uary 18, 1973
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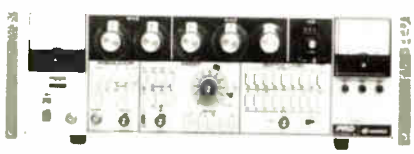
IMAGE SENSING WITH CHARGE-COUPLED DEVICES

6 Reasons to look to PRD for RF instruments

1 The 7815 Tunable Power Amplifier

It's tunable in 6 band-switched ranges from 10 to 500 MHz. Offers high power output (8 watts) and low distortion. Unit is solid state except for final amplifier tube, and provides output metering and overload protection. Has 2.0 to 5.0 MHz bandwidth.

Circle 211 on reader service card



2 The 7808 Synthesized Signal Generator

This is three instruments in one. It has synthesizer accuracy and stability, yet retains the manual tuning and sweep capabilities of conventional signal generators. Frequency range: 0.05 to 80 MHz in 1 kHz phase-locked steps, and an optional vernier provides 1 Hz resolution. Stability: 1 part in 10^6/mo. Frequency, modulation and attenuation are fully programmable.

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3 The 7828 Programmable Frequency Synthesizer

It's offered with 1 kHz phase-locked steps. An optional vernier provides 1 Hz resolution. It's fully programmable with contact closures, RTL, DTL, TTL logic. One part in 10^6/mo. stability; up to 1.0 volt output into 50 ohms.

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4 The 7805 Low Distortion Power Amplifier

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5 The NEW 7825 Wideband Power Amplifier

Designed for applications in the 10 Hz to 10 MHz range, this unit requires no tuning or adjustments and delivers 10 watts into a 50 ohm load with harmonics and intermodulation distortion down more than 40 dB. It provides over 15 watts with higher drive levels, and operates with 20 dB gain, overdrive protection and its 3 ohm output impedance will drive any load.

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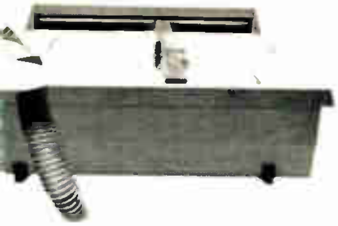

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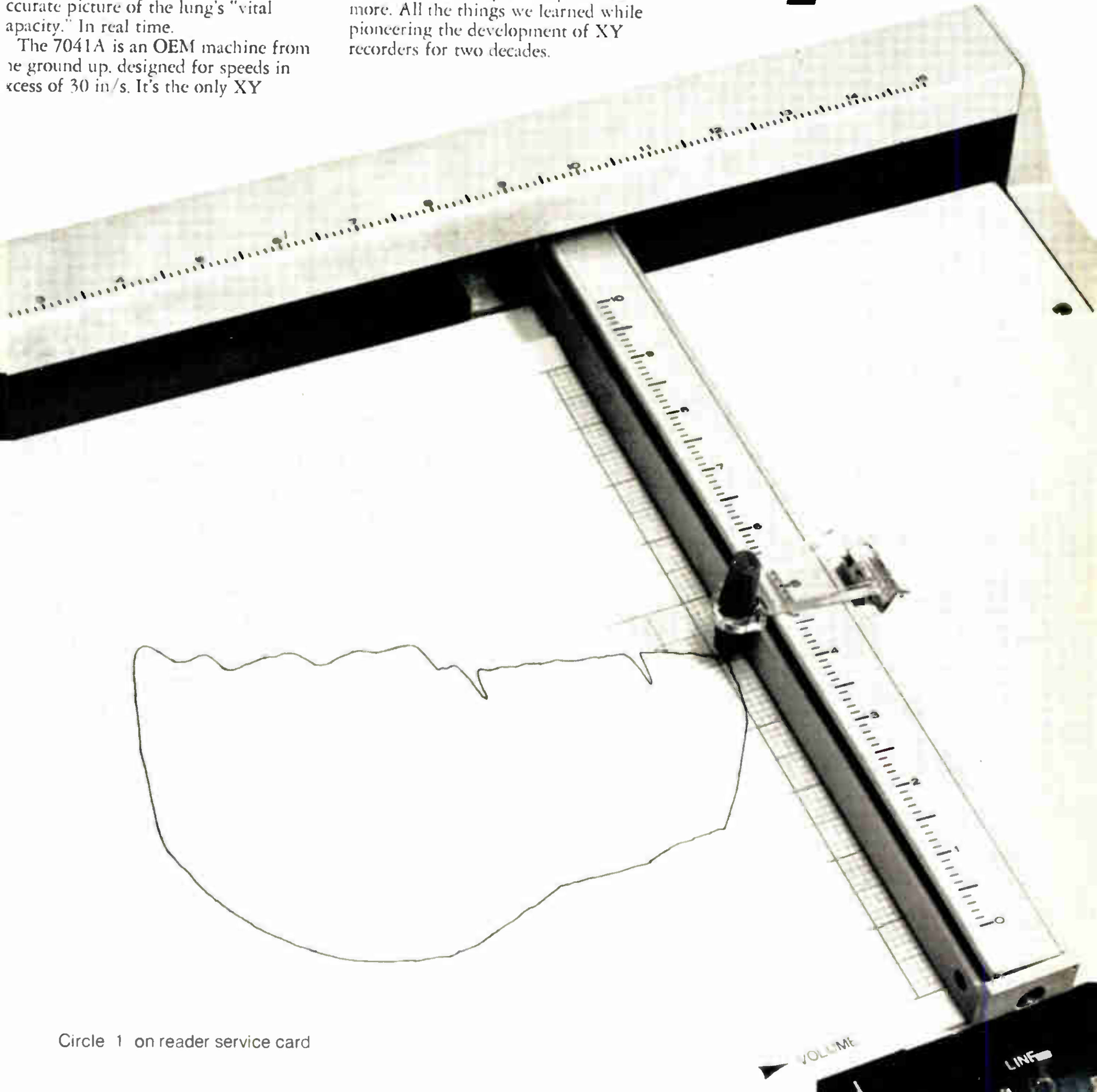

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For the really tough applications, OEM's like VIDAR choose HP.

How do you record millions of telephone calls daily, process this data, and bill millions of customers monthly — without any errors? The VITEL division of VIDAR tackled this problem and solved it with their unique new telephone message metering system.

To record the raw data, VIDAR needed a magnetic tape drive with proven reliability at a competitive price. That's why VIDAR chose HP's 7970E Tape Drive. They needed the best of both worlds and knew that HP quality was the result of 33 years of experience in engineering and mass production techniques that lower costs and improve reliability.

The VITEL system records "one-shot" data at a telephone company central office to provide accurate usage information. For instance, one system in a major metropolitan area handles 3.6 *million telephones* in over 100 offices. The system replaces mechanical message registers to bring a new level of accuracy to customer billing procedures.

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Circle 2 on reader service card

Electronics

The International Magazine of Electronics Technology

Vol. 46, No. 2 • January 18, 1973

Departments

APPLIED PHYSICS SECTION

Highlights

More join the ranks of the Army-Navy vendors, 135
Expectations that orders for ICs fabricated to Joint Army-Navy specifications will soon increase substantially have encouraged a lot of manufacturers to qualify as vendors with the Defense Electronics Supply Center. The present high prices of the very-high-reliability parts should drop as shipment sizes increase.

New cathode-ray tube creates color display, 155
Although displays in color convey more information more rapidly than black-and-white displays, the conventional color-TV tube is ill-adapted to this role. Therefore a special penetration tube has been developed that uses a single electron beam to obtain four colors and high resolution.

Charge-coupled devices will vie with vidicons, 162
As a solid-state substitute for the TV camera tube and for many other imaging applications, charge-coupling is almost an ideal technology. Its basic principle is simple, and even large chips can be made to produce quality images.

Easing the move from nonlinear to linear CAD, 174
By translating the parameters of a nonlinear charge-control transistor model into those of the linear hybrid-pi transistor model, a new program called Hypi enables its user to apply nonlinear data to linear circuit-analysis programs.

And in the next issue . . .
Magnetic sensor can read at any speed . . . a simple, low-cost way of designing program controllers . . . profile of a product design success.

The cover
A 106-by-126 element charge-coupled area device produced picture of Margaret Tompsett, wife of one of the authors of the article on p. 162. Also shown is a wafer containing 30 500-element charge-coupled linear devices.

The charge-coupled device story on page 162 details the latest refinements in applying this exciting new technology to imaging. Written by scientists at Bell Laboratories who pioneered in CCD imaging—Mike Tompsett, Wally Bertram, Dave Sealer and Carlos Séquin—the article shows how close to realization is an an all-solid-state video camera. Indeed, progress in CCD imaging is so impressive that the vidicon manufacturers are in a race to develop the first commercial CCD camera. The military is also interested in the attractive qualities of CCD imaging in both conventional and low-light-level cameras. Fairchild, TI, and RCA are competing in a big Navy contract that promises to yield a full-scale TV-quality camera by year's end.

Our bureau chief in Los Angeles, Paul Franson, has his byline on two articles in this issue. At Computer Automation, which is the subject of one Probing the News (see p. 142), Franson found an interesting sales trend. He says: "Where only recently OEM orders for minicomputers from that company were for five and 10 units, customers are interested in 500, 1,000, even 10,000 at a time. There's one quote out now for a 20,000–40,000-machine buy."

Franson also wrote the story on lasers emerging as an OEM component (see p. 144). He notes that lasers are entering the area of the use-price curve where a lot of action starts. They are, after years of waiting, being built into systems. Hughes, for one, is automating laser production to lower costs. Can increased laser applications be far behind?

The index of articles published in *Electronics* in 1972 will be available shortly. For a copy, circle 340 on the reader service card inside the back cover.

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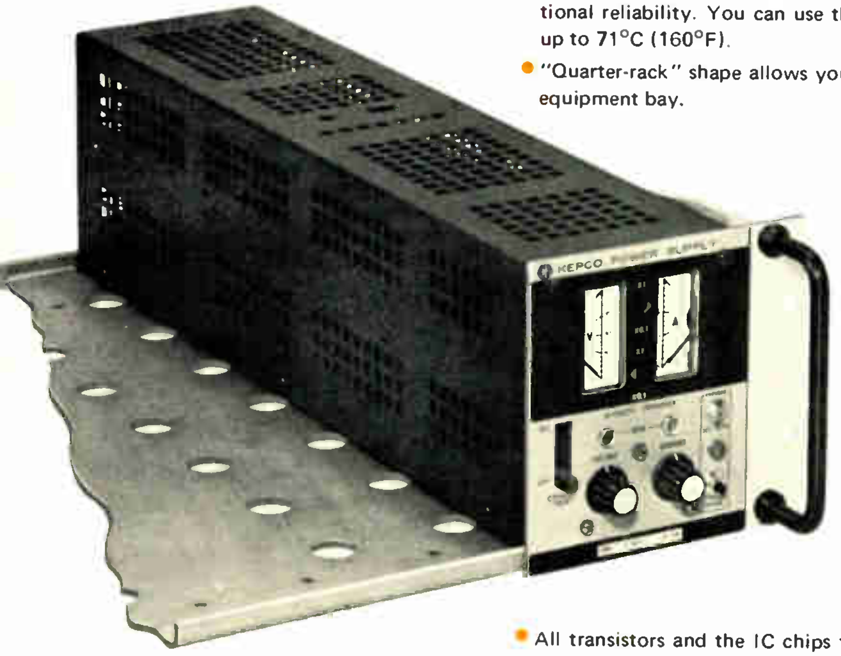

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Readers comment

Updating magnetic tapes

To the Editor: From the description in the article, "How to update tapes without recopying" [Nov. 6, 1972, p. 36], it appears that this procedure is based on the work of Roger Seeman of Boeing, who has reworked a program that I wrote several years ago. This program has been available for some time from the Digital Equipment Computer User's Society program library. I got the idea from David Custer of the Laboratory for Atmospheric and Space Physics, who published the original article about the general scheme in the Fall *Decus Symposium* in November 1969.

