply specify the design and operating conditions, plus the level of fire resistance required. We select the elastomer, then compound for fire retardancy with no sacrifice of performance. Write today for the new Stalwart Rubber Selector and technical bulletins.

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nary coded decimal output are also provided. Price of the Irradiscan 900 radiometer is $3,865.

International Light Inc.
Dexter Industrial Green
Newburyport, Mass. 01950 [357]

Displacement-measuring system has 0.5% linearity

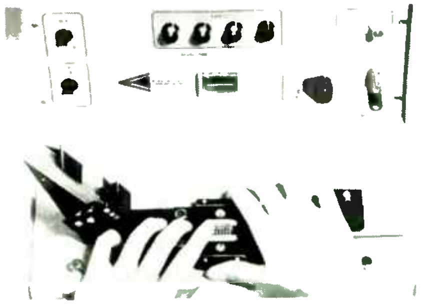
A low-cost displacement measuring system consisting of a modular signal-conditioning package and a linear variable differential transformer has a linearity of ±0.5% over a 0.200-in. displacement measuring range, operates over a temperature span of −65 to +180°F, and gives an output of ±5 v dc.

Use of hybrid circuitry permits housing the signal-conditioning components in an encapsulated package measuring 1.9 by 2.5 by 1.0 inches, making it suitable for OEM applications. The system's signal-conditioning package is available separately. Price is $75.80.

Schaevitz Engineering, P.O. Box 505,
Camden, N.J. 08101 [355]

IC test system handles 1,000 circuits per hour

Testing of all functionally specified parameters of integrated circuits is performed at a rate of 1,000 circuits per hour by the model 7000 system.



No special carriers are needed for DIPs, and shipping tubes are used for both input and output containers.

The circuits are gravity-fed, released by touch, positioned, and then they are automatically tested. Price is less than $2,000.

Electrodata Concepts Inc., 69 Connecticut Ave., Norwalk, Conn. 06854 [358]

Mark your calendar now for the 4th National Conference on Electronics in Medicine. It's coming March 27, 28, & 29, 1972, at the Conrad Hilton in Chicago.

The 4th National Conference on Electronics in Medicine is unique in its field and shouldn't be missed. It represents the only continuing effort to develop and maintain a dialogue among the medical and engineering professionals who are, and will be, responsible for the most significant advances in the application of electronics to worldwide health care.

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Conference Chairman, 4th National Conference on Electronics in Medicine
c/o Medical World News, 299 Park Avenue, New York, N.Y. 10017

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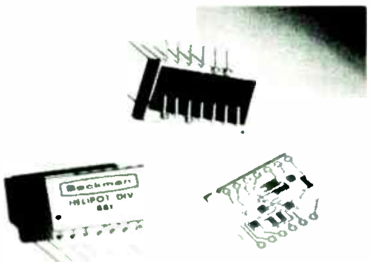
Components

Active filter has high Q

Low-cost thick film device designed as building block for variety of circuits

Universal or state-variable active filters were essentially custom devices until two companies—Varadyne Inc. and Kinetic Technology Inc.—took the first steps toward standardization.



Now, the Microcircuit Operations at Beckman Instruments Inc. is taking what it calls a further step in that direction with its model 881 state-variable active filter. It's a hybrid thick film device instead of discrete components in a potted module, and it's more flexible than previous devices, says George Smith, director of research and development.

Because of the low price ($25 for 1–9) and the standardization, Smith says the 881 will allow users to stock active filter building blocks, much as they stock operational amplifiers, and put them together in a variety of circuit configurations.

According to Smith, the model 881 has overcome the limitations in frequency range and Q that have hampered single-amplifier networks used as active filters. He looks for the unit to find widespread use in data communications modems, in which they'll select the specific frequency of interest, or in phase-locked loops—essentially any circuits or systems that require bandwidths up to 20 kilohertz.

The Beckman unit has four op amps, of which three give the three basic filter functions simultaneously—low-pass, high-pass, and bandpass—and the fourth, being uncommitted, might be used to accommodate an extra pole for odd-pole filter configurations, to sum the components in a filter, or to invert the outputs of the other poles.

The 881 can be tuned over a wide range of frequencies (practical range is 10 hertz to 10 kHz), and the practical Q range is from 0.3 to 200. "You can get the same frequency range from a single-amplifier network," Smith explains, "but not at a stable Q of 200."

The ceramic-packaged, polymer-sealed 13-pin unit has these key specifications: it can maintain 6% frequency stability from 0 to 70° C; Q is 6% initially at 25° C and 10% from O to 70°C; gain is 1.5% over that temperature range; and the model 881 runs off ± 15 volts.

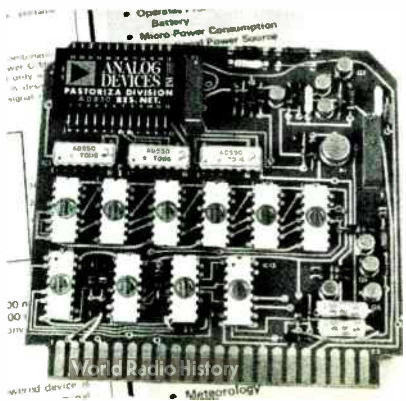
Three external resistors are required. Two establish the filter's cutoff frequency, and the third adjusts the circuit Q and therefore the sharpness of the rolloff.

screened onto the back of the substrate, and they can be trimmed to 1% tolerances, Smith says.

Microcircuit Operations, Helipot Division, Beckman Instruments Inc., 2500 Harbor Blvd., Fullerton, Calif. 92634 [341]

Micropower a-d converter needs a battery a year

Using complementary MOS logic circuits to conserve power, a 12-bit analog-to-digital converter can operate for one year from the same 15-volt battery. The unit holds its static battery drain to less than 600 microwatts and its power consumption to 7.5 milliwatts when the conversion rate is 100 hertz. Power consumption rises to 75 mW when conversion rate increases to 1 kilohertz.



Designed primarily for remote data acquisition, the device could be used on ocean buoys, earth and space probes, and in radiation monitoring devices. Another use is in highly sensitive or portable instrumentation, including medical electronic equipment.

The new converter accepts ± 10-V signals and yet runs from a single-polarity battery. It is also virtually immune to supply voltage variations. Output error is kept below ± 1 bit (0.025%) for a battery voltage drop from 15 to 12 V.

A clever circuit trick allows the unit to handle dual-polarity inputs with its single-polarity positive source [*Electronics*, March 29, p. 71]. An internal capacitor is charged to the 15-V battery level. When a conversion command is received, the voltage across the capacitor is used as the missing −15-V battery level. Since conversion time is only 85 microseconds, capacitor voltage remains relatively constant.

Some additional features include full monotonicity from 0 to 70°C, a relative accuracy of 0.01%, and a maximum conversion rate of 5 kHz.

Both serial and parallel outputs are provided for compatibility with TTL and C/MOS circuits.

Two models are available: the ADC-12QL/K, offering a temperature coefficient of 50 ppm/°C and the ADC-12QL/J, with a temperature coefficient of 20 ppm/°C. The first unit is priced at $950, and the second at $675. Delivery time is two weeks.

Analog Devices Inc., Route 1 Industrial Park, Norwood, Mass. 02062 [342]

Digital, alphanumeric units provide mixed display

For mixed-display applications, two readouts offer a ⅝-in. character height and operation on 5 volts for 7,000 foot-lamberts brightness. The Dip 1050-Digital is a seven-segment unit that can be mounted into a 14-pin dual in-line socket. The Dip

1050A-Alphanumeric is a 16-segment device for a 14-pin DIP socket.
Pinlites Div., Refac Technology Development Corp., P.O. Box 453, Caldwell, N.J. 07006 [343]

Readout, potentiometer combined in one assembly

Unlike separate digital turns-counting dials and potentiometer combinations, the model 3610 Digital Knobpot combines the readout and potentiometer into a single ⅞-in.-diameter assembly. No phasing is required because the unit is factory-phased to an accuracy of ±0.5% between electrical output and dial reading. This is the equivalent of better than ±0.5% terminal base linearity. Price is $15.30 in 500 to 999 quantities and $14.80 in 1,000 to 1,999 quantities.

Bourns Inc., 1200 Columbia Ave., Riverside, Calif. 92507 [347]

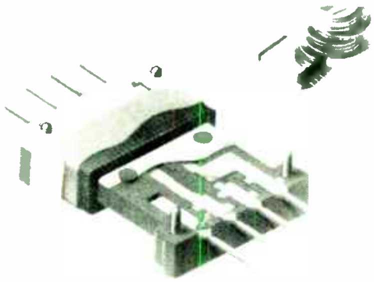
Capacitors for pc mounting offer tolerances to 0.1%

Tolerances of the type 54PX polystyrene film-foil capacitors extend to +0.1%, and they offer stability or retrace of less than 0.05%. The series is designed to maintain size uniformity for mounting primarily in printed circuit board applications. A premolded plastic case provides protection against moisture and physical abuse. Operating temperature range is from −55°C to +85°C. Applications are in oscillators, timing networks, filters, and other equipment requiring closely controlled values. The 54PX is available in capacities from 0.001 μF to 0.022 μF at 100 V dc.

Wesco Electrical Co. Inc., 27 Olive St., Greenfield, Mass. [344]

Reed relay is compatible with TTL integrated circuits

An integrated reed relay is designed to be totally compatible with TTL integrated circuits. Called the IR-, it is a magnetic reed with provisions for including an electromagnetic coil, coil termination, external pack-



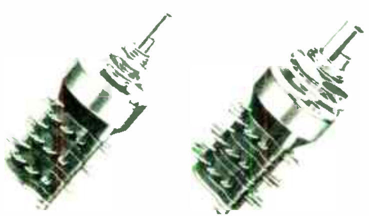
aging, and magnetic shield. Its glassless ferromagnetic contacts are sandwiched in a ceramic/glass polymer matrix.

Kam Corp., A subsidiary of Compac Engineering Inc., 845 Commercial St., San Jose, Calif. 95112 [346]

Terminals of switches are molded in position

Rotary switches in the series 71 have terminals that are molded into the switch decks, and one-piece housings are used in place of several-piece parts. The result is said to be a switch that is comparable in price to open-wafer switches but has additional environmental protection. Price is $5.10 for a one-deck switch. In 100 lots, the price drops to $3.06 each.

Grayhill Inc., 561 Hillgrove Ave., LaGrange, Ill. 60525 [348]

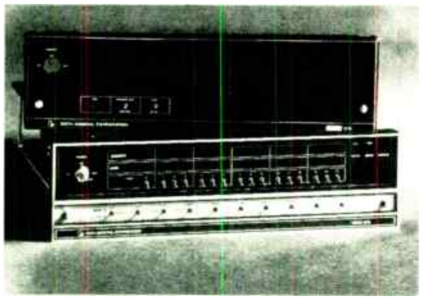


Data handling

3 Novas join mini battle

Data General also introduces 8,192-word memory card, plus ROM in main storage

In a price war, the customary tactic is to answer a low price with a lower one. But Data General Corp. has responded to the low-priced minicomputers introduced by the Digital Equipment Corp. and by Texas Instruments Inc. by pricing two of its new machines higher than either company's new minis.



DEC's PDP-11/05 [*Electronics*, Aug. 16, p.40], entered the lists at just under $5,000 each; TI's 960A [*Electronics*, Nov. 8, p.111] at $2,850. But DG's answer is three machines priced singly at $6,450 for the 820, $5,250 for the 1220, and $4,350 for the 1210. Each includes 4,096 words of core memory. The original Nova 800 sells for $6,950 and the 1200 for $5,450.

"Our sales tools will be performance, options, and discounts," says a DG official. He notes that a Nova 1210 with 4,000 words of memory (but without Teletype interface electronics) would sell in lots of 100 for about $400 less than the TI minicomputer. And a 1210 with a turnkey console, 2,000 words of memory, and no Teletype interface would run about $2,046 in lots of 100. TI quotes the $2,850 price in quantities of one to 100.

To cut production costs of the new machines, the power supply and back-panel structure have been integrated in a heavy-duty printed circuit assembly. "Everything we've been able to put on a pc board is on there, including a lot of wiring that was point-to-point on previous Novas," says a DG spokesman.

Discount schedules start fast: "About 25% below base price at 10 units," says a sales official.

Software for the machines includes Fortran, Basic, Algol, various assemblers, a real-time operating system, editor, debugging routines, math routines, a floating-point package, diagnostics, and a machine-tool programing language called Datapoint. DG does not charge for this software.

Data General also introduced for Nova-line computers a single-board, 8,192-word core memory priced at $4,100 and a 1,024 word bipolar read-only memory for $1,750. This is believed to be the first use of an electrically alterable semiconductor ROM to protect a debugged main memory [*Electronics*, Sept. 30, 1968, p. 147].

The Data General Corp., Southboro, Mass. 01772 [361]

High-resolution 2-color CRT aimed at display terminals

Resolution of color cathode ray tubes is largely determined by the spacing of the holes in the shadowmask: the closer they are, the better the picture. In a 14-inch, two-color CRT developed by GTE Sylvania, the shadowmask contains almost twice as many holes as a conventional mask. They are both smaller and rearranged in a compact pattern that reduces the spacings. Sylvania says mask resolution is improved 61% over that of entertainment-type tubes, and that the hole arrangement also increases brightness.

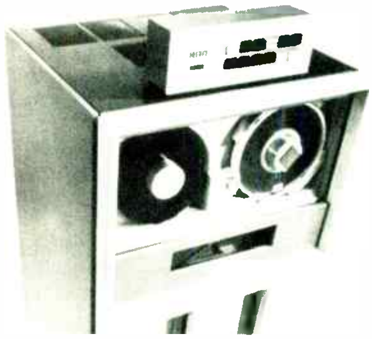
To match the capability of the two-color shadowmask, Sylvania has developed a high-resolution, electrostatically focused electron gun, two of which are mounted on the horizontal axis of the tube.

The tube, which is designated the 14VSP5110 and priced at $120 each for 100-999 quantities, is used in a two-color video monitor exhibited last week at the Fall Joint Computer Conference. Designed for computer terminals, the monitor can display 80 alphanumeric characters per line and more than 3,000 characters in a single frame of data.

GTE Sylvania Inc., 730 Third Ave., New York, N.Y. 10017 [362]

Magnetic tape transport operates at up to 200 in./s

A magnetic tape transport for the OEM market provides bidirectional tape speeds of up to 200 inches per second. The automatic-load, single-capstan device has a packing density of 1,600 bits per inch (phase-encoded) and/or 800 bits per inch (nine-track), and 800, 556, or 200 bits per inch NRZI (seven-track). Transfer rate is 320 kilobytes per



second at 200 in/s, and rewind speed is 2,400 feet of tape in 45 seconds. The model CDS 340 includes electrically operated reel/hubs, reel servo control by means of vacuum switch sensing, and in-column rewind under capstan control. Delivery time is 30 days.

Century Data Systems Inc., 1270 N. Kraemer Blvd., Anaheim, Calif. 92806 [364]

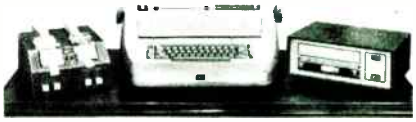
Computer system designed for factory automation

A real-time process control and data acquisition system for industrial applications is designed to operate in severe environments. Designated the IDACS 11/07, it can be either a stand-alone unit or a satellite in a hierarchical system, in which case 11/07s can be linked to each other and to medium- and large-scale computers. The 11/07 can monitor up to 256 analog or 512 digital points, and a specialized package permits it to communicate with other computers in DEC and IBM families. The system is enclosed in a steel cabinet to protect it from contaminants and extreme temperatures.

Digital Equipment Corp., Maynard, Mass. 01754 [368]

Terminal verifies data at remote locations

Automatic verification of computer-generated data at remote locations on a character-by-character basis is performed by the Holmes Tycom 35/37 Model E terminal. Applications include payroll check writing, tabulated balance sheets, purchase orders, invoicing, inventory control, and other business operations. Since the computer transmits 10-element ASCII code at 30 charac-



ters per second, the remote terminal can absorb the delay caused by the verification process and still print the data at 15 characters per second. Functions such as up-shift, down-shift, carriage return and line feed are delayed automatically by holding the verification phase.

Terminal Equipment Corp., 750 Hamburg Turnpike, Pompton Lakes, N.J. [365]

Universal programer also verifies any ROM

Interchangeable adapters permit the model 500 universal programer/verifier to program any programable ROM and to verify any semiconductor ROM. The programing is done automatically from a master ROM, an optical scanner, punched tape, or interfaced with other equipment. Data is manually entered through nine program

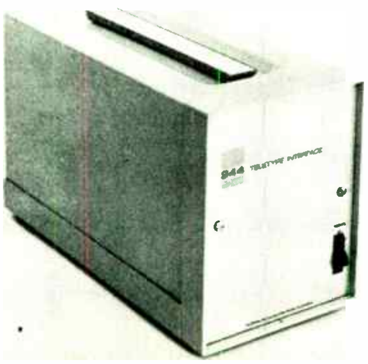
switches into a random-access memory, making it possible to set up and check an entire word before programing. Address capacity is 4,096 words, expandable to 65,536 words. Price for the basic model is $1,500, and adapters start at $360. The model 500 is modular in design, with plug-in circuit boards used throughout to facilitate service and minimize downtime.

Spectrum Dynamics, 2300 E. Oakland Park Blvd., Fort Lauderdale, Fla. 33306 [366]

Calculator can provide formatted printed output

An interface device for Tektronix's Scientist 909 and Statistician 911 calculators permits the user to format printed information and produce alphanumeric output under calculator control. The unit connects any standard Tektronix calculator to the Teletype ASR-33 without modification of either unit. The printed output exactly reproduces the display of the calculator, appearing in floating-point, fixed-point, or scientific notation and complete with sign. Price of the interface, type 944, is $1,390.

Tektronix Inc., P.O. Box 500, Beaverton, Ore. 97005 [367]



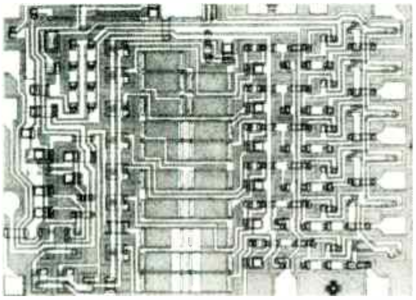
New products

Semiconductors

Converter built for flexibility

Low-priced six-bit d-a chip can be adapted to user's op amp, voltage reference

Truly monolithic digital-to-analog converters are rare and expensive. A six-bit multiplying d-a converter developed by Motorola, on the other hand, sells for $3.95 and is described as more important for what is not



included on the chip than for what is.

"We've gone to great lengths to think about that," says William Howard, product manager at Motorola's Semiconductor Products division. "We leave out some parts that others include, such as the output device—an operational amplifier— which is slow and can't take advantage of the 200-nanosecond settling time of the converter." The device is designated the MC1406L.

Howard adds that an op amp can take up considerable area if it's built into a monolithic chip, cutting into yields and boosting prices. This way, the user is free to add an op amp or not, as he wishes. Nor has Motorola included a voltage reference in the chip, because doing so would have compromised the device's temperature coefficient. By not including these components, Motorola believes it has given the user greater flexibility in applying the converter.

A typical application might be in a simple analog-to-digital converter system, in which the MC1406L would be inserted in a feedback loop to compare the input signal with the d-a converter's output. Such a system might consist of six chips in all.

"This way we give the user the flexibility of configuring his a-d converter any way he wants," Howard says, adding that the Motorola unit is still less expensive than either monolithic competitors or hybrids that perform a similar function. The unit can also be used for automatic gain control, to boost telephone line signals, for example.

Digital inputs to the converter are DTL- and TTL-compatible. Relative accuracy of the device is 0.7% maximum, and typical power dissipation is a low 95 milliwatts. Delivery is from stock.

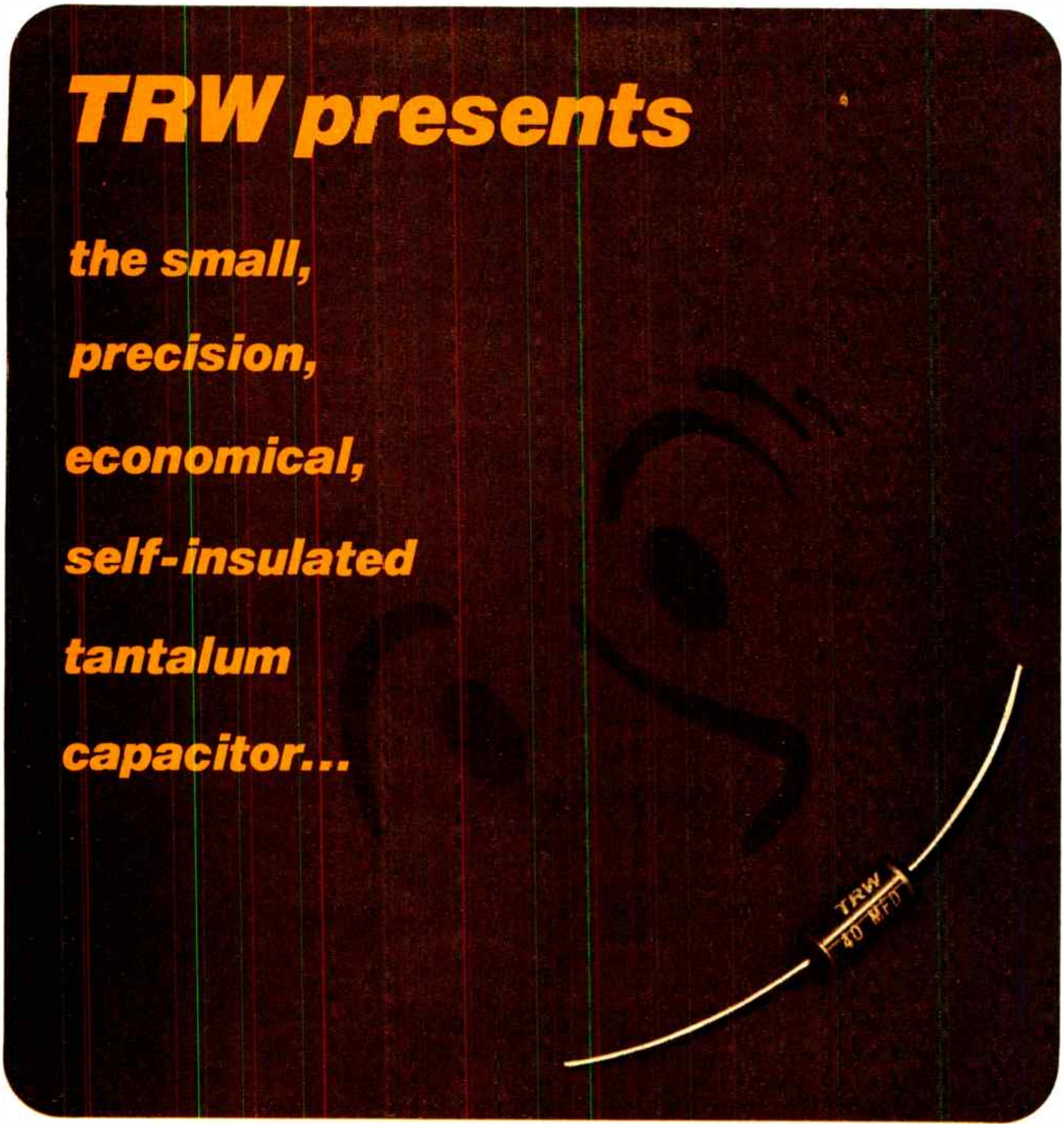
Motorola Semiconductors, Box 20912, Phoenix, Ariz. 85036 [411]

32-stage shift register uses bucket brigade technology

As far back as 1952, even before MOS, the first proposals for bucket-brigade circuits were being discussed. But the technology, which is easier still than MOS to fabricate, got bogged down in manufacturing and engineering problems. Now the first commercially available bucket brigade device, a p-channel MOS integrated circuit, has been introduced by the Amperex Electronic Corp., Cranston, R.I.

The unit, called the M31, is an analog shift register that transfers information from stage to stage, in 32 stages or "buckets," in response to timing signals. It also contains an input sampling circuit and an output follower. Since the device operates directly on the analog input signal, no analog-to-digital or digital-to-analog signal conversions are necessary.

The M31 consists of a chain of storage capacitors and charge transfer circuits, acting as the shift register, with an externally controlled shift rate. Information is stored in the array of capacitors as charge deficit rather than as charge level. This permits the use of a single transistor per storage capacitor and re-



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These are just a few of the advantages offered by the TRW Type 935 tantalum capacitor. In addition, they are remarkably inexpensive, due to the high speed molding techniques used in their production.

The versatile 935 is available from 6 through 50 volts, and from .0047 to 56 mfd. It is designed to operate from −55°C to +85°C at full rating, and up to +125°C with ⅓ derating.

For complete information and technical data, contact TRW Capacitor Division, Box 1000, Ogallala, Nebraska. Phone: (308) 284-3611. TWX: 910-620-0321.

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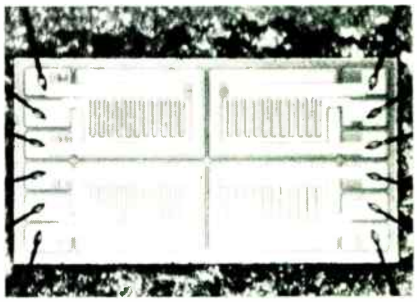
sults in less complex circuitry. And because of the absence of dc gate currents, attenuation is negligible. Applications include variable delay lines, scanning circuits, and time-axis conversion. Price in sample quantities of under 50 is $10 with delivery in from three to four weeks.

Amperex Electronic Corp., a North American Philips Co., Cranston, R.I. 02920 [413]

Quad transistor array delivers pulses up to 1 A

A high-current transistor array called the HT-6500 is intended primarily as a memory core driver, relay driver, or in similar applications requiring pulsed currents of up to 1 A at up to 50 V. The npn device consists of four transistors on a common chip, and in operation, one of the four functions at any one time. With



500-mA pulsed output current, output voltage is less than 0.5 V. In the nonconducting state, each transistor can withstand up to 70 V between the collector and emitter. Price is $9 for the military version, $5.85 for the commercial.

Harris Semiconductor, Melbourne, Fla. 32901 [414]

Dual-preamplifier IC offers gain of 68 dB per channel

Designed for stereo tape players, dictating machines and other consumer equipment, a dual-preamplifier IC for low-level signals in low-noise applications is a pin-for-pin replacement for the GE type PA239 preamplifier. Called the ULN-2126, the linear IC provides a typical gain of 68 dB per channel at a single power supply operating voltage between 10 and 24 V. The gain is defined by internal resistors rather than by external feedback. The ULN-2126 is available in the plastic 14-pin dual in-line and the plastic 14-lead quad in-line package.