Mr. Seeman has carefully analyzed my original program, found a bug, and eliminated it.

A major weakness of industry-standard tape systems is that there is no way to permanently mark the tape on blocks, except by the kluge mentioned in the referenced article. A single-tape unit, thus, is rather useless in the small-computer environment, since it is difficult to use as a random-storage device. Most small-computer operating systems require such devices, hence the DECtape and cassettes with block-marks are desirable. The big advantage of industry-standard magtape is that it is the only magnetic storage medium that is interchangeable between large and small computers and between computers of differen[t] manufacturers.

John C. Alderman Jr
Digital Communications Associate[s]
Atlanta, Ga

■ *The story did indeed come fro[m] Roger Seeman, who credits Alderma[n] with the basic idea. Seeman expand[s] thus on Alderman's explanation "His program would work well fo[r] several days, but then the syste[m] would blow up. Although block-ad[dressing] is valuable to many peopl[e] the program wasn't used much be[cause] of this tendency."*

1972 index is available

The index of articles published i[n] Electronics in 1972 will be availabl[e] shortly. For a copy, circle 340 on th[e] reader service card inside the bac[k] cover.

Circle 7 on reader service card

40 years ago

From the pages of Electronics, January 1933

A quarter of a million automobile radios will be sold during 1933, according to estimates made by prominent radio and automotive manufacturers. This optimistic figure is based on the growth of sales figures during 1932 and is colored somewhat by the high degree of public interest shown late in the year. The average price of these sets will be in the neighborhood of $45 if sold without power supply or approximately $10 more for complete a.c. operation.

As a result of a field-strength survey in Ohio of broadcast stations on several frequencies made by Professor J.F. Byrne of Ohio State University, and reported in its Bulletin 71, there is no longer any need or excuse for an ostrich-like attitude on the relative merits of frequency assignment at the two extremes of the present band. Although the research did not take into account unfavorable location of the transmitter, the results are most important.

Professor Byrne's studies conclusively prove "that the different frequencies in the broadcast band cannot be treated as equivalent, and that frequencies of 1,000 kilocycles or above are uneconomical for large coverage and high power. They also indicate that low-power stations are at present wasting good low frequency assignments that are suitable for high power.

The Edgerton Stroboscope, recently described in *Electronics,* has been applied by the General Radio Company, Cambridge, Mass., in determining the register of color printing as it is speeding through the presses. Its usefulness is in "stopping" the motion of color printing as each color is applied. The application, o course, is only to rotary presses such as are used for printing comi sections and long-run magazines.

In operation, a suitable make and-break contact is fastened to on roller of the rotary press, which wil flash the stroboscope as each shee goes by. This will, of course, give th effect to the eye of the sheets standing still.

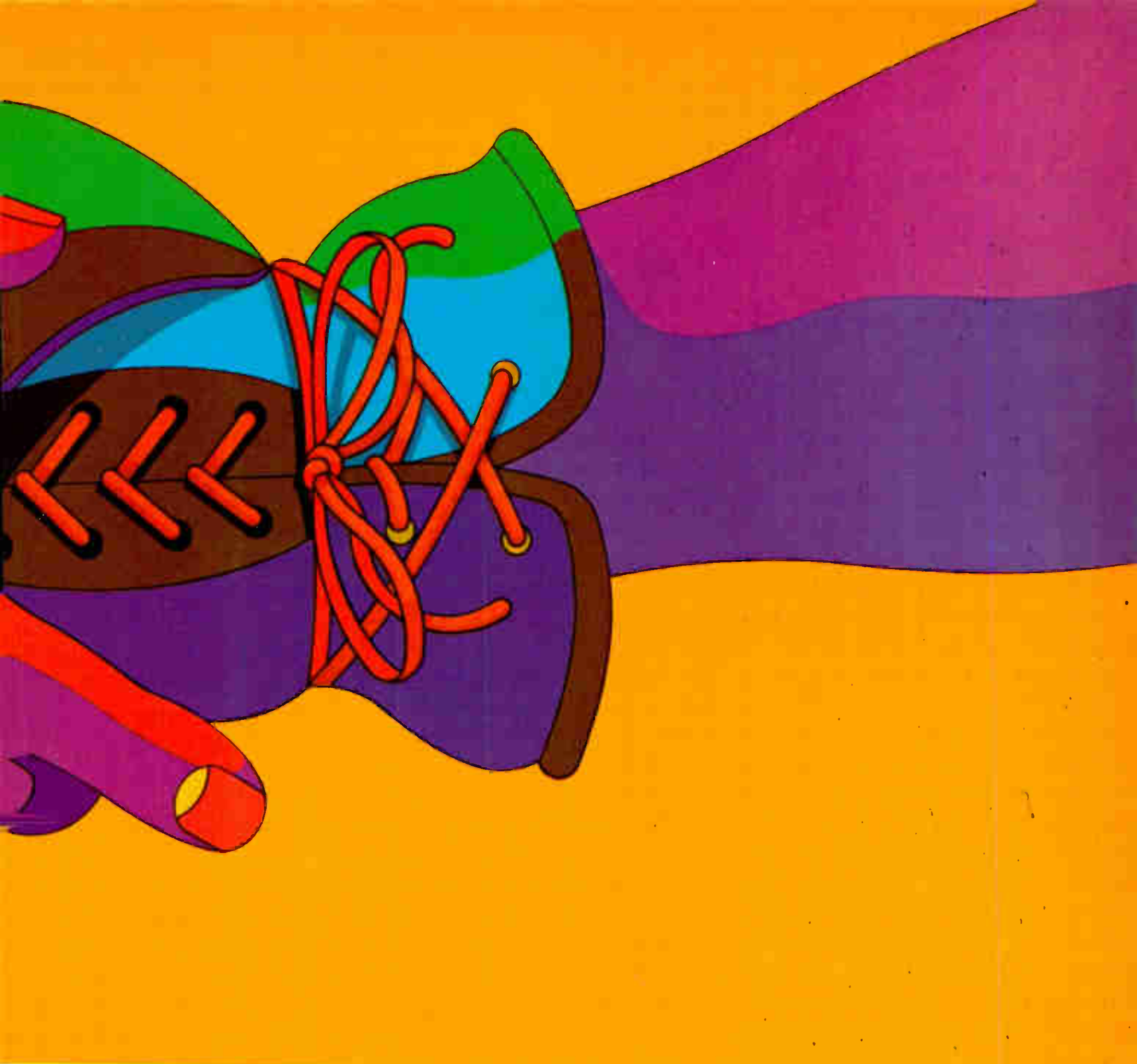
the data-processing industry. And with the addition a year ago of a new wafer-fabrication area totally committed to 3-inch wafers, the move to MOS is a natural. It was delayed somewhat, however, because the tremendous increase in the bipolar memory business took up much of the new facility's capacity.

The 32-year-old Downey, who had headed up MOS operations for Fairchild Semiconductor before moving to AMD, reports, "We are now in the process of establishing a business plan to develop a viable MOS operation." AMD presently has one MOS process in production (p-channel silicon-gate) with which it makes a 256-bit random-access memory, and Downey is planning to build on this foundation. "We are now deciding what new staff and equipment we will need for the near term." He feels that the present 3-in. wafer area with 30 tubes will suffice for a year, but then, "our total wafer requirement will be exceeded, and so a new facility will have to be added."

MOS trail. Downey has had quite a bit of experience in MOS. After he received his MSEE from the University of Arizona in 1964, he joined General Electric's Advanced Peripheral Equipment Lab in Sunnyvale. Two years later, he joined Fairchild Semiconductor as an MOS designer, became manager of the custom-MOS design center, and, from mid-1971 until September 1972, he was MOS operations manager. Then during one of the many management changes that have taken place in the Fairchild MOS department in the last year, he was made manager of operations for the joint venture of Fairchild and TDK of Japan. After getting Fairchild-TDK going, he joined AMD.

As for AMD's position in the MOS world, Downey says, "For now, we will concentrate on standard products" to get customers and to get visibility. He adds, however, "We will do custom work where it fits in with our standard-product goals," and he says that he is looking forward to heading an organization that defines, develops, and produces MOS and that "has the tools to do it."


Kamifuji



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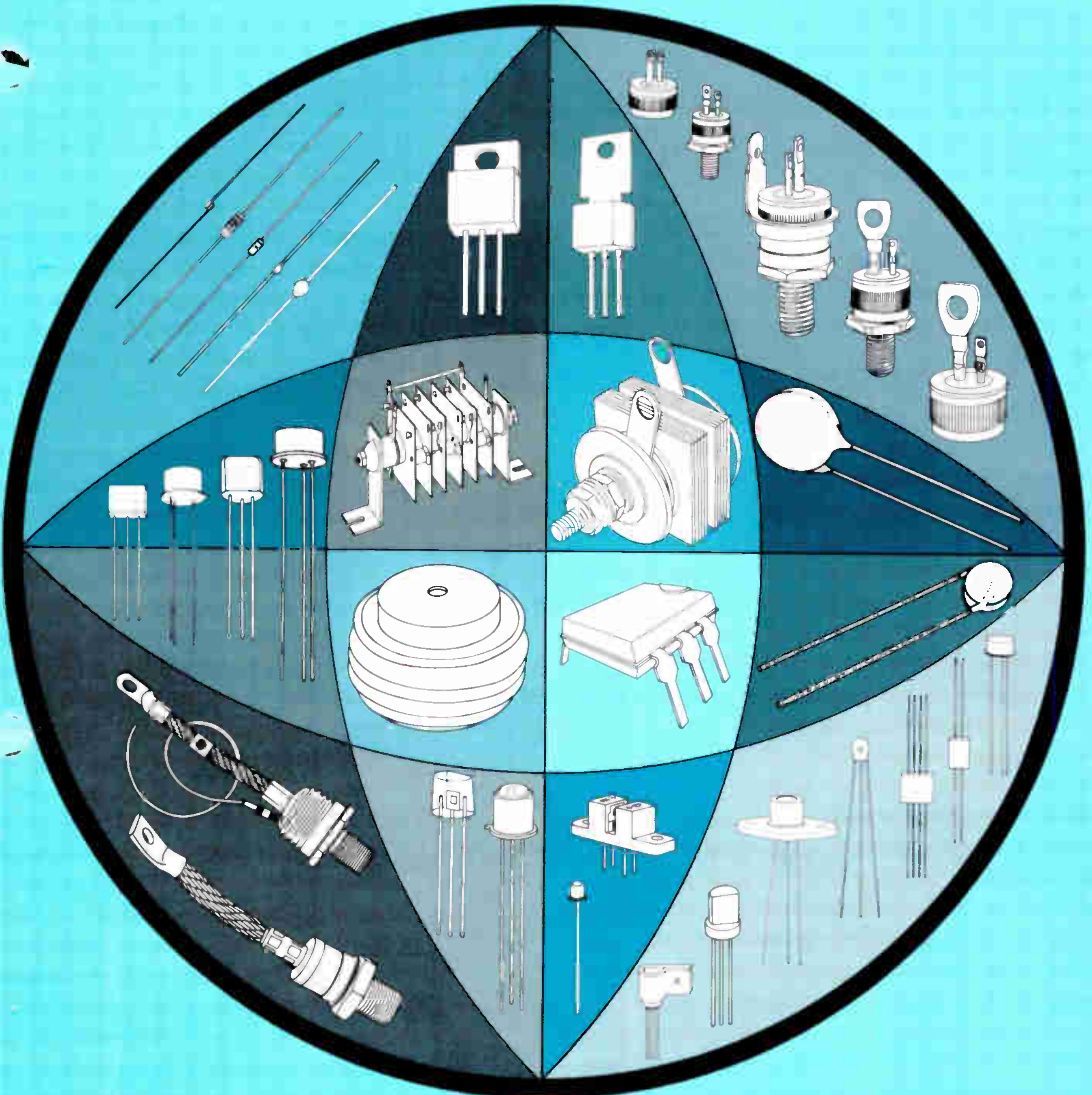