Sprague Electric Co., North Adams, Mass. 01247 [416]

Reference amplifiers aimed at high-stability applications

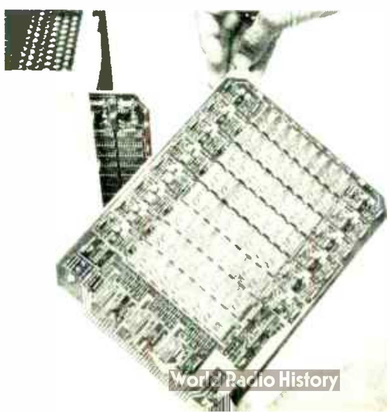
A family of reference amplifiers is for use in power supplies and precision measuring applications, including high-precision digital voltmeters. Designated CH2001-CH2004, the units provide high stability, with a temperature coefficient of refer-

ence voltage of ± 10 V, ± 50 ppm/°C and ±25V, ±100 ppm/°C. Prices start at $4.25 each in 1,000 lots.

Centralab Semiconductor, 4501 N. Arden Drive, El Monte, Calif. 91734 [417]

Modular MOS memory has cycle time of 450 ns

A self-contained memory system using 1,024-bit MOS RAMs is designed for mainframe and bulk storage applications. The in-10 system has a maximum cycle time of 450 ns and a maximum access time of 325 ns. Systems are assembled modularly, from 8- by 10-in. memory cards, each storing 4,096 18-bit words or



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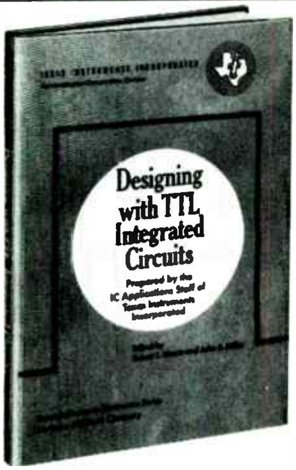

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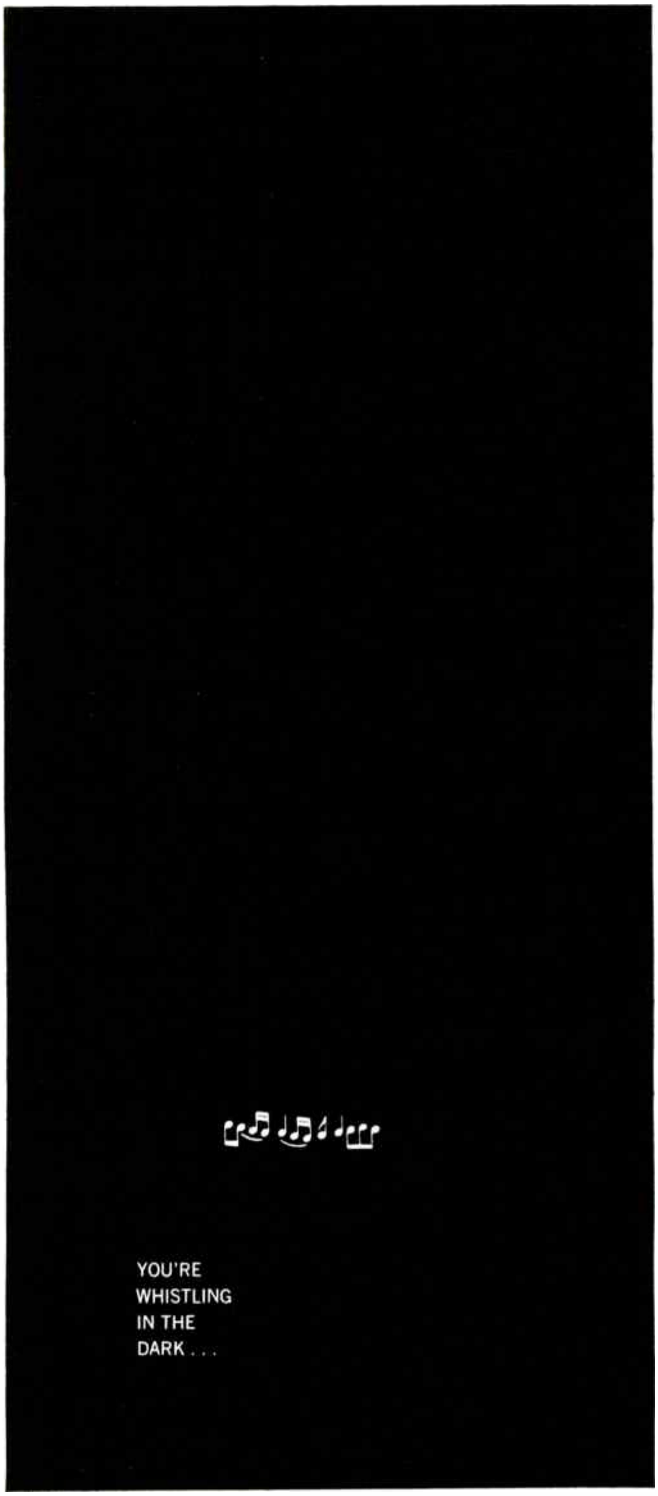

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8,192 nine-bit words. One control card serves up to eight memory cards. Price is about 1½ cents per bit for large orders.

Memory Systems, Intel Corp., 3065 Bowers Ave., Santa Clara, Calif. 95051 [415]

10 LED characters can be mounted in one square inch

Designed for use in calculators, hand-held instruments and probes, the Data-Lit 30 seven-segment LED display is only 0.125 inch high. It is housed in a 10-pin DIP with leads on 0.100-in. centers, and up to 10 of the readouts can be mounted in a square inch of space. Power dissipation is 50 mW, and continuous forward current is 80 mA maximum. Large-order price is $3.80.

Litronix Inc., 19000 Homestead Rd., Cupertino, Calif. 95014 [419]

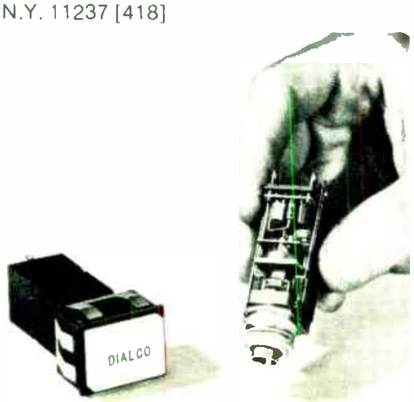
Contactless switch built for industrial environments

A light-emitting diode, photo-Darlington amplifier, and Schmitt trigger are all contained in a contactless switch that gives contamination-free operation and is specified at a minimum life of 10 million operations. The design of the pushbutton switch makes it suitable for industrial environments.

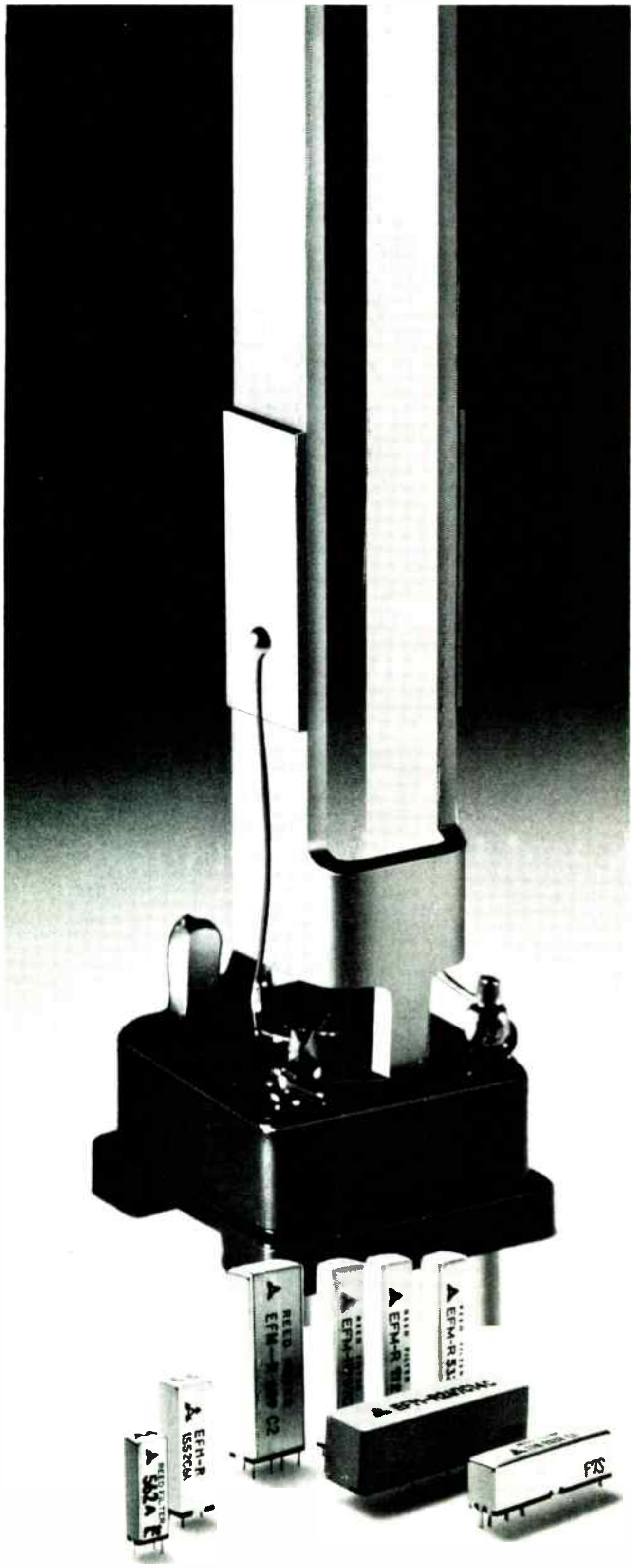
The output is an open-collector transistor that can sink 50 mA and withstand 16 V, enabling it to interface with discrete circuitry and IC logic families. Typical rise and fall times are 100 nanoseconds.

Both snap and nonsnap types are available in single-pole, single-throw and double-throw versions. Price is $6.82 each for one to nine, $4.03 in quantities of 1,000.

Dialight Corp., 60 Stewart Ave., Brooklyn, N.Y. 11237 [418]



New REED FILTERS from Panasonic pinpoint frequencies at 15 Hz intervals.

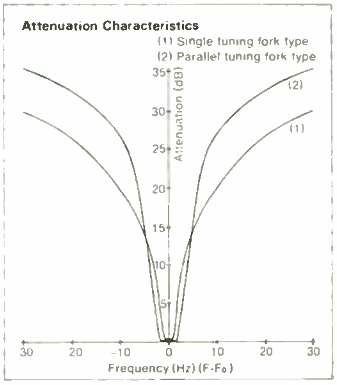


Constant bandwidth and selectivity regardless of center frequency:
Standard Panasonic Reed Filters have center frequencies between 502.5 and 1,912.5 Hz, at 15 Hz intervals. (Special types covering the 200 to 5,000 Hz range are also available.) Thanks to a new square U-shaped tuning fork, they provide the same bandwidth and high selectivity at any center frequency, and a very high Q. This permits, for instance, the design of large scale paging systems with these reed filters.

High temperature and humidity stability:
Changes in center frequency and attenuation characteristics are negligible between 14 and 140°F and after long-term operation in high humidity. This makes Panasonic Reed Filters ideal for outdoor applications such as telemetering equipment, mobile transceivers and others.

Protected against vibration, shock or aging:
Vibration and shock tests revealed only very small (0 to 0.2Hz) shifts in center frequency. Recovery took place within about ten hours. 5,000 hour continuous operation tests at room temperature and at 158°F showed practically no change in characteristics. Unlike reed selectors, Panasonic Reed Filters have no contacts. Instead we use bonded piezoelectric ceramic as electro-mechanical conversion elements.

Precision engineering in a variety of shapes and design:
Panasonic Reed Filters are extremely compact–the smallest is less than three quarters of an inch long. And any design can be supplied for any center frequency. For somewhat wider bandwidth and higher selectivity, there's a parallel tuning fork type with two forks. Available shapes are shown in the photographs below.



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Special Report

Japanese electronics firms search out new markets to pierce economic fog

U.S. economic moves and domestic snags slow up the all-important consumer sector and halve overall electronics growth for '71; the big gainers for the future will be data processing, defense/aerospace, and communications

By Arthur Erikson, Managing Editor, International, and Charles Cohen, Tokyo bureau

Contents

special REPORT

☐ It's high noon for the rising sun of Japanese industrial power. Throughout the late 1960s, the island nation, which to Westerners often seems one bewilderingly large industrial enterprise, consistently piled up yearly gains of 10% or more in its output of goods and services and catapulted into third spot among the world's industrial powers, behind the U.S. and the Soviet Union. But last year, recession started to slow that climb, and while the rising sun has yet to hit its zenith, what's in sight for this year threatens to cloud the bright light even further.

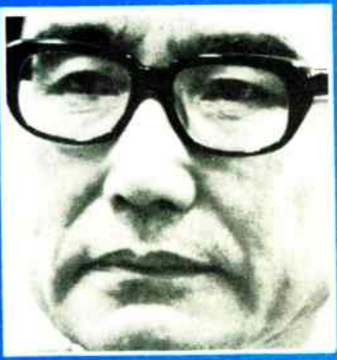
When Japan closes out its books for the 1971 fiscal year next March 31, it presumably will chalk up a total output of some $242 billion. That's more than enough to stay safely notched in the number-three ranking among industrial nations. But the $242 billion represents a rise of 5.5%, only half the growth rate the country was counting on. Just when it seemed Japan was ready to snap back from a near-year's recession, President Nixon in late summer stunned the country doubly with the import surtax and a monetary move that forced an upward shift in the exchange rate of the yen.

Growth rate halved

As a result, Japan's economists found a new term—Nixon shock—for their lexicon, and the country's electronics companies acquired a discomfiting set of conditions—a slowing market at home and a certain setback in their prime export market, the U.S. It will take some time after the yen gets a new parity and the world monetary situation settles down before Japanese companies can take a sure reading on what's ahead for them. Until then, "we are walking in a fog," says Tamefusa Onoye, an executive director of the trade association Electronic Industries Association of Japan (EIA-J).

One thing is certain: there's a stall in store for Japan's electronics production. The output of components and equipment for 1970 totted up to $9.65 billion, a hefty 25% rise over the 1969 level. This year's figure will be something on the order of $10.6 billion, judging by the figures released up to early fall by the Ministry of International Trade and Industry (MITI), the mentor and guide for kingpin industries in Japan. Those numbers work out to a drop of more than half in the electronics industry's growth rate.

Tamefusa Onoye of EIA-J says the impact of the U.S. economic program, which has slapped a 10% surcharge on imports and forced the value of the yen upward, has left Japanese electronics companies "walking in a fog." Economic moves added a new term, "Nixon shock," to the Japanese lexicon.



It's equally sure that Japan's electronics producers, who've grown accustomed to boom times, will have to narrow their horizons for the domestic market over the next year or so. *Electronics* sampled a cross-section of the country's equipment and component makers early this fall and came up with a wide assortment of views on the domestic market—but hardly any were optimistic. The sampling turned up an equipment market of $4.65 billion for 1970 and $4.99 billion for 1971. Chances are the market will move up to $5.36 billion next year, the survey showed. Until the monetary muddle clears, though, forecasting Japanese markets will be tricky. Much depends on how the Japanese fare in exports.

Whatever the market amounts to, its mainstay still will be consumer electronics. Color TV sales are booming this year, and some 60% of Japanese families now own a set. Even though this represents the beginning of saturation, and a slight slide is in sight for 1972, the set makers still will have a $1.45 billion market to romp in next year.

But the consumer sector won't provide what little growth is in store next year. Computers will shoot up 19% to $1.46 billion—not bad unless you're used to the 30% annual jumps that Japanese computer companies have enjoyed. Best off are the communications-equipment people. Premier Eisaku Sato's government is boosting its spending to counter the turndown in the economy, and a chunk of the money will go to improve the telecommunications network. Worst off are the passive-components producers. They're doubly hit by a lackluster overall market and a surge of linear integrated circuits in consumer hardware.

Consumer market grows up

For consumer electronics producers, 1970 was all too aptly characterized by the Oriental lunar calendar. It was the Year of the Dog and set makers generally found themselves out in the doghouse at year-end, consigned there largely by a consumers' strike that sent color TV sales plummeting. Manufacturers sailed into 1970 confident they'd sell at least 5 million color sets in their home market; they struggled out with a disappointing 4.8 million.

This year the trade winds are blowing consumers back into the appliance shops and department stores. That's why 1971 is shaping up as a fat year for color TV sales—about 5.6 million sets. Color TV, of course, currently is the big-money item in consumer electronics in Japan and the solid rise in color sales is carrying the consumer market to an estimated $2.44 billion this year.

But even at that total, the 1971 market is up only about 6% over 1970's $2.30 billion. That's a far cry from the giant steps set makers had been taking until they stumbled in 1970. And few in the industry see a return to the good old days of 15% and 20% annual growth before several years. When they wind up their New Year's festivities, set makers will face a fast-saturating color TV market. The tape recorder and hi-fi markets, to be sure, are still robust, but together they can barely offset the sag in color sales that seems sure for 1972. *Electronics'* survey pegs the 1972 consumer electronics market in Japan at $2.46 billion, essentially the same as this year's figure.

Although their color TV sales apparently have peaked, the major Japanese set makers by and large don't see their long-term outlook as particularly bleak. Flourishing a poster-size set of market charts, Noboru Yoshii, a managing director of Sony Corp., asserts, "By 1975, we'll have a need for 6 million color sets every year in Japan."

Next big item: VTRs

The company has high hopes that video recorders will mushroom into a mass market. "Our next big objective," Yoshii says, "is a complete video player system, from a dubbing machine to produce the tapes through to a consumer VTR player." Sony's first bid to start a consumer market for VTRs came late this summer when it set retail prices of $720 for a playback-only version and $1,060 for the play-record unit.

Sony will have plenty of native company in its quest. At least a dozen of the most powerful Japanese electronics producers have VTRs on the market or close to it. Hitachi Ltd., Matsushita Electric Industrial Co., Mitsubishi Electric Corp., and Tokyo Shibaura Electric Co. (Toshiba) have both VTRs and Columbia Broadcasting System's Electronic Video Recording (EVR) in mind. Hideo Abe, assistant general manager for consumer products at Hitachi, expects the market for what he calls "video packages" will start coming along strong in two or three years.

Like many executives at consumer electronics companies, Abe isn't unduly concerned over the lack of a single standard for video playback equipment, with cassette VTR, EVR, and other systems still in the running. "To a large extent," he says, "the growth of video-package sales will depend on the growth of available software." Concurs Sony's Yoshii, "Interchangeability is not the overriding question, the key is getting the concept of video players across to the public."

So far, little has gotten across. This year's sales of consumer VTRs amount to a scant $12.1 million, according to *Electronics'* survey. In 1972 they'll spurt about 50%, but even then will reach only an estimated level of $18.2 million. For several years, then, set makers will have to find most of their sustenance in a saturating, increasingly competitive market for color television sets.

New customers: new equipment

The market will start to polarize in 1972, figures Teiichi Asabe, head of TV development at Sharp Corp. His reasoning: next year a new class of customers, blue-collar workers whose household budgets run between $120 and $240 a month, will be coming into the market. In Japan, practically every one who works collects a substantial bonus twice a year and so there's no question of where the cash for a down payment—or even an outright buy—is coming from.

A new class of equipment will be on hand to welcome the new class of customers. The trend started late this summer when Dai-ei Inc., a supermarket chain, started selling a no-frills, 18-inch color receiver for $260. Crown

Noboru Yoshii of Sony Corp. is undeterred by the apparent peaking of color television sets in Japan. "By 1975," he says, "we'll have a need for 6 million color sets every year." Sony's next big objective: a complete video player system, from a dubbing machine through a consumer player.

Radio Corp., an export-oriented company hard hit by the slump in the U.S. market, produces the sets. But Crown can count on plenty of competition as set makers angle for shares in the low end of the market. All of the color sets now sold in Japan are all-solid state.

At the high end, prices figure to rise as set makers pack their receivers with deluxe features to attract well-heeled replacement-set buyers. So thoroughly has Sanyo Electric Co. billboarded its top-of-the-line set around Tokyo and Osaka, for example, that even visiting foreigners are soon aware that it features an ultrasonic remote control. Sanyo has no exclusive on remote control, and it's just one frill that's being offered among several, including digital clocks and fm radios. Electronic tuning, already common in Europe, is in sight, too.

Inside, the top-of-the-line sets are studded with ICs. Sharp's, for example, has no less than 17 IC packages; so does Matsushita's. Mitsubishi checks in with 15, Toshiba with 11, Hitachi with 10, and so on. Usually, these IC sets include both monolithic and hybrid packages, and a mix of standard and custom circuits. Video i-f, automatic frequency control, automatic fine tuning, audio i-f, and audio drivers are the functions most often handled by standard chips.

The custom linear ICs figure to get more and more complex. Matsushita's $575 top-of-the-line color TV, for example, has an MOS/LSI chip among its 17 ICs. The 200-element chip is a 10-step frequency divider that counts down a 31.5-kilohertz frequency to 60 hertz for the vertical deflection pulse. Sharp is moving to larger chips so it can improve color saturation and hue circuitry for sets with wireless remote control. Toshiba plans

Hideo Abe of Hitachi agrees that a strong market is coming up for video player systems, probably within two or three years. As for color TVs, Abe solemnly maintains that his company will "self-restrict" its sales in European markets, fearing a repeat of its U.S. market experiences.

to lump bandpass filters and the sound i-f functions on a single chip; other chips it's working on are oscillators for horizontal and vertical deflection paired with afc and video amplifiers. All told, the rush to get ICs into color TV sets and audio equipment has been so great that Masataka Takedai, Toshiba's semiconductor consumer-device application manager, says that sales of consumer ICs are tenfold higher this year than they were last.

But the race for distinguishing features wasn't the only spur for consumer ICs. Last year, set makers thought there might be a tax break for IC sets, then defined as having fewer than 18 discrete transistors. So they all started girding to produce IC sets. MITI and the finance ministry later decided against it, but with the

Shigeo Sugita of Mitsubishi stands practically alone among Japanese color TV executives in plumping the prospects for 110° picture tubes. His company's methods, claims Sugita, gives its 110° tube a brightness equivalent to 90° color tubes without the need for special deflection circuitry.

sets in the pipeline, the set makers brought them to market.

Most set makers are sticking with 90° picture tubes. The major exception is Mitsubishi, which is making a strong push with its thin-neck 110° models. Matsushita started selling a 110° tube set this summer, but TV division officials in Osaka say they're not terribly enthusiastic, mainly because of the higher power consumption and—Matsushita contends—poorer picture quality. Mitsubishi, however, maintains its 110° tube matches 90° tubes in brightness, and does it without special deflection circuits; the key is in the way the company lays down the phosphor color triads in the corners of the tube, says Shigeo Sugita, a Mitsubishi assistant general manager.

Higher volume for audio

In contrast to the certain slide in store for video in 1972, the outlook for audio equipment is definitely up—very slightly for complete stereo sets, somewhat for radios, significantly for tape recorders, sensationally for hi-fi components.

Stereo record players seem on the way to becoming as outmoded as kimonos in offices. The engine for change is quadraphonic sound: except for bottom-of-the-line models, quad matrix circuits will turn up in practically all stereo record players introduced for the year-end flurry of consumer buying.

Yasuhisa Mochizuki, manager for hi-fi product engineering at Toshiba, expects that more than half of the stereo sets sold during the peak season will be fitted to supply sound all around, although in many cases the second set of speakers will be optional extras. But the phono-combination market nonetheless looks rather lackluster. *Electronics'* survey puts the business this year at $297 million, and the forecast for 1972, at $305 million, shows practically no gain. As Mochizuki puts it, "Quadri is half a search for new sound effects and half a search for a new market."

Innovations in radios

The slight gain for radios, *Electronics'* survey estimates, will boost the market to $204 million next year from $187 million in 1971. Asked to single out the main factors behind the steady rise in a seemingly saturated market, Keiichi Takeoka, chief of the radio and stereo division at Matsushita, the country's top producer and exporter of radios, replies, "fm and clock radios."

Takeoka and the other brass at the radio division have opted for unique products to make headway in a radio market that's mature in Japan and worldwide. One of their latest "ours-alone" products: a talking clock radio that announces the time when you touch its top. The actual mechanism is a reading head that sweeps across two concentric magnetic disks, which have hour and minute announcements recorded on them. The disks, of course, are driven by the radio's clock movement.

There's a significant gain ahead next year for sales of tape recorders in Japan. *Electronics'* consensus charts show a boost to $219 million next year from 1971's estimated $196 million. That amounts to 12%, but it's not good enough for Masao Matsumoto, head of Matsushita's recording instrument division: he figures the market for annual gains from 15% to 20% this year, next year, and in 1973.

As their market rises, tape recorder makers will be improving on their goods. In high-quality tape equipment, Matsushita, for example, has shifted to hot-press ferrite for the heads instead of laminates. The hot-press heads are almost as hard as diamonds and they boost frequency response up to 30 kilohertz. Toshiba now tucks IC oscillators for erase and bias into the heads of about half the tape recorders it turns out; the idea is to prevent radiation from these oscillators from getting into the audio amplifier circuits. Matsushita, Sony, and the Victor Co. of Japan have worked out a Dolby-like system to suppress hiss on tapes. Unfortunately, the Japanese system, dubbed ANRS (for automatic noise reduction system), is not compatible with standard cassette players, and it seems certain to run into stubborn resistance from Philips' Gloeilampenfabrieken, which controls the patent rights on cassettes and sternly insists that anyone producing them keep them compatible.

As they puzzle out new strategies for entertainment-electronics markets, Japanese producers can find some solace in the outlook for one emerging market—microwave ovens. Last year, the oven makers' great expectations of a wild rise in sales were dashed by a radiation scare. This year the market dawdled again, dipping slightly below the 1970 level of $68 million, according to *Electronics'* consensus estimate. Next year most people think the market will start cooking again. The survey puts 1972 sales at $85 million.

Confidence has been spurred since the radiation scare was banished by new designs that shut off the cooking magnetron before the door can be opened. The usual combination: a squeeze handle on the oven door backed up by a microswitch near the door hinge. What's more, the new ovens are "a piece of kitchen equipment, not a piece of communications equipment," asserts Tetsujiro Nakao, executive vice president of Matsushita. The company redesigned a magnetron for mass production and currently turns out between 15,000 and 20,000 a month.

Sharp Corp., too, is counting heavily on bringing electronics into the kitchen. Some Japanese oven makers stoutly maintain that "browning" isn't important for Japanese cuisine; others insist that it is. When it comes to exports, there's no dispute, and Sharp is trying to come up with something better than an infrared heater to do the job. A hot-gas surround could be the answer, suggests Sanai Mito, an executive director of the company and its top technical planner. Mito sees household appliances as a major avenue for growth and has development teams looking at all sorts of equipment, even the kitchen sink.