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*Denotes Series

SELECTOR GUIDE TO-18 SILICON SIGNAL TRANSISTORS

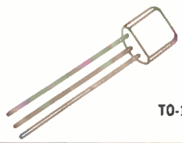
I_C (mA) / V_{CEO} (Volts)	50µA to 5mA		5mA to 25mA		25mA to 75mA		75mA to 800mA	
	NPN	PNP	NPN	PNP	NPN	PNP	NPN	PNP
10 to 19			GET706 GET3013 GET708 GET3563 GET914 GET3646 GET2369		GET706 GET2369 GET708 GET3013 GET914 GET3646		GET2369	
20 to 29	2N5810 2N6000 2N5812 2N6002	GET3638 2N5813 GET3638A 2N6001 2N5811 2N6003	GET3014 2N6002 2N6000 D32K1	GET3638 2N6001 GET3638A 2N6003	GET3014 2N6002 2N5451 D32K1 2N6000	GET3638 2N6001 GET3638A 2N6003 2N5447	2N5810 2N6002 2N5812 D32K1 2N6000	2N5811 2N6001 2N5813 2N6003
30 to 39	2N5368 D32P1 2N5369 D32P2 2N5370 D32P3 2N5371 D32P4	2N5372 2N5374 2N5373 2N5375	GET2221 2N5369 GET2222 2N5370 2N5368 2N5371	2N5372 2N5374 2N5373 2N5375	GET2221 2N5370 GET2222 2N5371 2N5368 2N5449 2N5369 2N5450	2N5372 2N5375 2N5373 2N5448 2N5374	2N5368 2N5370 2N5369 2N5371	2N5372 2N5374 2N5373 2N5375
40 to 49	2N5814 2N5827A 2N5816 2N5828 2N5818 2N5828A 2N5824 2N6004 2N5825 2N6006 2N5826 2N6010 2N5827 2N6012	GET2904 2N5819 GET2905 2N6005 GET2906 2N6007 GET2907 2N6011 2N5815 2N6013 2N5817	GET2221A 2N6006 GET2222A 2N6010 2N4994 2N6012 2N4995 D32K2 2N6004	GET2904 2N6005 GET2905 2N6007 GET2906 2N6011 GET2907 2N6013	GET2221A 2N6010 GET2222A 2N6012 2N6004 D32K2 2N6006	GET2904 2N6005 GET2905 2N6007 GET2906 2N6011 GET2907 2N6013	2N5814 2N6006 2N5816 2N6010 2N5818 2N6012 2N6004 D32K2	GET2904 2N5819 GET2905 2N6005 GET2906 2N6007 GET2907 2N6011 2N5815 2N6013 2N5817
50 to 59	GET929 GET930		GET929 GET930					
60 to 79	GET2484 2N6016 2N5820 2N6222 2N5822 2N6224 2N6014	2N5821 2N6017 2N5823 2N6223 2N6015 2N6225	GET2484 2N6222 2N6014 2N6224 2N6016	2N6015 2N6223 2N6017 2N6225	2N6014 2N6016	2N6015 2N6017	2N5820 2N6014 2N5821 2N6016 2N5822 2N5823	2N6015 2N6017
80 to 100	2N6218 2N6221 2N6219 2N6220		2N6218 2N6221 2N6219 2N6220					

SELECTOR GUIDE TO-98 SILICON SIGNAL

I_C (mA) / V_{CEO} (Volts)	50µA to 5mA		5mA to 25mA		25mA to 75mA		75mA to 800mA	
	NPN	PNP	NPN	PNP	NPN	PNP	NPN	PNP
to 19	2N2926 2N3662 2N3900 2N3663 2N3900A D16G6 2N3901		2N2926 2N3662 2N3900 2N3663 2N3900A D16G6 2N3901					
20 to 29	2N3390 2N3396 2N3391 2N3397 2N3391A 2N3398 2N3392 2N5172 2N3393 2N5998 2N3394 2N6008 2N3395	2N5354 2N6076 2N5355 2N5999 2N5356 2N6009	2N3390 2N5420 2N3391 2N5172 2N3391A 2N5998 2N3392 2N6008 2N3393 2N3402 2N3394 2N3403 2N3395 2N3414 2N3396 2N3415 2N3397 2N5305 2N3398 2N5306 2N5418 2N5306A 2N5419	2N5354 2N6076 2N5355 2N5999 2N5356 2N6009	2N5418 2N5305 2N5419 2N5306 2N5420 2N5306A 2N3402 2N5998 2N3403 2N6008 2N3414 D33D21 2N3415 D33D22	2N5354 2N6009 2N5355 D29E1 2N5356 D29E2 2N5999	D33D21 D33D22	D29E1 D29E2
30 to 39			2N3843 2N3854 2N3843A 2N3854A 2N3844 2N3855 2N3844A 2N3855A 2N3845 2N3856 2N3845A 2N3856A		2N3843 2N3854 2N3843A 2N3854A 2N3844 2N3855 2N3844A 2N3855A 2N3845 2N3856 2N3845A 2N3856A			
40 to 49	2N3858 2N3859 2N3860	D29F1 2N5365 D29F2 2N5366 D29F3 2N5367 D29F4	2N3858 2N4425 2N3859 2N5307 2N3860 2N5308 2N4424 2N5308A	D29F1 2N5365 D29F2 2N5366 D29F3 2N5367 D29F4	2N4424 D33D24 2N4425 D33D25 2N5307 D33D26 2N5308 D33D27 2N5308A	2N5365 D29E5 2N5366 D29E6 2N5367 D29E7 D29E4	D33D24 D33D25 D33D26 D33D27	D29E4 D29E5 D29E6 D29E7
50 to 59	2N5232 2N5309 2N5232A 2N5310 2N5249 2N5311 2N5249A		2N5232 2N5311 2N5232A 2N3404 2N5249 2N3405 2N5249A 2N3416 2N5309 2N3417 2N5310		2N3404 2N3405 2N3416 2N3417			
60 to 69	2N3858A 2N3859A 2N3860A	D29F5 D29F6 D29F7	2N3858A 2N3859A 2N3860A	D29F5 D29F6 D29F7	D33D29 D33D30	D29E9 D29E10	D33D29 D33D30	D29E9 D29E10
70 to 100	2N3877 2N5175 2N3877A 2N5176 2N5174		2N3877 2N5175 2N3877A 2N5176 2N5174					

MICRO MINIATURE EPOXY TRANSISTORS

V_{CEO} (Volts) \ I_C mA	To 5mA		5mA to 25mA		25mA to 75mA	
	NPN	PNP	NPN	PNP	NPN	PNP
0 to 19	D26G1 D26P1		D26P1		D26P1	
20 to 29	D26C1 D26C2 D26C3 D26C4 D26C5 D26P2 D26P3	D30A1 D30A2 D30A3 D30A4 D30A5	D26C1 D26C2 D26C3 D26C4 D26C5 D26P2 D26P3	D30A1 D30A2 D30A3 D30A4 D30A5	D26C1 D26C2 D26C3 D26C4 D26C5 D26P2 D26P3	D30A1 D30A2 D30A3 D30A4 D30A5
30 to 39						
40 to 49	D26E1 D26E2 D26E3 D26E4 D26E5 D26E6		D26E1 D26E2 D26E3 D26E4 D26E5 D26E6		D26E1 D26E2 D26E3 D26E4 D26E5 D26E6	