Tetsujiro Nakao of Matsushita is bullish about an emerging market within the consumer electronics sector—microwave ovens. Progress and acceptance of the units is such, he maintains, that microwave ovens now are "a piece of kitchen equipment, not a piece of communications equipment."

Westward ho

The outlook for exports of Japanese consumer goods reflects changing horizons, too. Now that their home market shows signs of dwindling and their major export market—the U.S.—has soured, Japanese color TV makers must move out into new territory if they want to keep their production lines purring efficiently.

Europe comes to mind immediately. It's mostly PAL country, though, and AEG-Telefunken has been wary about granting licenses to Japanese producers for its color TV system. The upshot has been a rash of color-decoding circuits that skirt Telefunken's patents. All the major producers have something of the sort ready or in the works.

Sony excepted, the big producers stoutly maintain they have no plans for an assault on Europe. Hayata Tokizane, director of Matsushita's TV division, says his company wants to talk with Telefunken before treading into PAL land. Rather than color TV now, Matsushita plans to mount a worldwide campaign to push unusual products like its 1½-inch black-and-white set. Hitachi Ltd. has a PAL license good for all countries except West Germany and Italy, but Hitachi's Abe insists his firm is going to "self-restrict" its color TV business in Europe—it doesn't want to get hit there the same way it was in the U.S. Sharp's president, Akira Saeki, has gone on record with much the same sentiment.

How long this self-limitation will last remains to be seen. Sony Corp. has launched a strong sales push in Europe for its small color sets with resounding success. "We're increasing sales 50% yearly there," says Yoshii. Europe now accounts for 9% of Sony's sales, which totaled $414 million for fiscal 1970. And to handle its fast-rising business on the Continent and in England, Sony is setting up a big new inventory center at Utrecht in the Netherlands. The center should be operational by the last half of 1972. Sony also is making a big investment in the U.S. with a plant in California to produce small-screen color TVs.

For Japanese tape recorder producers, Japan is just another market. The 28 producers that belong to EIA-J are turning out some 15 million tape recorders this year, between 85% and 90% of them cassette types. A scant 30% of these found their way into the home market. In addition to the EIA-J members, about 100 smaller outfits are building a total of 11 or 12 million units, practically all of them for export. The numbers are fairly staggering, but so is the capacity of consumers around the world to snap them up. Matsushita's Matsumoto expects there'll be at worst a slight slump in Japanese sales to the pivotal U.S. cassette recorder market. Since U.S. production of cassette machines is insignificant, the Japanese won't lose market shares, as they are in color TV, because of the cost edge American producers acquired through the 10% surcharge and the upward float of the yen.

Some wind leaves computer sales

It's a different game of "go," too, for the Japanese computer industry. "We've had abnormal growth rates of 30% to 40%," says Kaoru Ando, a top computer executive at Fujitsu Ltd. "Now it's normalizing at 20% to 25% a year."

Quibblers about percentage points excepted, no one would quarrel with Ando's assessment. At IBM-Japan, the word is that banks and financial institutions continue to plump out their data-processing facilities as before, but that there's a definite falloff on the industrial side. The hitch in Japan's economic growth, in fact, has transformed many medium and small companies from seemingly sure customers to merely good prospects. And at big companies, notes Shiro Omata, an executive vice president at Nippon Univac, "End users are most sophisticated and nobody is buying a computer anymore just for the sake of having another computer." What's more, a reshuffling of domestic computer suppliers is in the offing. And who wants to order a machine that might in only a year or two turn into a lame duck?

Even in the changed game, though, there are plenty of pebbles for the players' bowls. *Electronics'* survey puts the data-processing market this year at $1.2 billion, including minicomputers and desk calculators. Next year, the consensus outlook is for something close to $1.5 billion, an increase of 19% and admittedly way off the mark of previous years. The Japan Electronic Computer Co. (JECC), the government-backed firm that finances leases for the six domestic computer makers, logged a 44.4% annual gain when it made its annual count of computers in service at the end of the fiscal year last March 31. At that time, there were nearly 9,500 computers (not counting minicomputers), worth roughly $2.5 billion, operating in the country.

MITI protects computer makers

Many of the rules of the old game, to be sure, remain in effect. MITI, as before, will keep them rigged as much as possible to help the native companies snatch points from the Japanese subsidiaries of IBM, Univac, National Cash Register, and other U.S. computer companies. MITI's "administrative guidance" for key industries keeps computers a "nonliberalized" sector. That makes new capital investments by foreigners taboo and puts computer imports on a "case-by-case" basis, much to the detriment of would-be foreign suppliers. Explains a computer industry watcher at the U.S. embassy in Tokyo, "It's very difficult to do business in nonliberalized sectors. The burden of proof is on the importer; he's put through the wringer to explain why he's buying a non-Japanese product."

Under MITI's watchful "guidance," Japanese computer makers have steadily upped their collective market share over the years. At the end of fiscal 1970, 55.3% of the computers in Japan were made by Japanese producers. A decade ago, the figure was 27.3%. Fujitsu, Hitachi, Nippon Electric Co., Toshiba, Mitsubishi, and Oki Electric Industry Co. are the native producers (computers made in Japan by IBM count as foreign machines).

Japan, of course, has been under heavy pressure from her major trading partners—particularly the U.S.—to knock down the barriers that keep foreigners from doing business freely in key industries. Late this summer, MITI threw some crumbs to the pack pounding on its doors. It announced that it would liberalize imports of computer peripherals—memories excepted—starting next April, and after another three years, liberalize investments in computers, including mainframes.

Yujira Degawa of NEC feels that the six Japanese computer companies will go along with the Ministry of International Trade and Industry's thinking and form alliances to strengthen the native industry, in the process reducing the number of domestic computer producers to three.

MITI, of course, has its own peculiar definition of liberalization. New investments in liberalized sectors must be 50-50 joint ventures with a Japanese partner. And the choice of partners so far is subject to every sort of restrictive criterion. For example, the Japanese partner must already be in the computer business, but it can't transfer its existing business wholly to the joint venture.

While MITI keeps outsiders from setting up computer plants in Japan, it's continuing to nurture the native industry so that it can meet the competition when liberalization finally comes. To make sure the home producers will have top-drawer machines by the middle of the decade, MITI put the six native producers to work on a $35 million large-computer project. They have brought forth a machine that's in the same class as Control Data Corp.'s CDC 6600 [*Electronics*, May 24, p.42]. Already some of the technology developed for the project's central processing unit has been incorporated into commercial machines. Hitachi has orders for three.

MITI, though, doesn't plan to bow out of the act when the large-scale project winds up officially next spring. Late this summer, the agency's Electrotechnical Laboratory bared a $106 million plan to ready the country's computer industry for the 1980s. The new giant computer will emphasize fast processing of large quantities of pattern information, like the ideographs used to write Japanese. The first large-scale project emphasized processing speed and a large, fast memory: 50-nanosecond add time and an 8-million-byte main memory with a cycle time of 700 ns.

Hitachi and Fujitsu team up

But MITI isn't just strengthening the six native producers' technological hand. The word has gone out that MITI thinks two or maybe three would be a much better complement of computer companies for the nation than the current half-dozen. The pairing off already has started. Last month, Hitachi and Fujitsu signed a pact to work together on "post-3.5-generation" computers. The alliance makes sense: Fujitsu is the sole native Japanese computer company with solely native technology; Hitachi found itself completely on its own technologically when RCA suddenly pulled out of the computer business in September. However, the firm for some time before that had been edging toward independence—witness the commercial versions of the large-scale computer added to the top of its line. Between them, Hitachi and Fujitsu account for more than half the computer sales by native companies and together compare favorably to IBM in Japan.

The Hitachi-Fujitsu tieup should make an arrangement on computers inevitable for NEC and Toshiba. Both have technology ties to Honeywell Information Systems. Executives at both companies shy away from talk about specifics, but Yujira Degawa, an executive vice president at NEC, reluctantly admits that the industry will come around to MITI's way of thinking.

That leaves Oki and Mitsubishi. Oki builds computers jointly with the Univac division of Sperry Rand (the venture is called Oki-Univac-Kaisha Ltd.), and Mitsubishi works as a subcontractor with Oki-Univac in addition to building some computers on its own. That seems like the makings for a group, and if it comes off, the computer market would be split mainly among four groups—Hitachi-Fujitsu, NEC-Toshiba, the Univac crew, and IBM-Japan.

The time-sharing competition

There's no guessing about what's ahead in time-sharing: it should spurt in the next few years. By law, only the government's Nippon Telegraph and Telephone Public Corp. has been able so far to tie a group of strangers into a central computer facility. Among other things, NTT runs a scientific and technical computer service, based on a Nippon Electric NEAC 2200-500 computer; there's also a sales and inventory service that ties 30 users into a Fujitsu Facom 50.

Now there's competition in sight for NTT. Starting in September, the government authorized shared data services among unrelated companies as long as the lines are leased. By the summer of 1973, NTT expects to have shifted to message-unit counting for local times; after that's been done, time-sharing service operators can start using regular switched lines. It points to a boom for data terminal makers.

Of course, NTT will bow out of the time-sharing business—it has NEC, Fujitsu, and Hitachi at work on a project known as DIPS-1 (for Dendenkosha Information Processing System-1). DIPS-1 is slated to go into commercial service in 1973, and its technology largely fell out of the large-scale project. Two, three, or four central processors will be paired with as many as 16 memory modules of 1-megabyte capacity. A three-processor system, NTT says, could handle some 600 subscribers and would have triple the capacity of the largest domestically produced computer available.

Holding the line in minicomputers, calculators

MITI's hand shows up again in minicomputers. The agency this spring gave its blessing to a deal that licenses Data General Corp.'s Nova machines to a new company called Nippon Minicomputer. Takeda Riken, a ranking instrument producer, is a major stockholder in Nippon Minicomputer, along with Kozo Keikaku Kenkyusho, a software outfit.

Meanwhile, MITI is keeping Digital Equipment Corp., which wants to set up shop in Japan, at arm's length. It's not DEC's hardware that's feared, good as it is; what concerns the Japanese is DEC's extensive software inventory. DEC has nonetheless managed to get some 200 machines into Japan, many of them as OEM units in test systems, but hasn't been able to score heavily. Says a DEC applications engineer on the scene, "MITI usually approves applications by end users for single machines. But OEM orders for more than 10 machines get turned down."

Thus DEC and other U.S. minimakers are shut out of an emerging big market: this year's figure is $22 million, up 30% over the 1970 mark. Before Nixon's double shock shook up the prospects for Japan's economy, Japanese minicomputer makers figured they'd sell at least 3,000 units in 1972. Now no one knows how high that estimate will turn out to have been, but *Electronics* hazards a 1972 figure of $27.6 million for minis.

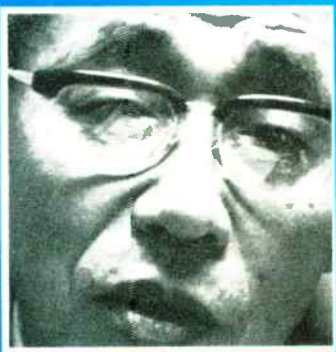
In computers, the Japanese have yet to make much of a mark in exports. Fujitsu has had some success in East Europe (and a flop in the U.S.) and NEC has sold a few units in Rumania, but that's about the extent of it. However in electronic desk calculators, the tail end of the data-processing market, Japanese producers dominate the market around the world. Last year, for example, the score or so of companies churning out calculators nearly tripled their output and made some 1.3 million units. Slightly more than 60% of them went overseas. This year's figures are 1.6 million units, better than 70% of them exported. Next year the Japanese expect to make something like 3 million and hold their export ratio.

Nonetheless, it figures to be a rough year for the calculator makers. Prices have plummeted in the domestic market: an eight-digit, battery-operated model listing for less than $100 debuted at the September Business Machines Show in Osaka and others will follow. One upshot of the price cuts is a downturn—in value—for desk calculator sales even though the number of unit

Calculators multiply. After tripling production to 1.3 million units last year, Japan's calculator makers will make 1.6 million this year.

sales is up. *Electronics*' survey puts the 1971 market at $136 million, $30 million below the 1970 figure. There'll be a slight gain for 1972, according to the survey.

What's happening in the domestic market, of course, is a tipoff to what's ahead in exports. There'll be heavy price competition, particularly for eight-digit "consumer" calculators built around one- or two-chip MOS/LSI circuits. Tadashi Sasaki, an executive vice president at Sharp and the man largely responsible for Sharp's top spot among calculator producers, expects



Tadashi Sasaki of Sharp senses a split coming up in the booming Japanese electronic calculator market. As Sasaki sees it, there will be two distinct varieties, "consumer" versions and "business" machines, with eight-digit, liquid-crystal-readout calculators dominating the low-priced sector.

the market will split into two distinct segments next year, "consumer" and business machines. Home and school calculators, he expects, will go for well below $100 by mid-1972. The eight-digit machines with liquid-crystal readout, no memory, and throwaway dry cells will dominate that market. The upper end of the "consumer" range will be the province of eight- or 16-digit office units with light-emitting diodes readout, a memory registor, and ac-dc operation. Defined this way, this year's market for consumer calculators will amount to 336,000 machines. Anything fancier gets classed as a business machine, and some calculators are fancy enough to pass as junior computers.

Hajime Karatsu, an executive at Matsushita Communication Industrial Co., also sees a shift coming in the domestic calculator market. Up to now, he points out, companies with big sales networks—like Matsushita, Toshiba, Hitachi, Sharp, and Sony—have been marketing high-priced machines, while companies without widespread sales organizations have been peddling low-priced units. Karatsu expects that the big companies will soon enter the lists with under-$100 machies, and that may force some of the smaller firms to drop out of the low end of the business.