TO-18

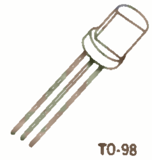
SILICON SIGNAL COMPLEMENTARY PAIRS

TO-18 PACKAGE

Device NPN	Device PNP	BV_{CEO} (V)	h_{FE} Min.-Max.	@ I_C, V_{CE} (V)	$V_{CE(SAT)}$ (V) Max.	@ I_C, I_B	Complement
2N5368		30	60-200	150mA,10	0.3	150mA,15mA	2N5372
2N5369		30	100-300	150mA,10	0.3	150mA,15mA	2N5373
2N5370		30	200-600	150mA,10	0.3	150mA,15mA	2N5374
2N5371		30	60-600	150mA,10	0.3	150mA,15mA	2N5375
	2N5372	30	40-120	150mA,10	0.3	150mA,15mA	2N5368
	2N5373	30	100-300	150mA,10	0.3	150mA,15mA	2N5369
	2N5374	30	200-400	150mA,10	0.3	150mA,15mA	2N5370
	2N5375	30	40-400	150mA,10	0.3	150mA,15mA	2N5371
2N5380		40	50-150	10mA,1	0.2	10mA,1mA	2N5382
2N5381		40	100-300	10mA,1	0.2	10mA,1mA	2N5383
	2N5382	40	50-150	10mA,1	0.2	10mA,1mA	2N5380
	2N5383	40	100-300	10mA,1	0.25	10mA,1mA	2N5381
	2N5447	25	60-300	50mA,5	0.25	50mA,5mA	2N5449
	2N5448	30	30-150	50mA,5	0.25	50mA,5mA	2N5450
2N5449		30	100-300	50mA,2	0.6	100mA,5mA	2N5447
2N5450		30	50-150	50mA,2	0.8	100mA,5mA	2N5448
2N5451		20	30-600	50mA,2	1.0	100mA,5mA	2N5447
2N5810		25	60-200	2mA,2	0.75	500mA,50mA	2N5811
	2N5811	25	60-200	2mA,2	0.75	500mA,50mA	2N5810
2N5812		25	150-500	2mA,2	0.75	500mA,50mA	2N5813
	2N5813	25	150-500	2mA,2	0.75	500mA,50mA	2N5812
2N5814		40	60-120	2mA,2	0.75	500mA,50mA	2N5815
	2N5815	40	60-120	2mA,2	0.75	500mA,50mA	2N5814
2N5816		40	100-200	2mA,2	0.75	500mA,50mA	2N5817
	2N5817	40	100-200	2mA,2	0.75	500mA,50mA	2N5816
2N5818		40	150-300	2mA,2	0.75	500mA,50mA	2N5819
	2N5819	40	150-300	2mA,2	0.75	500mA,50mA	2N5818
2N5820		60	60-120	2mA,2	0.75	500mA,50mA	2N5821
	2N5821	60	60-120	2mA,2	0.75	500mA,50mA	2N5820
2N5822		60	100-200	2mA,2	0.75	500mA,50mA	2N5823
	2N5823	60	100-200	2mA,2	0.75	500mA,50mA	2N5822
2N6000		25	100-300	10mA,1	0.4	300mA,30mA	2N6001
	2N6001	25	100-300	10mA,1	0.75	300mA,30mA	2N6000
2N6002		25	250-500	10mA,1	0.4	300mA,30mA	2N6003
	2N6003	25	250-500	10mA,1	0.75	300mA,30mA	2N6002
2N6004		40	100-300	10mA,1	0.4	300mA,30mA	2N6005
	2N6005	40	100-300	10mA,1	0.75	300mA,30mA	2N6004
2N6006		40	250-500	10mA,1	0.4	300mA,30mA	2N6007
	2N6007	40	250-500	10mA,1	0.75	300mA,30mA	2N6006
2N6010		40	100-300	10mA,1	0.25	300mA,30mA	2N6011
	2N6011	40	100-300	10mA,1	0.6	300mA,30mA	2N6010
2N6012		40	250-500	10mA,1	0.25	300mA,30mA	2N6013
	2N6013	40	250-500	10mA,1	0.6	300mA,30mA	2N6012
2N6014		60	100-300	10mA,1	0.25	300mA,30mA	2N6015
	2N6015	60	100-300	10mA,1	0.6	300mA,30mA	2N6014
2N6016		60	250-500	10mA,1	0.25	300mA,30mA	2N6017
	2N6017	60	250-500	10mA,1	0.6	300mA,30mA	2N6016
2N6222		60	75-200	2mA,5	0.125	10mA,1mA	2N6223
	2N6223	60	75-200	2mA,5	0.250	10mA,1mA	2N6222
2N6224		60	150-300	2mA,5	0.125	10mA,1mA	2N6225
	2N6225	60	150-300	2mA,5	0.250	10mA,1mA	2N6224
GET2221		30	40-120	150mA,10	0.3	150mA,15mA	GET2904
GET2221A		40	40-120	150mA,10	0.3	150mA,15mA	GET2904
GET2222		30	100-300	150mA,10	0.3	150mA,15mA	GET2905
GET2222A		40	100-300	150mA,10	0.3	150mA,15mA	GET2905
	GET2904	40	40-120	150mA,10	0.4	150mA,15mA	GET2221A
	GET2905	40	100-300	150mA,10	0.4	150mA,15mA	GET2222A
GET3903		40	50-150	10mA,12	0.3	50mA,5mA	GET3905
GET3904		40	100-300	10mA,12	0.3	50mA,5mA	GET3906
	GET3905	40	50-150	10mA,12	0.4	50mA,5mA	GET3903
	GET3906	40	100-300	10mA,12	0.4	50mA,5mA	GET3904

SILICON SIGNAL COMPLEMENTARY PAIRS

TO-98 OUTLINE

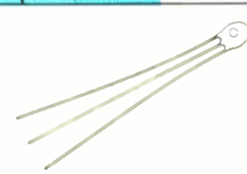


TO-98

Device NPN	Device PNP	BV_{CEO} (V)	h_{FE} Min.-Max.	@ I_C, V_{CE} (V)	$V_{CE(SAT)}$ (V) Max.	@ I_C, I_B	Complement
2N3858		40	60-120	2mA,5	0.125	10mA,1mA	D29F1
2N3859		40	100-200	2mA,5	0.125	10mA,1mA	D29F2
2N3860		40	150-300	2mA,5	0.125	10mA,1mA	D29F3
2N3858A		60	60-120	2mA,5	0.125	10mA,1mA	D29F5
2N3859A		60	100-200	2mA,5	0.125	10mA,1mA	D29F6
2N3860A		60	150-300	2mA,5	0.125	10mA,1mA	D29F7
2N5172		25	100-500	10mA,10	0.25	10mA,1MA	2N6076
2N5232		50	250-500	2mA,5	0.125	10mA,1mA	D29F4
	2N5354	25	40-120	50mA,1	0.25	50mA,2.5mA	2N5418
	2N5355	25	100-300	50mA,1	0.25	50mA,2.5mA	2N5419
	2N5356	25	250-500	50mA,1	0.25	50mA,2.5mA	2N5420
2N5418		25	40-120	50mA,1	0.25	50mA,2.5mA	2N5354
2N5419		25	100-300	50mA,1	0.25	50mA,2.5mA	2N5355
2N5420		25	250-500	50mA,1	0.25	50mA,2.5mA	2N5356
2N5998		25	150-300	10mA,2	0.25	50mA,2.5mA	2N5999
	2N5999	25	150-300	10mA,2	0.25	50mA,2.5mA	2N5998
2N6008		25	250-500	10mA,2	0.25	50mA,2.5mA	2N6009
	2N6009	25	250-500	10mA,2	0.25	50mA,2.5mA	2N6008
	2N6076	25	100-500	10mA,10	0.25	10mA,1mA	2N5172
	D29E1	25	60-200	2mA,2	0.75	500mA,50mA	D33D21
	D29E2	25	150-500	2mA,2	0.75	500mA,50mA	D33D22
	D29E4	40	60-120	2mA,2	0.75	500mA,50mA	D33D24
	D29E5	40	100-200	2mA,2	0.75	500mA,50mA	D33D25
	D29E6	40	150-300	2mA,2	0.75	500mA,50mA	D33D26
	D29E7	40	250-500	2mA,2	0.75	500mA,50mA	D33D27
	D29E9	60	60-120	2mA,2	0.75	500mA,50mA	D33D29
	D29E10	60	100-200	2mA,2	0.75	500mA,50mA	D33D30
	D29F1	40	60-120	2mA,5	0.25	10mA,1mA	2N3858
	D29F2	40	100-200	2mA,5	0.25	10mA,1mA	2N3859
	D29F3	40	150-300	2mA,5	0.25	10mA,1mA	2N3860
	D29F4	40	250-500	2mA,5	0.25	10mA,1mA	2N5232
	D29F5	60	60-120	2mA,5	0.25	10mA,1mA	2N3858A
	D29F6	60	100-200	2mA,5	0.25	10mA,1mA	2N3859A
	D29F7	60	150-300	2mA,5	0.25	10mA,1mA	2N3860A
D33D21		25	60-200	2mA,2	0.75	500mA,50mA	D29E1
D33D22		25	150-500	2mA,2	0.75	500mA,50mA	D29E2
D33D24		40	60-120	2mA,2	0.75	500mA,50mA	D29E4
D33D25		40	100-200	2mA,2	0.75	500mA,50mA	D29E5
D33D26		40	150-300	2mA,2	0.75	500mA,50mA	D29E6
D33D27		40	250-500	2mA,2	0.75	500mA,50mA	D29E7
D33D29		60	60-120	2mA,2	0.75	500mA,50mA	D29E9
D33D30		60	100-200	2mA,2	0.75	500mA,50mA	D29E10

SILICON SIGNAL COMPLEMENTARY PAIRS

MICRO MINIATURE PACKAGE



Device NPN	Device PNP	BV_{CEO} (V)	h_{FE} Min.-Max.	@ I_C, V_{CE} (V)	$V_{CE(SAT)}$ (V) Max.	@ I_C, I_B	Complement
D26C1		25	30-90	10mA,5	0.25	10mA,1mA	D30A1
D26C2		25	60-180	10mA,5	0.25	10mA,1mA	D30A2
D26C3		25	140-300	10mA,5	0.25	10mA,1mA	D30A3
D26C4		25	250-500	10mA,5	0.25	10mA,1mA	D30A4
D26C5		25	400-800	10mA,5	0.25	10mA,1mA	D30A5
	D30A1	25	30-90	10mA,5	0.25	10mA,1mA	D26C1
	D30A2	25	60-180	10mA,5	0.25	10mA,1mA	D26C2
	D30A3	25	140-300	10mA,5	0.25	10mA,1mA	D26C3
	D30A4	25	250-500	10mA,5	0.25	10mA,1mA	D26C4
	D30A5	25	400-800	10mA,5	0.25	10mA,1mA	D26C5