Telecommunications still thriving

Telecommunications equipment makers in Japan seem to flourish no matter what. When all is going well in the country they come in for their cut of the general prosperity, and when things aren't going well—the case now—they can count on the government to boost the budget of its telecommunications monopoly, NTT. An added $75 million looks likely for this fiscal year. In the telecommunications club, about the only members who don't enjoy this best-of-all-worlds arrangement are the microwave-link makers: more than half of their output goes for exports and the new parity for the yen means they face harder times abroad.

But weep not overly for the microwave makers. Their companies are all wired into other facets of the telecommunications business and can find solace in NTT's whopping investment budget—$2.48 billion for the 1971 fiscal year. Some of the major items: $265 million for switching equipment (overwhelmingly electromechanical), $120 million for carrier equipment, $55 million for microwave links, and $49 million for handsets.

This kind of spending should go on for several years; there's much communicating to be done in Japan and still not enough hardware to go around. Right now, 3 million applicants are lined up for telephones and 25 million handsets are in use. "The demand will continue until there are 50 million phones, perhaps in 1977," says Kanji Yamamoto, a director at Fujitsu. And when demand dwindles for voice equipment, a surge for data-transmission hardware will take its place. Hiroya Enda, manager of the engineering planning department at Oki Electric, is convinced that data transmission will be the fastest-growing segment of the telecommunications market over the next few years, logging annual gains of 30%.

As if this weren't enough, there'll be new communications equipment markets opening up after 1973. NTT expects to have message-unit counters installed on all its lines by then and will throw them open to all sorts of acoustically coupled hardware. Facsimile, particularly, should flower.

This year, communications equipment makers will ring up sales of $717 million in Japan, according to *Electronics*' survey. Next year's prospects show a jump of 11%, to just below $800 million. These figures exclude nonelectronic equipment like carbon-granule handsets and crossbar exchange gear.

The exclusion will cover less and less of NTT's equipment. NTT has started a transition to electronic exchanges and to electronic pushbutton handsets. Two prototype electronic exchanges are under trial in Tokyo and seven production models, with a capacity of 40,000 lines each, have been ordered. In what a U.S. phone company executive has called "cooperative competition," the business is going to NEC, Fujitsu, Hitachi, and Oki.

All-purpose phone hardware

The first seven production exchanges, designated the D-10, are just a beginning. NTT's research laboratory is hard at work on software that will make D-10 hardware much easier to fit into the telephone system. Since blocks of 40,000 lines aren't handy outside big cities, NTT's idea is to split the control and speech-path portions of the exchange so that a single master control in a big town can supervise one or two satellite switching units in small towns up to 20 kilometers away. The satellites can handle up to 16,000 lines, and the master can control satellites with a total of 40,000 lines, including its own. Ties between the two portions are 24-channel pulse code modulation links with a 1.54-megabit-per-second rate.

The combination gives the economies of a large electronic switching system without paying a penalty for excess speech paths. "The system works near capacity from the outset," says Ei Shikiba, an NTT staff engineer, "and growth is no problem. You can add a control unit later and turn a satellite into a master if it becomes necessary." NTT calls the split system master R-1 and plans to start field tests at its laboratories next spring, with commercial tests to follow by a year.

Electronics hardware also is moving into handsets, where the potential is tremendous: NTT will add some 2.5 million subscribers this year and even more next. Only a lucky relative few get electronic pushbutton handsets. "Some 100,000 will be in use by the end of 1971 and 160,000 by 1972," reports Masao Miyake, the NTT managing director in charge of construction and installation.

New telephone services

Pushbuttom-phone subscribers pay just under $4 a month extra for their phone, but with the added extra on the phone bill comes the right to have 20 preregistered numbers that can be dialed by punching only three digits. And anyone with such a phone in Tokyo or Osaka can ring for calculator service and punch out his problems on the phone keyboard. The tariff for this service is just over 2 cents for every 21 seconds a subscriber remains connected after he accesses the NEAC 2200-500 computer that does the calculating.

Like telephone systems in industrialized countries around the world, NTT isn't quite sure what to do about video phones. The problems: what bandwidth to use and how much to charge for video phone service. Trials will start next year with both 1-MHz and 4-MHz bandwidths and the 50 subscribers involved will get billed (but won't have to pay) for the service. "We want to see how they react," says Miyake. The wait for the reaction will put commercial service a year behind NTT's original 1973 startup. But whatever the actual date, equipment makers will be ready: NEC and Fujitsu, for example, have experimental systems in their headquarters buildings.

Although the decision still could go either way, Miyake thinks NTT may have to go with a 4-MHz bandwidth. In his opinion, video phones will be used more to transmit drawings, documents, and pictures of products than for face-to-face conversation, applications that require 4 MHz for adequate picture quality. NTT will be moving up to 60-MHz cable-carrier equipment, Miyake points out, making it possible for NTT to keep videophone bills in line.

Facsimile to peak before videophones

Before the lines form to sign up for video phone service, though, facsimile should be firmly entrenched. Most equipment makers expect the market to boom once NTT opens its switched lines to other than voice equipment. Yuichi Makino, general manager of Toshiba's telecommunications division, spots the facsimile market this year at around $6 million, zooming to around $30 million by 1974 or 1975, he predicts. In Japan, remember, a teleprinter is not the medium for the message. That's why there's such potential for facsimile, so much so that consumer-oriented companies like Matsushita and Sharp, too, have facsimile equipment in the works.

Kanji Yamamoto of Fujitsu predicts that strong demand for telephone sets will continue in the telecommunications market until there are 50 million telephones in use in Japan. When demand for voice gear diminishes, he says, a surge for data transmission hardware will take its place, probably after 1977.

All the new services NTT has in mind will force it to continue the unflagging effort to expand its trunkline capacity, much to the benefit of NEC, the major supplier. And as the needs go up, so do operating frequencies. NTT is beefing up its Tokyo-Osaka main route with 12-gigahertz, 2,700-channel coaxial-cable carrier systems. By 1973, the phone people expect to start work on a 60-MHz cable carrier system. Initially, it will have two cables, each with six 10,800-channel coaxial pairs. This system should be in service by 1975.

As for radio links, there's a fourth main route along the Pacific coast slated for 1972, and most of the year's microwave money will go there. This will be NTT's last go with 6-GHz, 1,800-channel hardware. The 6-GHz band is overcrowded and NTT has wangled some 5-GHz allocations, for which 2,700-channel gear has been developed. Quasi-millimeter-wave equipment will follow as NTT solves its spectrum problem by going higher than any other user. NEC will supply some 70 repeaters for NTT's experimental 20-GHz link next year. By 1976, NTT expects to have a 20-GHz backup line in service between Tokyo and Osaka. Then the phone system's engineering brass will have to decide whether it's to be millimeter waveguides or fiber optics for transmission in the 1980s.

In communications satellite ground stations, most of

Masao Miyake of NTT notes a strong trend to electronics in telephones. The major vehicle here is pushbutton phones; Miyake predicts that 100,000 will be in use by the end of this year and 160,000 by 1972. Pushbutton users can access computer for calculations.

the action for Japanese manufacturers at the moment is overseas. NEC has orders from nine countries for its Spade terminal equipment and seems on the way to at least doubling its customer list. With Spade (for single-channel-per-carrier PCM multiple-access, demand-assignment equipment), groups of ground stations can share a pool of satellite channels, a more efficient arrangement than assigning channels to individual stations.

Like telecommunications equipment manufacturers, radar makers have a commendable prime customer—a government that steps up its spending when the economy starts to sour. There's a setback in supertanker installations, to be sure, but no signs of a turndown in fishing radars. Next year, civilian airways authorities will start a three-year crash program to equip a score of airports with electronic aids, including radars, instrument landing systems, and precision distance-measuring equipment. All told, the radar market should move up steadily—but not spectacularly—over the next few years.

Industrial sector falls out of bed

Industrial electronics makers have found out that sometimes what's bad for Japan can be horrible for them. They were braced for a lull in instrument sales this year but figured there would be an upturn with a new round of plant-building starting in 1972.

The round is nowhere in sight. "Most big projects have been delayed or cancelled," reports Carlton W. Johnson, Honeywell Inc.'s Far East regional director for control systems. Capital investments in general sagged with the recession. And worries about pollution regulations have made petrochemical companies uneasy about ordering new plants.

What's more, invoices for boiler controls are very low. "They are a key indicator," says Masaaki Toyama, who heads the sales engineering department at Yokogawa Electric Works, Japan's ranking controls company. "The boilers are usually ordered a year before the actual start on a plant."

With the telltale indicator, and most of the lesser ones showing no growth, the market figures in *Electronics'* survey come as no surprise. They show a drop to $400 million in this year from 1970's $420 million, and though the outlook for 1972 is a very slight rise over $400 million, even that unexciting prospect may not come to pass. "If the market holds steady we'll be lucky," says Toyama.

Almost to a man, controls makers feel it will be another 18 or 24 months before their sales get back on the track. Meanwhile, "We're in a period of preparation," says Masahiro Shimizu, president of Hokushin Electric Corp. Hokushin and Yamatake-Honeywell are neck-and-neck behind Yokogawa in the running for the controls business.

Hokushin's preparations include a new minicomputer and a drive to boost exports, items that turn up high on the works lists of other industrial electronics producers. Although the market is off overall, a strong rise—perhaps 20%—is in sight for integrated test systems, and they depend on minis. Any system, in fact, that saves labor has a good chance of finding a customer since labor is tight in Japan despite the economic growth slowdown.

Hokushin, for example, is developing a medium-size process-control computer that fills a niche between the

Coming attraction. As in the U.S., videophone service in Japan is behind schedule. One big question remaining is whether to use a 1-megahertz or a 4-MHz bandwidth. Trials with both systems are delaying commercial service at least a year beyond the 1973 launching date.

IBM 1800 model and the Digital Equipment Corp. PDP-8. It has a 32,768-word wire main memory and can have up to four 1-million-word drum memories tacked on to it. The Hokushin machine is intended mainly for direct-digital-control applications.

Yokogawa, too, is thinking about building its own mini. This computer likely will be an offshoot of the special-purpose machine it builds for direct digital systems. Japanese oil and chemical companies are moving into those systems faster than U.S. companies. Yokogawa Electric's Toyama, who of course has systems to peddle, attributes the lead to a "Japanese" style that's evolving in that sector. Early installations had a single computer to handle the relatively slow chore of process supervision and the fast one of direct digital control. With the computer working both fast and slow, prudence dictates heavy analog backup.

In the new Japanese style, Toyama says, a general-purpose computer takes over the supervisory chore and a fast special-purpose computer (Yokogawa's Yodic-600, for example) pulses the digital controls. The savings in analog backup controllers, Toyama contends, mean that a two-computer system costs only 10% to 15% more than a single-computer setup. This initial out-of-pocket extra, he continues, gets paid back over the life of the plant through the savings possible in operators' wages.

Hokushin's Shimizu, however, maintains the next wave of installations will be one-computer systems—of sorts. The latest trend he says, is to a single process-control-computer but with little analog backup. The insurance a big plant needs against frequent shutdowns comes from a standby general-purpose machine—an IBM 370, say— whose main job might be inventory control. It's this concept that shaped the design of Hokushin's new computer. The 32,768-word internal memory is adequate for direct digital control and the 4-million word external memory is plenty for interfacing with the standby computer.

Projects for traffic, pollution control

Some things that are bad for Japan, though, are good for industrial electronics manufacturers. Auto traffic is so awesome in urban centers that the government has a $550 million program under way to computerize traffic controls in all cities with populations of 200,000 and more.

Last year, "preprogram" systems went into Yokohama, Nagoya, Hiroshima, Sendai, and Fukuoka. This year's slice of the program is $45 million—for the greening of the main thoroughfares of Sapporo, Chiba, Shizuoka, Kobe, and Kitakyushu. Matsushita Communication Industrial Co., Sumitomo Electric Industries Ltd., and Omron Tateisi have the contracts.

Pollution, too, should bring in some business. Air and water pollution monitoring networks are popping up throughout Japan; the Tokyo metropolitan government, for example, has been using a laser link to transmit pollution charts over closed-circuit television between two offices. Japan Radio Co. has in the works a balloon-tracking system for pollution control. Karatsu of Matsushita Communication says his company is counting mainly on traffic control, pollution control,

Yuichi Makino of Toshiba spots another burgeoning market in the telecommunications sector: facsimile. By 1974 or 1975, he predicts, the present $6 million market for facsimile equipment should shoot up dramatically to about $30 million. Consumer firms are eyeing market for fax gear.

and educational hardware to bring an 18% to 20% upward burst in sales next year. Under conditions that Karatsu terms as "very difficult," Matsushita Communication managed only to stay even with 1970 sales this year.

Tough time for testers

Test instrument makers, too, had to rework their market digits and the new numbers aren't encouraging. This year's market should just about reach $133 million, according to *Electronics'* survey, a scant 6.5% rise over last year's figure. That estimate is pretty firm; the survey turned up only a whisper of a rise to $137 million.

There are some differences of opinion, though, on oscilloscopes. Fred Bode, a director at Yokogawa-Hewlett-Packard, thinks that sales of top-drawer, 250-MHz-and-up units perhaps won't fare as poorly as less-sophisticated models. Research and development can't come to a halt even during a recession, and it's R&D that buoys that sector of the market, he feels.

At Iwatsu Electric Co., the reading is exactly opposite. Kozo Uchida, the company's chief engineer for instruments, figures that the R&D people will have to make do with their old scopes as companies hold down spending. "The upward drift in frequencies," he insists, "has halted." In his view, the market mainstays next year will be scopes for computer and color TV service.