Advertisement

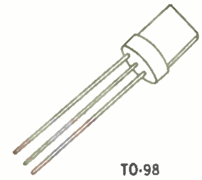
TO-18

SILICON SIGNAL GENERAL PURPOSE AMPLIFIERS
TO-18 OUTLINE

Device	Type	BV_{CEO} @ 10mA (V)	h_{FE} Min.-Max.	@ I_C, V_{CE} (V)	$V_{CE(sat)}$ (V) Max.	@ I_C, I_B	f_T Typical (MHz)	C_{ob} @ 10V, 1MHz Typical (Pf)	P_T @ 25°C (mW)
2N4954	NPN	45	40-160	10mA,10			400	1	360
2N4995	NPN	45	100-400	10mA,10			400	1	360
2N5368	NPN	30	60-200	150mA,10	.30	150mA,15mA	300	5	360
2N5369	NPN	30	100-300	150mA,10	.30	150mA,15mA	300	5	360
2N5370	NPN	30	200-600	150mA,10	.30	150mA,15mA	300	5	360
2N5371	NPN	30	60-600	150mA,10	.30	150mA,15mA	300	5	360
2N5372	PNP	30	40-120	150mA,10	.30	150mA,15mA	250	6	360
2N5373	PNP	30	100-300	150mA,10	.30	150mA,15mA	250	6	360
2N5374	PNP	30	200-400	150mA,10	30	150mA,15mA	250	6	360
2N5375	PNP	30	40-400	150mA,10	.30	150mA,15mA	250	6	360
2N5380	NPN	40	50-150	10mA,1	.2	10mA,1mA	300	4	360
2N5381	NPN	40	100-300	10mA,1	.2	10mA,1mA	300	4	360
2N5382	PNP	40	50-150	10mA,1	.25	10mA,1mA	300	4	360
2N5383	PNP	40	100-300	10mA,1	.25	10mA,1mA	300	4	360
2N5447	PNP	25	60-300	50mA,5	.25	50mA,5mA	150	8	360
2N5448	PNP	30	30-150	50mA,5	25	50mA,5mA	150	8	360
2N5449	NPN	30	100-300	50mA,2	6	100mA,5mA	150	7	625
2N5450	NPN	30	50-150	50mA,2	.8	100mA,5mA	150	7	625
2N5451	NPN	20	30-600	50mA,2	1.0	100mA,5mA	150	7	625
2N5810	NPN	25	60-200	2mA,2	.75	500mA,50mA	150	7	625
2N5811	PNP	25	60-200	2mA,2	.75	500mA,50mA	150	8	500
2N5812	NPN	25	150-500	2mA,2	.75	500mA,50mA	150	7	625
2N5813	PNP	25	150-500	2mA,2	.75	500mA,50mA	150	7	500
2N5814	NPN	40	60-120	2mA,2	.75	500mA,50mA	150	7	625
2N5815	PNP	40	60-120	2mA,2	.75	500mA,50mA	150	7	500
2N5816	NPN	40	100-200	2mA,2	.75	500mA,50mA	150	7	625
2N5817	PNP	40	100-200	2mA,2	.75	500mA,50mA	150	7	500
2N5818	NPN	40	150-300	2mA,2	.75	500mA,50mA	150	7	625
2N5819	PNP	40	150-300	2mA,2	.75	500mA,50mA	150	7	500
2N5820	NPN	60	60-120	2mA,2	.75	500mA,50mA	150	7	625
2N5821	PNP	60	60-120	2mA,2	.75	500mA,50mA	150	7	500
2N5822	NPN	60	100-200	2mA,2	.75	500mA,50mA	150	7	625
2N5823	PNP	60	100-200	2mA,2	.75	500mA,50mA	150	7	500
2N5824	NPN	40	60-120	2mA,2	.125	10mA,1mA	200	2	360
2N5825	NPN	40	100-200	2mA,5	.125	10mA,1mA	200	2	360
2N5826	NPN	40	150-300	2mA,5	.125	10mA,1mA	200	2	360
2N5827	NPN	40	250-500	2mA,5	.125	10mA,1mA	200	2	360
2N5827A	NPN	40	250-500	2mA,5	.125	10mA,1mA	200	2	360
2N5828	NPN	40	400-800	2mA,5	.125	10mA,1mA	200	2	360
2N5828A	NPN	40	400-800	2mA,5	.125	10mA,1mA	200	2	360
2N6000	NPN	25	100-300	10mA,1	.175	100mA,10mA	200	5	400
2N6001	PNP	25	100-300	10mA,1	.175	100mA,10mA	250	7	400
2N6002	NPN	25	250-500	10mA,1	.175	100mA,10mA	200	5	400
2N6003	PNP	25	250-500	10mA,1	.175	100mA,10mA	250	7	400
2N6004	NPN	40	100-300	10mA,1	.175	100mA,10mA	200	5	400
2N6005	PNP	40	100-300	10mA,1	.175	100mA,10mA	250	7	400
2N6006	NPN	40	250-500	10mA,1	.175	100mA,10mA	200	5	400
2N6007	PNP	40	250-500	10mA,1	.175	100mA,10mA	250	7	400
2N6010	NPN	40	100-300	10mA,1	.25	300mA,30mA	150	7	625
2N6011	PNP	40	100-300	10mA,1	.60	300mA,30mA	150	8	500
2N6012	NPN	40	250-500	10mA,1	.25	300mA,30mA	150	7	625
2N6013	PNP	40	250-500	10mA,1	.60	300mA,30mA	150	8	500
2N6014	NPN	60	100-300	10mA,1	.25	300mA,30mA	150	7	625
2N6015	PNP	60	100-300	10mA,1	.60	300mA,30mA	150	8	500
2N6016	NPN	60	250-500	10mA,1	.25	300mA,30mA	150	7	625
2N6017	PNP	60	250-500	10mA,1	.60	300mA,30mA	150	8	500
2N6218	NPN	300	20-	20mA,10	1.0	10mA,1mA	80	3	500
2N6219	NPN	250	20-	20mA,10	1 0	10mA,1mA	80	3	500
2N6220	NPN	200	20-	20mA,10	2.0	20mA,2mA	80	3	500
2N6221	NPN	150	20-	20mA,10	2 0	20mA 2mA	80	3	500
2N6222	NPN	60	75-200	2mA,5	.125	10mA,1mA	200	2	360
2N6223	PNP	60	75-200	2mA,5	.25	10mA,1mA	200	2	360
2N6224	NPN	60	150-300	2mA,5	.125	10mA,1mA	250	2	360
2N6225	PNP	60	150-300	2mA,5	.25	10mA,1mA	250	2	360
D32P1	NPN	30	40-80	2mA,5	.150	10mA,1mA	250	.9	360
D32P2	NPN	30	60-120	2mA,5	.150	10mA,1mA	250	.9	360
D32P3	NPN	30	100-200	2mA,5	.150	10mA,1mA	300	.9	360
D32P4	NPN	30	150-300	2mA,5	.150	10mA,1mA	300	.9	360
GET929	NPN	50	60-120	10μA,5	.125	10mA,1mA	200	2	360
GET930	NPN	50	100-300	10μA,5	.125	10mA,1mA	200	2	360
GET2221	NPN	30	40-120	150mA,10	.30	150mA,15mA	300	5	360
GET2221A	NPN	40	40-120	150mA,10	.30	150mA,15mA	300	5	360
GET2222	NPN	30	100-300	150mA,10	.30	150mA,15mA	300	5	360
GET2222A	NPN	40	100-300	150mA,10	.30	150mA,15mA	300	5	360
GET2484	NPN	60	150-900	2mA,5*	.35	1mA,.1mA	100	2	360
GET2904	PNP	40	40-120	150mA,10	.40	150mA,15mA	150	5	360
GET2905	PNP	40	40-120	150mA,10	.40	150mA,15mA	150	5	360
GET2906	PNP	40	100-300	150mA,10	.40	150mA,15mA	150	5	360
GET2907	PNP	40	100-300	150mA,10	.40	150mA,15mA	150	5	360
GET3563	NPN	12	20-200	8mA,10			750	.9	200
GET3638	PNP	25	30-800	50mA,1	.25	50mA,2 5mA	200	5	360
GET3638A	PNP	25	100-800	50mA,1	.25	50mA,2 5mA	200	5	360
GET3903	NPN	40	50-150	10mA,1	.3	50mA,5mA	250	4	310
GET3904	NPN	40	100-300	10mA,1	.3	50mA,5mA	250	4	310
GET3905	PNP	40	50-150	10mA,1	.4	50mA,5mA	250	4	310
GET3906	PNP	40	100-300	10mA,1	.4	50mA,5mA	250	4	310

SILICON SIGNAL GENERAL PURPOSE AMPLIFIERS

TO-98 OUTLINE



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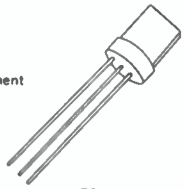
Device	Type	BV_{CEO} @ 10mA (V)	h_{FE} Min.-Max.	@ I_C, V_{CE} (V)	V (V) Max.	@ I_C, I_B	f_T Typical (MHz)	C_{ob} @ 10V, 1MHz Typical (Pf)	P_T @ 25 C (mw)
2N2711	NPN	18	30-90	2mA,5	1.6	50mA,3mA	120	7	360
2N2712	NPN	18	75-225	2mA,5	1.6	50mA,3mA	120	7	360
2N2713	NPN	18	30-90	2mA,5	0.3	50mA,3mA	120	5	360
2N2714	NPN	18	75-225	2mA,5	0.3	50mA,3mA	120	5	360
2N2923	NPN	25	90-180*	2mA,10	1.6	50mA,3mA	120	7	360
2N2924	NPN	25	150-300*	2mA,10	1.6	50mA,3mA	120	7	360
2N2925	NPN	25	235-470*	2mA,10	1.6	50mA,3mA	120	7	360
2N2926	NPN	18	35-470*	2mA,10	1.6	50mA,3mA	120	7	360
2N3390	NPN	25	400-800	2mA,5	1.6	50mA,3mA	120	7	360
2N3391	NPN	25	250-500	2mA,5	1.6	50mA,3mA	120	7	360
2N3391A	NPN	25	250-500	2mA,5	1.6	50mA,3mA	120	7	360
2N3392	NPN	25	150-300	2mA,5	1.6	50mA,3mA	120	7	360
2N3393	NPN	25	90-180	2mA,5	1.6	50mA,3mA	120	7	360
2N3394	NPN	25	55-110	2mA,5	1.6	50mA,3mA	120	7	360
2N3395	NPN	25	150-500	2mA,5	1.6	50mA,3mA	120	7	360
2N3396	NPN	25	90-500	2mA,5	1.6	50mA,3mA	120	7	360
2N3397	NPN	25	55-500	2mA,5	1.6	50mA,3mA	120	7	360
2N3398	NPN	25	55-800	2mA,5	1.6	50mA,3mA	120	7	360
2N3402	NPN	25	75-225	2mA,5	0.3	50mA,3mA	150	5	560
2N3403	NPN	25	180-540	2mA,5	0.3	50mA,3mA	150	5	560
2N3404	NPN	50	75-225	2mA,5	0.3	50mA,3mA	150	5	560
2N3405	NPN	50	180-540	2mA,5	0.3	50mA,3mA	150	5	560
2N3414	NPN	25	75-225	2mA,5	0.3	50mA,3mA	150	5	360
2N3415	NPN	25	180-540	2mA,5	0.3	50mA,3mA	150	5	360
2N3416	NPN	50	75-225	2mA,5	0.3	50mA,3mA	150	5	360
2N3417	NPN	50	180-540	2mA,5	0.3	50mA,3mA	150	5	360
2N3662	NPN	12	20-	8mA,10	0.6	10mA,1mA	1000	.9	200
2N3663	NPN	12	20-	8mA,10	0.6	10mA,1mA	1000	.9	200
2N3843	NPN	30	20-40	2mA,5	0.2	10mA,1mA	150	2	360
2N3843A	NPN	30	20-40	2mA,5	0.2	10mA,1mA	150	2	360
2N3844	NPN	30	35-70	2mA,5	0.2	10mA,1mA	150	2	360
2N3844A	NPN	30	35-70	2mA,5	0.2	10mA,1mA	150	2	360
2N3845	NPN	25	60-120	2mA,5	0.2	10mA,1mA	150	2	360
2N3845A	NPN	25	60-120	2mA,5	0.2	10mA,1mA	150	2	360
2N3854	NPN	36	35-70	2mA,5	0.2	10mA,1mA	200	1.7	360
2N3854A	NPN	36	35-70	2mA,5	0.2	10mA,1mA	200	1.7	360
2N3855	NPN	36	60-120	2mA,5	0.2	10mA,1mA	200	1.7	360
2N3855A	NPN	36	60-120	2mA,5	0.2	10mA,1mA	200	1.7	360
2N3856	NPN	36	100-200	2mA,5	0.2	10mA,1mA	200	1.7	360
2N3856A	NPN	36	100-200	2mA,5	0.2	10mA,1mA	200	1.7	360
2N3858	NPN	40	60-120	2mA,5	.125	10mA,1mA	150	2	360
2N3858A	NPN	60	60-120	2mA,5	.125	10mA,1mA	150	2	360
2N3859	NPN	40	100-200	2mA,5	.125	10mA,1mA	150	2	360
2N3859A	NPN	60	100-200	2mA,5	.125	10mA,1mA	150	2	360
2N3860	NPN	40	150-300	2mA,5	.125	10mA,1mA	150	2	360
2N3900	NPN	18	250-500	2mA,5	1.6	50mA,3mA	120	7	360
2N3900A	NPN	18	250-500	2mA,5	1.6	50mA,3mA	120	7	360
2N3901	NPN	25	350-700	2mA,5	1.6	50mA,3mA	120	7	360
2N4424	NPN	40	180-540	2mA,5	0.3	50mA,3mA	150	5	360
2N4425	NPN	40	180-540	2mA,5	0.3	50mA,3mA	150	5	360
2N5172	NPN	25	100-500	10mA,10	0.25	10mA,1mA	100	2	360
2N5232	NPN	50	250-500	2mA,5	.125	10mA,1mA	150	2	360
2N5232A	NPN	50	250-500	2mA,5	.125	10mA,1mA	150	2	360
2N5249	NPN	50	400-800	2mA,5	.125	10mA,1mA	150	2	360
2N5249A	NPN	50	400-800	2mA,5	.125	10mA,1mA	150	2	360
2N5309	NPN	50	60-120	10μA,5	.125	10mA,1mA	150	2	360
2N5310	NPN	50	100-300	10μA,5	.125	10mA,1mA	150	2	360
2N5311	NPN	50	250-500	10μA,5	.125	10mA,1mA	150	2	360
2N5354	PNP	25	40-120	50mA,1	0.25	50mA,2.5mA	350	5	360
2N5355	PNP	25	100-300	50mA,1	0.25	50mA,2.5mA	350	5	360
2N5356	PNP	25	250-500	50mA,1	0.25	50mA,2.5mA	350	5	360
2N5365	PNP	40	40-120	50mA,1	0.25	50mA,2.5mA	350	5	360
2N5366	PNP	40	100-300	50mA,1	0.25	50mA,2.5mA	350	5	360
2N5367	PNP	40	250-500	50mA,1	0.25	50mA,2.5mA	350	5	360

* h_{FE} at 1KHz



TO-98

SILICON SIGNAL GENERAL PURPOSE AMPLIFIERS

TO-98 OUTLINE

Device	Type	BV_{CEO} @ 10mA (V)	h_{FE} Min.-Max.	@ I_C, V_{CE} (V)	$V_{CE(sat)}$ (V) Max.	@ I_C, I_B	f_T Typical (MHz)	C_{ob} @ 10V, 1MHz Typical (Pf)	P_T @ 25°C (mw)
2N5418	NPN	25	40-120	50mA,1	0.25	50mA,2.5mA	250	4	400
2N5419	NPN	25	100-300	50mA,1	0.25	50mA,2.5mA	250	4	400
2N5420	NPN	25	250-500	50mA,1	0.25	50mA,2.5mA	250	4	400
2N5998	NPN	25	150-300	10mA,2	0.25	50mA,2.5mA	250	4	400
2N5999	PNP	25	150-300	10mA,2	0.25	50mA,2.5mA	350	5	400
2N6008	NPN	25	250-500	10mA,2	0.25	50mA,2.5mA	250	4	400
2N6009	PNP	25	250-500	10mA,2	0.25	50mA,2.5mA	350	5	400
2N6076	PNP	25	100-500	10mA,10	0.25	10mA,1mA	300	5	360
D16G6	NPN	12	20-	8mA,10	0.6	10mA,1mA	1000	0.9	200
D29E1	PNP	25	60-200	2mA,2	0.75	500mA,50mA	150	9.4	500
D29E2	PNP	25	150-500	2mA,2	0.75	500mA,50mA	165	9.4	500
D29E4	PNP	40	60-120	2mA,2	0.75	500mA,50mA	120	9.4	500
D29E5	PNP	40	100-200	2mA,2	0.75	500mA,50mA	135	9.4	500
D29E6	PNP	40	150-300	2mA,2	0.75	500mA,50mA	150	9.4	500
D29E7	PNP	40	250-500	2mA,2	0.75	500mA,50mA	165	9.4	500
D29F9	PNP	60	60-120	2mA,2	0.75	500mA,50mA	120	9.4	500
D29E10	PNP	60	100-200	2mA,2	0.75	500mA,50mA	135	9.4	500
D29F1	PNP	40	60-120	2mA,5	0.25	10mA,1mA	150	2.1	360
D29F2	PNP	40	100-200	2mA,5	0.25	10mA,1mA	150	2.1	360
D29F3	PNP	40	150-300	2mA,5	0.25	10mA,1mA	150	2.1	360
D29F4	PNP	40	250-500	2mA,5	0.25	10mA,1mA	150	2.1	360
D29F5	PNP	60	60-120	2mA,5	0.25	10mA,1mA	150	2.1	360
D29F6	PNP	60	100-200	2mA,5	0.25	10mA,1mA	150	2.1	360
D29F7	PNP	60	150-300	2mA,5	0.25	10mA,1mA	150	2.1	360
D33D21	NPN	25	60-200	2mA,2	0.75	500mA,50mA	150	9.4	625
D33D22	NPN	25	150-500	2mA,2	0.75	500mA,50mA	165	9.4	625
D33D24	NPN	40	60-120	2mA,2	0.75	500mA,50mA	120	9.4	625
D33D25	NPN	40	100-200	2mA,2	0.75	500mA,50mA	135	9.4	625
D33D26	NPN	40	150-300	2mA,2	0.75	500mA,50mA	150	9.4	625
D33D27	NPN	40	250-500	2mA,2	0.75	500mA,50mA	165	9.4	625
D33D29	NPN	60	60-120	2mA,2	0.75	500mA,50mA	120	9.4	625
D33D30	NPN	60	100-200	2mA,2	0.75	500mA,50mA	135	9.4	625

18.3

SILICON SIGNAL GENERAL PURPOSE AMPLIFIERS

MICRO MINIATURE PACKAGE

Device	Type	BV_{CEO} (V)	h_{FE} Min.-Max.	@ I_C, V_{CE} (V)	$V_{CE(sat)}$ (V) Max.	@ I_C, I_B	f_T Typical (MHz)	C_{ob} @ 10V, 1MHz Typical (Pf)	P_T @ 25°C (mw)
D26C1	NPN	25	30-90	10mA,5	0.25	10mA,1mA	250	5	90
D26C2	NPN	25	60-180	10mA,5	0.25	10mA,1mA	250	5	90
D26C3	NPN	25	140-300	10mA,5	0.25	10mA,1mA	250	5	90
D26C4	NPN	25	250-500	10mA,5	0.25	10mA,1mA	250	5	90
D26C5	NPN	25	400-800	10mA,5	0.25	10mA,1mA	250	5	90
D26E1	NPN	45	100-300	10μA,5	1.0	10mA,0.5mA	150	2	90
D26E2	NPN	40	40-90	100μA,2.5	0.25	10mA,1mA	150	2	90
D26E3	NPN	40	70-145	100μA,2.5	0.25	10mA,1mA	150	2	90
D26E4	NPN	40	115-220	100μA,2.5	0.25	10mA,1mA	150	2	90
D26E5	NPN	40	180-330	100μA,2.5	0.25	10mA,1mA	150	2	90
D26E6	NPN	40	40-330	100μA,2.5	0.25	10mA,1mA	150	2	90
D26G1	NPN	15	20-	3mA,1	0.4	10mA,1mA	1000	0.9	90
D30A1	PNP	25	30-90	10mA,5	0.25	10mA,1mA	250	5	90
D30A2	PNP	25	60-180	10mA,5	0.25	10mA,1mA	250	5	90
D30A3	PNP	25	140-300	10mA,5	0.25	10mA,1mA	250	5	90
D30A4	PNP	25	250-500	10mA,5	0.25	10mA,1mA	250	5	90
D30A5	PNP	25	400-800	10mA,5	0.25	10mA,1mA	250	5	90
D26P1	NPN	12	2000-	2mA,5	1.0	50mA,50μA	60	7.6	90
D26P2	NPN	25	2000-20000	2mA,5	1.0	50mA,50μA	60	7.6	90
D26P3	NPN	25	7000-70000	2mA,5	1.0	50mA,50μA	60	7.6	90

SILICON SIGNAL GENERAL PURPOSE SWITCHES
TO-18 OUTLINE


TO-18

Device	Type	BV_{CEO} (V)	t_{on}	t_{off}	Conditions
2N5368	NPN	30	40nsec	350nsec	I_C = 150mA, I_B = 15mA, V_{CC} = 30V
2N5369	NPN	30	40nsec	350nsec	I_C = 150mA, I_B = 15mA, V_{CC} = 30V
2N5370	NPN	30	40nsec	400nsec	I_C = 150mA, I_B = 15mA, V_{CC} = 30V
2N5371	NPN	30	40nsec	400nsec	I_C = 150mA, I_B = 15mA, V_{CC} = 30V
2N5372	PNP	30	50nsec	150nsec	I_C = 150mA, I_B = 15mA, V_{CC} = 30V
2N5373	PNP	30	50nsec	150nsec	I_C = 150mA, I_B = 15mA, V_{CC} = 30V
2N5374	PNP	30	50nsec	175nsec	I_C = 150mA, I_B = 15mA, V_{CC} = 30V
2N5375	PNP	30	50nsec	175nsec	I_C = 150mA, I_B = 15mA, V_{CC} = 30V
2N6000	NPN	25	25nsec	320nsec	I_C = 150mA, I_{B1} = $-I_{B2}$ = 15mA, V_{CC} = 30V
2N6001	PNP	25	23nsec	230nsec	I_C = 150mA, I_{B1} = $-I_{B2}$ = 15mA, V_{CC} = 30V
2N6002	NPN	25	25nsec	410nsec	I_C = 150mA, I_{B1} = $-I_{B2}$ = 15mA, V_{CC} = 30V
2N6003	PNP	25	23nsec	300nsec	I_C = 150mA, I_{B1} = $-I_{B2}$ = 15mA, V_{CC} = 30V
2N6004	NPN	40	25nsec	320nsec	I_C = 150mA, I_{B1} = $-I_{B2}$ = 15mA, V_{CC} = 30V
2N6005	PNP	40	23nsec	230nsec	I_C = 150mA, I_{B1} = $-I_{B2}$ = 15mA, V_{CC} = 30V
2N6006	NPN	40	25nsec	410nsec	I_C = 150mA, I_{B1} = $-I_{B2}$ = 15mA, V_{CC} = 30V
2N6007	PNP	40	23nsec	300nsec	I_C = 150mA, I_{B1} = $-I_{B2}$ = 15mA, V_{CC} = 30V
2N6010	NPN	40	37nsec	400nsec	I_C = 150mA, I_{B1} = $-I_{B2}$ = 15mA, V_{CC} = 30V
2N6011	PNP	40	45nsec	425nsec	I_C = 150mA, I_{B1} = $-I_{B2}$ = 15mA, V_{CC} = 30V
2N6012	NPN	40	37nsec	500nsec	I_C = 150mA, I_{B1} = $-I_{B2}$ = 15mA, V_{CC} = 30V
2N6013	PNP	40	45nsec	525nsec	I_C = 150mA, I_{B1} = $-I_{B2}$ = 15mA, V_{CC} = 30V
2N6014	NPN	60	37nsec	400nsec	I_C = 150mA, I_{B1} = $-I_{B2}$ = 15mA, V_{CC} = 30V
2N6015	PNP	60	45nsec	425nsec	I_C = 150mA, I_{B1} = $-I_{B2}$ = 15mA, V_{CC} = 30V
2N6016	NPN	60	37nsec	500nsec	I_C = 150mA, I_{B1} = $-I_{B2}$ = 15mA, V_{CC} = 30V
2N6017	PNP	60	45nsec	525nsec	I_C = 150mA, I_{B1} = $-I_{B2}$ = 15mA, V_{CC} = 30V
GET2221A	NPN	40	35nsec	285nsec	I_{CC} = 150mA, I_{B1} = I_{B2} = 15mA, V_{CC} = 30V
GET2222A	NPN	40	35nsec	285nsec	I_{CC} = 150mA, I_{B1} = I_{B2} = 15mA, V_{CC} = 30V
GET2904	PNP	40	50nsec	110nsec	I_{CC} = 150mA, I_{B1} = I_{B2} = 15mA, V_{CC} = 30V
GET2905	PNP	40	50nsec	110nsec	I_{CC} = 150mA, I_{B1} = I_{B2} = 15mA, V_{CC} = 30V
GET2906	PNP	40	50nsec	110nsec	I_{CC} = 150mA, I_{B1} = I_{B2} = 15mA, V_{CC} = 30V
GET2907	PNP	40	50nsec	110nsec	I_C = 150mA, I_{B1} = I_{B2} = 15mA, V_{CC} = 30V
GET3638	PNP	25	75nsec	170nsec	I_C = 300mA, I_{B1} = $-I_{B2}$ = 30mA, V_{CC} = 10V
GET3638A	PNP	25	75nsec	170nsec	I_C = 300mA, I_{B1} = $-I_{B2}$ = 30mA, V_{CC} = 10V
GET3903	NPN	40	70nsec	225nsec	I_C = 10mA, I_{B1} = I_{B2} = 1mA, V_{CC} = 10V
GET3904	NPN	40	70nsec	250nsec	I_C = 10mA, I_{B1} = I_{B2} = 1mA, V_{CC} = 10V
GET3905	PNP	40	70nsec	260nsec	I_C = 10mA, I_{B1} = I_{B2} = 1mA, V_{CC} = 10V
GET3906	PNP	40	70nsec	350nsec	I_C = 10mA, I_{B1} = I_{B2} = 1mA, V_{CC} = 10V