Luckily, all sectors of the test instrument market don't seem condemned, as do oscilloscopes, to a no-growth year. Digital voltmeters, for example, should score a 10% rise. Takeda Riken hopes to bolster its market share with a $330 DVM that has autoranging over four ranges from 1 millivolt to 1,000 volts. Takeda, Iwatsu and Yokogawa are main contenders in the DVM market. There's also strong potential for computerized test systems, everyone agrees, but a market size is nearly impossible to pin down.

Whatever the mainstays turn out to be, they'll fall far short of maintaining the sharp upward climb Japanese test instrument makers got used to in recent years. So Iwatsu has started looking more outward than ever; it's going into the low end of the U.S. market with oscilloscopes in the 2-MHz to 50-MHz range. At the other extreme, Iwatsu intends to offer an 18-GHz sampling scope. It's an offshoot of a pulse generator with 130-picosecond rise time for a 15-volt output. Iwatsu is allied with E-H Research Labs Inc., Oakland, Calif.

Takeda Riken also has eyes on the U.S. and European digital counter and meter markets; the company's president has been sounding out possible partners in both areas.

Deep into space

A significant space program is one of the trappings that mark a major industrial power and Japan intends to deck itself out suitably. This year's spending for space is pegged at $60 million, but next year the figure will double, maintains Yasuhiro Kuroda, director of systems planning at the National Space Development Agency.

Nasda now has the space program, once scattered throughout 14 different agencies, well in hand. To be sure, the University of Tokyo still carries on with its own program of small scientific satellites and rockets to get them into orbit, and had its first successful launch this September. But Nasda carries the weight for the major programs.

Last fall, in fact, the Prime Minister's Space Activities Commission charted a new course for Japan's space program and put Nasda at the controls. The new short-term cornerstone of the Japanese program is an engineering test satellite that replaces an ionospheric sounding satellite now given a secondary role. The rocket program, too, has been revamped; instead of going it strictly on its own, Japan plans to tap the U.S. for Thor-Delta technology to speed things up.

Masahiro Shimizu of Hokushin is among executives of control-manufacturing firms who feel their market will continue in the doldrums for another 18 to 24 months. In the meanwhile, Hokushin is taking advantage of the lull to make preparations for its future business.

Originally, plans called for Nasda to develop a four-stage "Q" rocket that could put a 185-pound payload in orbit. In the revamped program "Q" is out and the "N" rocket gets priority. It will develop 150,000 pounds of thrust from a Thor-Delta liquid-fuel first stage, topped by two solid-fuel stages developed for the "Q" version. There's a strong chance that the first "N" rocket to fly will have an imported knocked-down Thor-Delta first stage. The following birds will be made in Japan under license. Contractors are Mitsubishi Heavy Industries, Ishikawajima-Harima Heavy Industries, Nissan Motors, NEC, and Mitsubishi Electric.

To keep its new schedule, Nasda must have two "N" rockets ready by 1975. The first will launch ETS-1 in a circular orbit at 1,000 kilometers altitude with an inclination of 30°. The second will loft the ISS into a circular orbit, also 1,000 km high, but with an inclination of 70°. Both satellites will weigh 185 pounds.

With ETS-1, Nasda will check out its launcher, train crews in tracking and control, try out antenna-rod deployment, and get a precise idea of the environment inside the satellite. If all goes well, ETS-2 will be put into a 36,000-km synchronous orbit in 1976.

It will be a 220-pound bird with an experimental communications satellite. Down for a 1977 launch, the ECS design is in the concept stage, but Nasda and the other organizations involved—notably NTT, the broadcasting service NHK, and the overseas telecommunications company KDD—are aiming at something like 1,000 channels operating above 10 GHz.

Then, too, Nasda has a rough outline for a post-1977 program. On the tentative agenda: a meteorological satellite, a full-fledged communications satellite, a navigation satellite, a geodesic satellite, and a broadcasting satellite to beam TV programs to Asian countries. At the moment, the meteorological unit is uppermost on Kuroda's mind. It may have to get pushed way up on the schedule; Japan has signed on for a world program of weather-watching from space that will start next year with a U.S. launch and can't fall too far behind her partners. "It's a very sensitive subject," says Kuroda.

Defense creeps up

Defense electronics doesn't count for much in Japan. The country channels very little of its technology and manpower into its armed forces, which, after World War 2 were baptized the ground, maritime, and air Self-Defense Forces. What's more, companies that do "self-defense" work make as little ado about it as possible. In Japan, no one wants a militaristic image.

All the same, the budget for defense gets a little higher every year. Japan gets Okinawa back next year from the U.S., and that will stretch the defense perimeter so much that heavier outlays seem inevitable. For the current fiscal year, a little more than $2 billion was earmarked for total defense spending. Next year, the defense forces establishment wants the Diet to boost its budget to just under $2.5 billion. "I don't expect we'll get quite that much," explains an official of the defense agency. Even with $2.5 billion, the defense agency would have less than 1% of the country's gross national product to dispense, a portion that would make military men in Europe and the U.S. feel they'd been banished to the poorhouse.

Whatever their funding, the defense people will get their fourth five-year buildup plan started during fiscal 1972. The major procurement during the plan's span will be some 150 F-4 Phantom fighter-interceptors. At the outset, they'll be assembled from imported kits by Mitsubishi Heavy Industries. But over the years, the Japanese content will be stepped up.

"Make it in Japan" is the byword and the dictum applies particularly to electronics. The avionics for Japanese F-4's will be mostly black boxes designed in the U.S. but fabricated in Japan. Following generations of

Into the air. Japanese avionics makers are riding a "Made in Japan" trend, with more and more of its Self-Defense Forces equipment made there. The home-grown C-1 transport, of which 30 will be built in the next five-year plan, will carry a phased-array, early warning system.

Self-Defense planes—a close-support fighter and an antisubmarine patrol plane could be first— will almost surely have avionics hardware designed in Japan.

During the fourth plan, for example, Mitsubishi, Toshiba, and NEC will complete the R&D for an active antenna for aircraft fire-control systems. A tiny solid state transmitter-receiver will be tucked into each array element, and the elements will be scanned under the control of a common computer.

Fourth plan defense projects

There's also an airborne early warning system in the works, "something like the Grumman E-2", in the words of an official at Self-Defense headquarters in Rappongi. But instead of the E-2's big umbrella-like antenna, the Japanese plane will bristle with phased arrays at the rear of the fuselage. The system will fly on the C-1 twin-jet transport, of which 30 will be built during the fourth plan by Kawasaki Heavy Industries. Only one will be fitted with the unit, however; it's supposed to be flying by 1976.

Some noteworthy on-the-ground electronics hardware will be readied during the fourth plan, too. All six of Japan's native computer companies have a hand in the new automatic data-processing system. It's a $30 million project to develop a ruggedized, medium-size computer for field headquarters of divisions and will be paired with a status board so the commanding general can see what he has to cope with on the battlefield. As yet, the production unit contractor is not selected.

Then there's an electronic field telephone exchange, another $30 million project, for which NEC is prime contractor. This exchange will handle several hundred PCM channels, with random access to channels and discrete addresses. It's slated to be ready by 1976. Then there's an artillery-shell-spotting radar; the prototype should be ready next year.

Finally, the fourth plan will see some cleaning up of projects started earlier. The Self-Defense microwave network, a $45 million affair, will get its last links. And the air defense network will be bettered by replacing old hardware with Mitsubishi three-dimensional radars. The radars are similar to the air traffic control Mitsubishi offers [*Electronics*, June 21, p. 68].

Components get sidetracked

Components makers, by and large, have much the same notion of where they're going as do tourists strolling with the crowds in the back streets of Shinjinku, one of the fun-and-games sections of Tokyo. Like many a tourist, many a components maker has a gnawing feeling he's headed in the wrong direction.

And there's much to throw components manufacturers off the track they were on until last year. That track led to annual sales gains of 25% and more, but now, equipment makers, their own headlong rush checked, have slowed their components buying. In Japan, "it's traditional for companies to squeeze their subsidiaries when there's a recession," says Sharp executive director Sanai Mito. Export markets for components, too, have sagged.

There's an added woe for capacitor and resistor

Yasuhiro Kuroda of Nasda, Japan's space agency, has good reason to be optimistic. Japan's present space budget, at $60 million, is expected to double next year and keep on doubling for the next several years. Nasda is busily consolidating its grip on Japan's far-flung space agencies and programs.

makers. Their growth has long been stunted by ICs, which have been moving into the many fields of industrial hardware. Now there's a heavy rush to linear ICs for TV sets, a further jolt to resistor and capacitor makers. To cushion the jolt, EIA-J is trying to persuade its members to slow the rush. Even so, the outlook is so touch-and-go that an executive at one big maker of passive components, who understandably doesn't want the company identified, says the question top brass is asking these days is "What should we make and what technology should we use?"

Equally difficult is the question of market sizes. At Alps Electric Co., an independent parts maker, the feeling is that this year's components market will wind up between 6% and 10% ahead of 1970 and that 1972 at best will see no gain. At Murata Mfg. Co., Alps' assessment would look about right. Some other makers, though, expect a drop from 10% to 20%. *Electronics'* survey turned up a 1970 market of $2.35 billion, a 7.5% rise to $7.53 billion this year, and a slight drop to $7.52 billion next year.

MOS/LSI leads IC rise

There are pockets of visibility, nonetheless, when it comes to integrated circuits. They'll continue to zoom upward: it's not a question of whether, only how much. One big flurry at the moment centers on MOS/LSI packages for desk calculators. "There's almost as much controversy over calculator LSI here as there was over the SST back home," says an executive of a major American semiconductor house. So far, U.S. producers hold around three-quarters of the Japanese MOS/LSI market. "We hope to make it 50-50 next year" says Toshio Inoue, deputy manager for engineering of the devices group at Hitachi. The survey spots a rise in MOS/LSI next year to $102 million from this year's $64 million.

Hitachi, NEC, Toshiba, and Mitsubishi all have calculator-on-a-chip packages well along in development. Hitachi, in fact, already has a single-package unit—but with two chips inside—in production. The pair of chips totals 2,300 elements, and Hitachi insists it's competitive in cost with Texas Instruments' one-chip device, which touched off the rush to one-chip calculators. The TI package, competitors say, sells for $12 to $15 in large quantities. "TI is so strong that the fact they have a plant in Japan is not a factor," says a competitor.

Thus, a scramble for calculator LSI customers is in the offing. But it seems likely that prices will not tumble the way they did for transistor-transistor logic. Hiroe Osafune, general manager of the semiconductor division at NEC, cites two main reasons: only the smaller calculator producers, he feels, will settle for standard chips, and MITI undoubtedly will keep a protective cocoon around the Japanese MOS/LSI makers. MITI already has started throttling calculator LSI imports. "If we'd approved all the import applications, there would have been enough kits this year to make 4 million calculators," insists Yoshihiko Sekiyama, head of the agency's electronic and electrical machinery division.

Yoshihiko Sekiyama, head of MITI's electronic and electrical machinery division, defends his agency's cocoon around MOS/LSI makers. "If we'd approved all the import applications," he maintains, "there would have been enough kits this year to manufacture 4 million calculators."

Don't forget memories

By the time the calculator LSI market has stabilized, there'll surely be a groundswell for MOS/LSI memories for peripherals. Name any big Japanese semiconductor maker and you've named a company that is readying a line of MOS memories. At the outset, peripherals will be the main market, but by late 1973 or 1974 mainframes will be getting semiconductor memories, too. NEC's Osafune, as a matter of fact, expects that computer mainframes will head the list of outlets for the company's LSI production in two years or so. Memories for peripherals will rank second, followed by linear ICs, and finally by calculator LSI.

It's high tide already for consumer linear ICs. They'll spurt from $27 million this year to $50 million next, according to *Electronics'* survey. Japanese companies dominate that market, largely because most of the big IC companies have semiconductor divisions. Motorola, nonetheless, has managed to line up three setmakers as customers for its low-level synchronous detector for color TV and has been talking with three other good prospects. Shoji Akutsu, the company's sales manager for Japan, has high hopes for another advanced consumer IC, a coil-less multiplex decoder for fm stereo sets. Fairchild Semiconductor, too, has "some substantial programs" for color TV ICs, reports R.J. Coan, marketing manager for Japan.

Substantial will be an outright understatement for the orders that the first company on the market with a low-cost, solid state display will write. The advanced-technology companies are moving at flank speed to develop light-emitting diodes, liquid crystals, or anything else that can outshine the Nixie tube. The price threshold for a market explosion for seven-segment displays is 1.8 times the cost of a Nixie, estimates Hitachi's Inoue.