SILICON SIGNAL DARLINGTON AMPLIFIERS
TO-18 OUTLINE

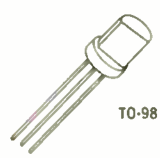
Device NPN	BV_{CEO} (V)	h_{FE} Min.-Max.	@ I_C, V_{CE} (V)	$V_{CE(SAT)}$ (V) Max.	@ I_C, I_B
GET5305	25	2K-20K	2mA,5	1.4	200mA,200μA
GET5306	25	7K-70K	2mA,5	1.4	200mA,200μA
GET5306A	25	7K-70K	2mA,5	1.4	200mA,200μA
GET5307	40	2K-20K	2mA,5	1.4	200mA,200μA
GET5308	40	7K-70K	2mA,5	1.4	200mA,200μA
GET5308A	40	7K-70K	2mA,5	1.4	200mA,200μA

SILICON SIGNAL DARLINGTON AMPLIFIERS
TO-98 OUTLINE


TO-18

Device NPN	BV_{CEO} (V)	h_{FE} Min.-Max.	@ I_C, V_{CE} (V)	$V_{CE(SAT)}$ (V) Max.	@ I_C, I_B
2N5305	25	2K-20K	2mA,5	1.4	200mA,200μA
2N5306	25	7K-70K	2mA,5	1.4	200mA,200μA
2N5306A	25	7K-70K	2mA,5	1.4	200mA,200μA
2N5307	40	2K-20K	2mA,5	1.4	200mA,200μA
2N5308	40	7K-70K	2mA,5	1.4	200mA,200μA
2N5308A	40	7K-70K	2mA,5	1.4	200mA,200μA
D16P1	12	2K-	2mA,5	1.4	200mA,200μA

SILICON SIGNAL HIGH VOLTAGE TYPES
TO-18 OUTLINE


TO-98

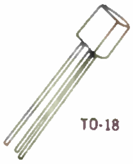
Device NPN	BV_{CEO} (V)	h_{FE} Min.-Max.	@ I_C, V_{CE} (V)	I_{CBO} Max.	@ V_{CB} (V)	$V_{CE(SAT)}$ (V) Max.	@ I_C, I_B
2N6218	300	20	20mA,10	500nA	250	1.0	10mA,1mA
2N6219	250	20	20mA,10	1μA	200	1.0	10mA,1mA
2N6220	200	20	20mA,10	1μA	150	2.0	20mA,2mA
2N6221	150	20	20mA,10	10μA	100	2.3	20mA,2mA

SILICON SIGNAL HIGH VOLTAGE TYPES
TO-98 OUTLINE

Device NPN	BV_{CEO} (V)	h_{FE} Min.-Max.	@ I_C, V_{CE} (V)	I_{CBO} Max.	@ V_{CB} (V)	$V_{CE(SAT)}$ (V) Max.	@ I_C, I_B
2N3877	70	20	2mA,5	100nA *	40	.125	10mA,1mA
2N3877A	85	20	2mA,5	100nA *	40	.125	10mA,1mA
2N5174	75	40-600	10mA,5	500nA	60	.950	10mA,1mA
2N5175	100	55-160	10mA,5	500nA	60	.950	10mA,1mA
2N5176	100	140-300	10mA,5	500nA	60	.950	10mA,1mA

* I_{CES}

SILICON SIGNAL HIGH SPEED SWITCHES
TO-18 OUTLINE



TO-18

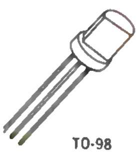
Device NPN	BV_{CEO} (V)	t_{ON}	t_{OFF}	Conditions
D32K1	25	45	100	$I_C = 500mA$, $I_B = -I_{B2} = 50mA$, $V_{CC} = 30V$
D32K2	40	45	100	$I_C = 500mA$, $I_{B1} = -I_{B2} = 50mA$, $V_{CC} = 30V$
GET706	15	40	75	$I_C = 10mA$, $I_B = 3mA$, $I_{B2} = 1mA$, $V_{CC} = 3V$
GET708	15	40	75	$I_C = 10mA$, $I_B = 3mA$, $I_{B2} = 1mA$, $V_{CC} = 3V$
GET914	15	40	40	$I_C = 200mA$, $I_{B1} = 40mA$, $I_{B2} = -20mA$, $V_{CC} = 5V$
GET3013	15	15	25	$I_C = 300mA$, $I_B = -I_{B2} = 30mA$, $V_{CC} = 15V$
GET3014	20	16	25	$I_C = 30mA$, $I_{B1} = -I_{B2} = 3mA$, $V_{CC} = 2V$
GET3646	15	18	28	$I_C = 300mA$, $I_B = -I_{B2} = 30mA$, $V_{CC} = 10V$

SILICON SIGNAL LOW NOISE AMPLIFIERS
TO-18 OUTLINE

TO-18

Device	Type	BV_{CEO} (V)	h_{FE} Min.-Max.	@ I_C, V_{CE} (V)	NF (db)	Conditions
2N5827A	NPN	40	250-500	2mA,5	5	$V_{CE} = 5V$, $I_C = 100\mu A$, $R_g = 5K$, $BW = 15.7KHz$
2N5828A	PNP	40	400-800	2mA,5	5	$V_{CE} = 5V$, $I_C = 100\mu A$, $R_q = 5K$, $BW = 15.7KHz$
2N6000	NPN	25	100-300	10mA,1	3	$V_{CE} = 5V$, $I_E = 100\mu A$, $R_s = 5K$, $BW = 15.7KHz$
2N6001	PNP	25	100-300	10mA,1	3	$V_{CE} = 5V$, $I_E = 100\mu A$, $R_s = 5K$, $BW = 15.7KHz$
2N6002	NPN	25	250-500	10mA,1	2	$V_{CE} = 5V$, $I_E = 100\mu A$, $R_s = 5K$, $BW = 15.7KHz$
2N6003	PNP	25	250-500	10mA,1	1.5	$V_{CE} = 5V$, $I_E = 100\mu A$, $R_s = 5K$, $BW = 15.7KHz$
2N6004	NPN	40	100-300	10mA,1	3	$V_{CE} = 5V$, $I_E = 100\mu A$, $R_s = 5K$, $BW = 15.7KHz$
2N6005	PNP	40	100-300	10mA,1	3	$V_{CE} = 5V$, $I_E = 100\mu A$, $R_s = 5K$, $BW = 15.7KHz$
2N6006	NPN	40	250-500	10mA,1	2	$V_{CE} = 5V$, $I_E = 100\mu A$, $R_s = 5K$, $BW = 15.7KHz$
2N6007	PNP	40	250-500	10mA,1	1.5	$V_{CE} = 5V$, $I_E = 100\mu A$, $R_s = 5K$, $BW = 15.7KHz$
2N6010	NPN	40	100-300	10mA,1	5	$V_{CE} = 5V$, $I_E = 100\mu A$, $R_s = 5K$, $BW = 15.7KHz$
2N6011	PNP	40	100-300	10mA,1	3	$V_{CE} = 5V$, $I_E = 100\mu A$, $R_s = 5K$, $BW = 15.7KHz$
2N6012	NPN	40	250-500	10mA,1	3	$V_{CE} = 5V$, $I_E = 100\mu A$, $R_s = 5K$, $BW = 15.7KHz$
2N6013	PNP	40	250-500	10mA,1	2	$V_{CE} = 5V$, $I_E = 100\mu A$, $R_s = 5K$, $BW = 15.7KHz$
2N6014	NPN	60	100-300	10mA,1	5	$V_{CE} = 5V$, $I_E = 100\mu A$, $R_s = 5K$, $BW = 15.7KHz$
2N6015	PNP	60	100-300	10mA,1	3	$V_{CE} = 5V$, $I_E = 100\mu A$, $R_s = 5K$, $BW = 15.7KHz$
2N6016	NPN	60	250-500	10mA,1	3	$V_{CE} = 5V$, $I_E = 100\mu A$, $R_s = 5K$, $BW = 15.7KHz$
2N6017	PNP	60	250-500	10mA,1	2	$BW = 15.7KHz$, $f = 10Hz$ to $10KHz$
GET929	NPN	50	60-120	10µA,5	4	$V_{CE} = 5V$, $I_C = 10\mu A$, $R_s = 10K$, $BW = 15.7KHz$, $f = 10Hz$ to $10KHz$
GET930	NPN	50	100-300	10µA,5	3	$V_{CE} = 5V$, $I_C = 10\mu A$, $R_s = 10K$, $BW = 15.7KHz$, $f = 10Hz$ to $10KHz$
GET2484	NPN	60	100 min	10µA,5	3	$V_{CE} = 5V$, $I_C = 10\mu A$, $R_s = 10K$, $BW = 15.7KHz$, $f = 10Hz$ to $10KHz$
GET5306A	NPN	25	7K-70K	2mA,5	5	$V_{CE} = 5V$, $I_C = 600\mu A$, $R_g = 160K$, $BW = 15.7KHz$, $f = 10Hz$ to $10KHz$
GET5308A	NPN	40	7K-70K	2mA,5	5	$V_{CE} = 5V$, $I_C = 600\mu A$, $R_g = 160K$, $BW = 15.7KHz$, $f = 10Hz$ to $10KHz$