At the bottom of the list (or very close to it) must come receiving tubes, fast fading as OEM items. So shaky is the outlook for production of receiving tubes that the Self-Defense Agency next year will buy all the replacements it needs to keep its obsolescent tube-based hardware in action for the rest of its now-limited service life. Taps for the last receiving-tube plant in Japan will probably sound before 1980. □

Japanese electronics markets 1970-1972

Components

(millions of dollars)

	1970	1971	1972
Antennas, TV	23.3	25.7	23.6
Capacitors, fixed and variable	280.0	297.0	277.3
Connectors, plugs and sockets	53.0	61.0	63.6
Crystals and crystal filters	10.9	11.8	12.1
Delay lines	3.8	4.2	4.2
Display tubes	20.8	24.6	24.5
Loudspeakers (OEM type)	69.7	72.7	72.7
Magnetic tape	38.0	45.5	49.4
Microphones (OEM type)	18.8	20.8	21.8
Potentiometers, composition	65.3	71.5	71.5
Potentiometers, wire wound	15.8	16.8	16.8
Printed circuits	88.0	95.3	89.1
Relays	91.4	98.8	97.0
Resistors, fixed	113.5	115.0	100.3
Semiconductors, discrete	463.1	461.3	462.6
Microwave diodes	6.8	8.7	9.2
Rectifiers and diodes (rated more than 100 mA)	76.6	80.8	84.4
Signal diodes (rated less than 100 mA)	59.5	49.4	49.1
Thyristors, SCRs, four-layer diodes	26.7	32.1	37.9
Transistors, power	122.7	130.3	131.8
Transistors, small-signal	159.5	148.2	137.0
Zener diodes	11.3	11.7	13.2
Semiconductors, integrated circuits	204.9	259.9	320.4
Hybrid ICs, all types	23.2	28.8	39.2
Digital bipolar, small (less than 12 gates)	57.0	60.9	59.1
Digital bipolar, MSI (12 to 100 gates)	13.3	17.5	25.9
Digital bipolar LSI (more than 100 gates)	3.5	6.3	9.5
Digital MOS, small and MSI	59.1	46.8	22.7
Digital MOS, LSI	25.8	63.5	102.1
Linear ICs, (except operational amplifiers)	15.8	27.0	49.5
Operational amplifiers, monolithic only	7.2	9.1	12.4
Semiconductors, optoelectronic devices	2.9	7.9	12.6
Switches (for communications and electronics)	59.1	64.9	64.5
Transformers, chokes and coils (including TV yokes and flybacks)	255.5	301.5	297.0
Tubes, cathode ray (except for TV)	4.2	3.9	3.8
Tubes, power type (including microwave)	33.3	37.3	37.9
Tubes, receiving	50.0	31.8	21.2
Tubes, TV picture	387.9	400.0	375.8
TOTAL COMPONENTS	**2,353.2**	**2,529.1**	**2,519.7**

Note: Estimates in these charts are market figures and were developed from inputs supplied by some 80 companies. They reflect the market outlook as of Oct. 15, 1971, and are based on a conversion rate of $1=330 yen. Since at that time the value of the yen in terms of the dollar had not been finally set and there was no indication of how long the U.S. import surcharge would remain in effect, subsequent changes in both will significantly affect market prices.

Equipment

(factory prices in millions of dollars)

	1970	1971	1972
CONSUMER PRODUCTS			
Electronic ranges	68.2	66.7	84.9
Hi-fi component equipment	37.9	51.1	64.8
Stereo sets and combinations	280.6	296.7	304.5
Radios (including car radios)	169.7	186.7	204.2
Audio tape recorders	166.0	195.5	219.1
Video tape recorders (for home use)	8.5	12.1	18.2
TV sets, black and white	173.6	131.5	113.3
TV sets, color	1,403.0	1,500.0	1,454.5
TOTAL	2,307.5	2,440.3	2,463.5
COMPUTERS AND RELATED HARDWARE			
Analog and hybrid computers	6.1	6.1	6.1
Digital computers (except minicomputers)	395.2	456.1	530.3
Digital minicomputers (value to $13M)	17.4	22.0	27.6
Mass memories, external	261.0	312.1	387.9
Read-in and readout equipment	168.2	181.8	187.9
Remote terminal equipment	59.1	106.1	174.2
Electronic desk calculators	166.7	136.4	142.4
TOTAL	1,073.7	1,220.6	1,456.4
COMMUNICATIONS EQUIPMENT			
Broadcast equipment	73.5	75.5	78.2
Closed-circuit TV	15.8	16.7	18.6
Intercoms and intercom systems	13.6	15.2	16.8
Microwave relay systems	53.0	58.5	64.2
Navigation aids (except radar)	55.5	65.3	73.9
Radar (air, marine, ground)	40.6	43.6	47.6
Radio communications (except public broadcast)	134.7	150.5	168.2
Telephone switching, electronic or semielectronic	9.1	14.8	27.3
Wire message equipment (except telephone)	97.9	106.1	116.7
Wire telephone carrier equipment	154.5	170.5	187.3
TOTAL	648.2	716.7	798.8
INDUSTRIAL EQUIPMENT			
Industrial X-ray inspection and gauging equipment	30.3	32.1	33.3
Machine tool controls	40.9	42.4	42.4
Power electronics equipment	20.6	19.1	18.5
Process controls and related equipment (including computers)	291.5	266.7	266.7
Ultrasonic cleaning and inspection equipment	6.1	6.7	7.3
Welding equipment	30.3	33.3	34.8
TOTAL	419.7	400.3	403.0
TEST AND MEASURING INSTRUMENTS			
Amplifiers, laboratory type	10.6	11.2	11.9
Calibrators and standards, active and passive	15.2	16.4	16.7
Components testers	7.6	8.0	8.0
Counters and timers	7.3	7.8	7.9
Electronic meters, analog	10.3	11.5	11.7
Electronic meters, digital	4.4	4.9	5.4
Generators and synthesizers (to 1 GHz)	12.0	12.3	12.9
Microwave test and measuring instruments (above 1 GHz)	8.5	9.3	9.9
Oscillators	9.6	10.5	10.6
Oscilloscopes and accessories	28.5	29.8	30.0
Recorders, analog and digital	10.6	11.1	11.5
TOTAL	124.6	132.8	136.5
MEDICAL ELECTRONICS EQUIPMENT			
Diagnostic equipment, except X ray	22.7	26.7	31.2
Patient monitoring equipment	3.9	5.5	6.5
Therapeutic equipment, except X ray	7.6	8.8	10.2
X-ray equipment, diagnostic and therapeutic	40.0	43.0	49.4
TOTAL	74.2	84.0	97.3
TOTAL EQUIPMENT CONSUMPTION	4,647.9	4,994.7	5,355.5

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Press Pack Thyristors

Type Series	V_{BO} (V) peak	I_C A avg	I_{FM} A peak	T_j C max	Turn off time μs	Remarks
CA01	2,000–2,500	1,000	17,000	125	–	General use
CC02	800–1,200	300	15,000	125	–	
CC11	800–1 200	300	15,000	125	–	
CE11	200–800	600	10,000	125	–	
CH03	1,800–2,500	400	8,000	125	–	
CH11	200–1 600	400	5,500	125	–	
CJ11	200–1 000	250	3,500	125	–	
CH03V	800–1,200	400	8,000	115	50	Fast turn-off type
CH11V	200–600	400	5,000	125	20, 30, 50	
CJ11V	200–1,000	250	3,000	125	20, 30, 50	

Press Pack Reverse Conducting Triode Thyristors

Type Series	V_{FBO} (V) peak	I_O (A) avg	I_{FM} (A) peak	T_j (C) max	Turn-off time μs
CH04V	1,200	400	5,000	115	25
CJ51V	200–400	250	4,500	115	15,25

Press Pack Rectifier Diodes

Type Series	PRV (V) peak	I_O A avg	I_{FM} A peak	T_j C max
A01	2,500	1,600	26,000	150
C01	2,000–2,500	800	13,000	150
J11	800–1,200	200	2,000	125

HITACHI

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November 22, 1971

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1	22	43	64	85	106	127	148	169	190	211	232	253	274	295	316	337	358	379	400	421	442	463	484	960
2	23	44	65	86	107	128	149	170	191	212	233	254	275	296	317	338	359	380	401	422	443	464	485	961
3	24	45	66	87	108	129	150	171	192	213	234	255	276	297	318	339	360	381	402	423	444	465	486	962
4	25	46	67	88	109	130	151	172	193	214	235	256	277	298	319	340	361	382	403	424	445	466	487	963
5	26	47	68	89	110	131	152	173	194	215	236	257	278	299	320	341	362	383	404	425	446	467	488	964
6	27	48	69	90	111	132	153	174	195	216	237	258	279	300	321	342	363	384	405	426	447	468	489	965
7	28	49	70	91	112	133	154	175	196	217	238	259	280	301	322	343	364	385	406	427	448	469	490	966
8	29	50	71	92	113	134	155	176	197	218	239	260	281	302	323	344	365	386	407	428	449	470	491	967
9	30	51	72	93	114	135	156	177	198	219	240	261	282	303	324	345	366	387	408	429	450	471	492	968
10	31	52	73	94	115	136	157	178	199	220	241	262	283	304	325	346	367	388	409	430	451	472	900	969
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15	36	57	78	99	120	141	162	183	204	225	246	267	288	309	330	351	372	393	414	435	456	477	953	974
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18	39	60	81	102	123	144	165	186	207	228	249	270	291	312	333	354	375	396	417	438	459	480	956	977
19	40	61	82	103	124	145	166	187	208	229	250	271	292	313	334	355	376	397	418	439	460	481	957	978
20	41	62	83	104	125	146	167	188	209	230	251	272	293	314	335	356	377	398	419	440	461	482	958	979
21	42	63	84	105	126	147	168	189	210	231	252	273	294	315	336	357	378	399	420	441	462	483	959	980

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14	35	56	77	98	119	140	161	182	203	224	245	266	287	308	329	350	371	392	413	434	455	476	952	973
15	36	57	78	99	120	141	162	183	204	225	246	267	288	309	330	351	372	393	414	435	456	477	953	974
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17	38	59	80	101	122	143	164	185	206	227	248	269	290	311	332	353	374	395	416	437	458	479	955	976
18	39	60	81	102	123	144	165	186	207	228	249	270	291	312	333	354	375	396	417	438	459	480	956	977
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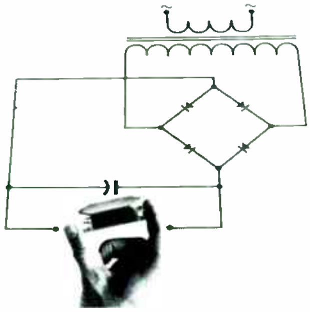

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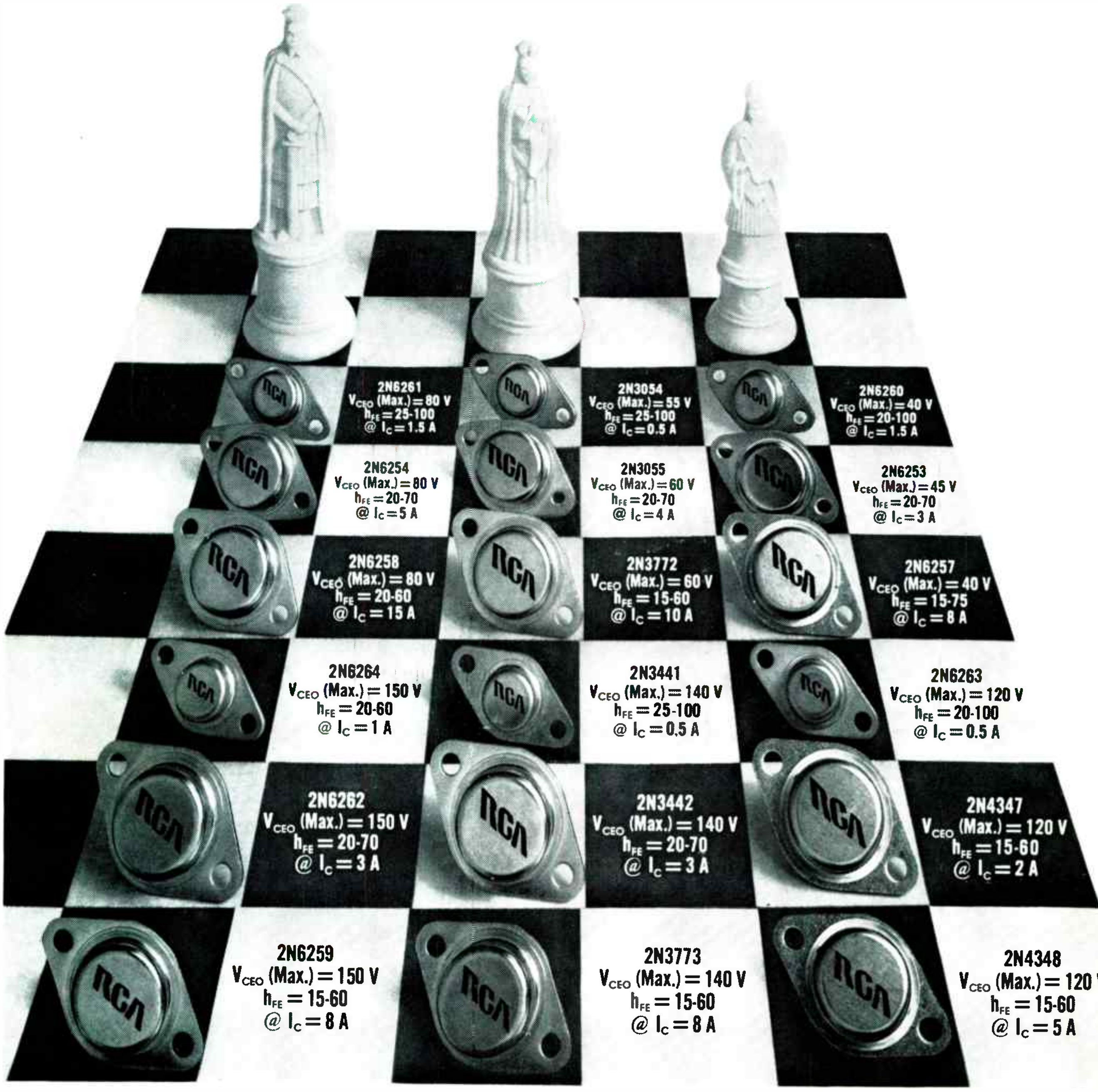

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