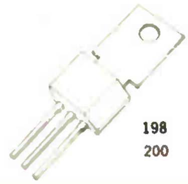
SILICON SIGNAL LOW NOISE AMPLIFIERS
TO-98 OUTLINE



TO-98

Device	Type	BV_{CEO} (V)	h_{FE} Min.-Max.	@ I_C, V_{CE} (V)	NF (db)	Conditions
2N3391A	NPN	25	250-500	2mA,5	5	$V_{CE} = 5V$, $I_C = 10\mu A$, $R_s = 5K$, $BW = 15.7KHz$, $f = 10Hz$ to $15.7KHz$
2N3844	NPN	30	35-70	2mA,5	10.2	$V_{CE} = 10V$, $I_C = 1mA$, $R_s = 20$, $f = 2MHz$, $BW = 100KHz$
2N3844A	NPN	30	35-70	2mA,5	8.5	$V_{CE} = 10V$, $I_C = 1mA$, $R_s = 20$, $f = 2MHz$, $BW = 100KHz$
2N3845	NPN	30	60-120	2mA,5	10.2	$V_{CE} = 10V$, $I_C = 1mA$, $R_s = 20$, $f = 2MHz$, $BW = 100KHz$
2N3845A	NPN	30	60-120	2mA,5	8.5	$V_{CE} = 10V$, $I_C = 1mA$, $R_s = 20$, $f = 2MHz$, $BW = 100KHz$
2N3900A	NPN	18	250-500	2mA,5	5	$V_{CE} = 5V$, $I_C = 100\mu A$, $R_s = 5K$, $BW = 15.7KHz$, $f = 10Hz$ to $15.7KHz$
2N3901	NPN	18	350-700	2mA,5	5	$V_{CE} = 5V$, $I_C = 10\mu A$, $R_s = 5K$, $BW = 15.7KHz$, $f = 10Hz$ to $15.7KHz$
2N5232A	NPN	50	250-500	2mA,5	5	$V_{CE} = 5V$, $I_C = 10\mu A$, $R_s = 5K$, $BW = 15.7KHz$, $f = 10KHz$ to $15.7KHz$
2N5249A	NPN	50	400-800	2mA,5	3	$V_{CE} = 5V$, $I_C = 100\mu A$, $R_s = 5K$, $BW = 15.7KHz$, $f = 10KHz$ to $15.7KHz$
2N5306A	NPN	25	7K-70K	2mA,5	5	$V_{CE} = 5V$, $I_C = 600\mu A$, $R_s = 160K$, $BW = 15.7KHz$, $f = 10Hz$ to $10KHz$
2N5308A	NPN	40	7K-70K	2mA,5	5	$V_{CE} = 5V$, $I_C = 600\mu A$, $R_s = 160K$, $BW = 15.7KHz$, $f = 10Hz$ to $10KHz$
2N5309	NPN	50	60-120	10µA,5	4	$V_{CE} = 5V$, $I_C = 20\mu A$, $R_s = 5K$, $f = 1KHz$, $BW = 15.7KHz$
2N5310	NPN	50	100-300	10µA,5	3	$V_{CE} = 5V$, $I_C = 20\mu A$, $R_s = 5K$, $f = 1KHz$, $BW = 15.7KHz$
2N5311	NPN	50	250-500	10µA,5	3	$V_{CE} = 5V$, $I_C = 20\mu A$, $R_s = 5K$, $f = 1KHz$, $BW = 15.7KHz$
2N5998	NPN	25	150-300	10mA,2	1.5	$V_{CE} = 5V$, $I_C = 100\mu A$, $R_s = 5K$, $BW = 15.7KHz$, $f = 10Hz$ to $10KHz$
2N5999	PNP	25	150-300	10mA,2	1.5	$V_{CE} = 5V$, $I_C = 100\mu A$, $R_s = 5K$, $BW = 15.7KHz$, $f = 10Hz$ to $10KHz$
2N6008	NPN	25	250-500	10mA,2	1.5	$V_{CE} = 5V$, $I_C = 100\mu A$, $R_s = 5K$, $BW = 15.7KHz$, $f = 10Hz$ to $10KHz$
2N6009	PNP	25	250-500	10mA,2	1.5	$V_{CE} = 5V$, $I_C = 100\mu A$, $R_s = 5K$, $BW = 15.7KHz$, $f = 10Hz$ to $10KHz$

NPN SILICON POWER TRANSISTORS DARLINGTON—HIGH GAIN

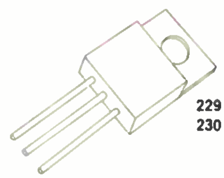


198
200

GE Type	P_T $T_C = 25°C$ Max. (W)	V_{CEO} Min. (V)	I_C Cont. (A)	h_{FE} @ 5V, 200mA Min.	h_{FE} @ 5V, 200mA Max.	f_T Typical (MHz)	Comments	Package Type	Package Outline No.	Specification Sheet No.
D40C1	6.25	30	.5	10,000	60,000	75	Very high gain: 60k typical. High input impedance: 50k ohm typ. 1.2 watts P_T @ 25°C ambient. Applications: audio output, touch switch, oscillator, buffer, high power transistor driver, relay replacement.	BROWN Encapsulated Power Tab	198	50.60
D40C2	6.25	30	.5	40,000	—	75				
D40C3	6.25	30	.5	90,000	—	75				
D40C4	6.25	40	.5	10,000	60,000	75				
D40C5	6.25	40	.5	40,000	—	75				
D40C7	6.25	50	.5	10,000	60,000	75				
D40C8	6.25	50	.5	40,000	—	75				

SILICON POWER TRANSISTORS NPN HIGH VOLTAGE

198
200



229
230

GE Type	P_T $T_C = 25°C$ Max. (W)	V_{CEO} Min. (V)	I_C Cont. (A)	h_{FE} @ 10V, 20mA Min.	h_{FE} @ 10V, 20mA Max.	h_{FE} @ 10V, 500mA Min.	h_{FE} @ 10V, 500mA Max.	f_T Typical (MHz)	Comments	Package Type	Package Outline No.	Specification Sheet No.
D40N1	6.25	250	.1	30	90	—	—	80	TYPICAL APPLICATIONS • 120V AC Line Operated Amplifiers • Regulators • TV Video and Chroma Output • Inverters Converters	BROWN Encapsulated Power Tab	198, 200	50.66
D40N2	6.25	250	.1	60	180	—	—	80				
D40N3	6.25	300	.1	30	90	—	—	80				
D40N4	6.25	300	.1	60	180	—	—	80				
D40N5	6.25	375	.1	20	—	—	—	80				
D40P1	6.25	120	.5	40 [1]	—	20 [2]	—	—		BROWN Encapsulated Power Tab	198, 200	50.73
D40P3	6.25	180	.5	40 [1]	—	20 [2]	—	—				
D40P5	6.25	225	.5	40 [1]	—	20 [2]	—	—				
D42R1	15	250	1.0	—	—	30	—	55		RED Encapsulated Power Tab	198, 200	50.74
D42R2	15	300	1.0	—	—	30	—	55				
D44Q1	31.25	125	4.0	30 [3]	—	20 [4]	—	50		RED Encapsulated Power Pac	229, 230	50.76
D44Q3	31.25	175	4.0	30 [3]	—	20 [4]	—	50				
D44Q5	31.25	225	4.0	30 [3]	—	20 [4]	—	50				
D44R1	31.25	250	1.0	—	—	30	90	40	FEATURES • Glass Passivated Mesa Construction • Fast Switching • High Voltage	RED Encapsulated Power Pac	229, 230	50.70
D44R2	31.25	250	1.0	—	—	75	175	40				
D44R3	31.25	300	1.0	—	—	30	90	40				
D44R4	31.25	300	1.0	—	—	75	175	40				
D44R5	31.25	250	1.0	—	—	30	—	40				
D44R6	31.25	300	1.0	—	—	30	—	40				
D44R7	31.25	250	1.0	—	—	150	300	40				
D44R8	31.25	300	1.0	—	—	150	300	40				

[1] Measured at 80mA
[2] Measured at 2mA
[3] Measured at 200mA
[4] Measured at 2A

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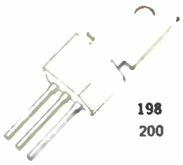

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SILICON POWER TRANSISTORS COMPLEMENTARY—1 AMPERE

GE Type NPN	GE Type PNP	P_T $T_C = 25°C$ Max. (W)	V_{CEO} Min. (V)	I_C Cont. (A)	h_{FE} @ 2V, 100mA Min.	h_{FE} @ 2V, 100mA Max.	h_{FE} @ 2V, 1A Min.	Package Type	Package Outline No.	Specification Sheet No.
D40D1	—	6.25	30	1.0	50	150	10	BROWN Power Tab	198, 200	50.63
—	D41D1	6.25	—30	—1.0	50	150	10	BLACK Power Tab	198, 200	50.64
D40D2	—	6.25	30	1.0	120	360	20	BROWN Power Tab	198, 200	50.63
—	D41D2	6.25	—30	—1.0	120	360	20	BLACK Power Tab	198, 200	50.64
D40D3	—	6.25	30	1.0	290	—	10	BROWN Power Tab	198, 200	50.63
—	D41D3	6.25	—30	—1.0	290	—	10	BLACK Power Tab	198, 200	50.64
D40D4	—	6.25	45	1.0	50	150	10	BROWN Power Tab	198, 200	50.63
—	D41D4	6.25	—45	—1.0	50	150	10	BLACK Power Tab	198, 200	50.64
D40D5	—	6.25	45	1.0	120	360	10	BROWN Power Tab	198, 200	50.63
—	D41D5	6.25	—45	—1.0	120	360	10	BLACK Power Tab	198, 200	50.64
D40D7	—	6.25	60	1.0	50	150	10	BROWN Power Tab	198, 200	50.63
—	D41D7	6.25	—60	—1.0	50	150	10	BLACK Power Tab	198, 200	50.64
D40D8	—	6.25	60	1.0	120	360	10	BROWN Power Tab	198, 200	50.63
—	D41D8	6.25	—60	—1.0	120	360	10	BLACK Power Tab	198, 200	50.64
40D10	—	6.25	75	1.0	50	150	10	BROWN Power Tab	198, 200	50.63
—	D41D10	6.25	—75	—1.0	50	150	10	BLACK Power Tab	198, 200	50.64
D40D11	—	6.25	75	1.0	120	360	10	BROWN Power Tab	198, 200	50.63
—	D41D11	6.25	—75	—1.0	120	360	10	BLACK Power Tab	198, 200	50.64
D40D12	—	6.25	75	1.0	290	—	10	BROWN Power Tab	198, 200	50.63
—	D41D12	6.25	—75	—1.0	290	—	10	BLACK Power Tab	198, 200	50.64
D40D13	—	6.25	75	1.0	50	150	10	BROWN Power Tab	198, 200	50.63
—	D41D13	6.25	—75	—1.0	50	150	10	BLACK Power Tab	198, 200	50.64
D40D14	—	6.25	75	1.0	120	360	10	BROWN Power Tab	198, 200	50.63
—	D41D14	6.25	—75	—1.0	120	360	10	BLACK Power Tab	198, 200	50.64

Comments:

TYPICAL APPLICATIONS
- Amplifier Output and Driver Stages
- Regulators series, shunt, and switching
- Inverters/Converters

FEATURES
- High Free Air Dissipation (1.25 Watts @ 25°C)
- Low Collector Saturation Voltage (0.5V Typ. @ 1.0A)
- Excellent Linearity
- Fast Switching
- TO-5 Compatible
- Typical f_T, 150 MHz

198
199
200

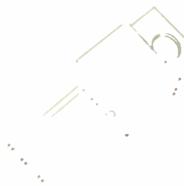
SILICON POWER TRANSISTORS COMPLEMENTARY—3 AMPERE

GE Type NPN	GE Type PNP	P_T $T_C = 25°C$ Max. (W)	V_{CEO} Min. (V)	I_C Cont. (A)	h_{FE} @ 1V, 200mA Min.	h_{FE} @ 1V, 200mA Max.	h_{FE} @ 1V, 1A Min.	Comments	Package Type	Package Outline No.	Specification Sheet No.
D42C1	—	12.5	30	3.0	25	—	10		RED Power Tab	198,199,200	50.61
—	D43C1	12.5	—30	—3.0	25	—	10		GREEN Power Tab	198,199,200	50.62
D42C2	—	12.5	30	3.0	40	120	20		RED Power Tab	198,199,200	50.61
—	D43C2	12.5	—30	—3.0	40	120	20		GREEN Power Tab	198,199,200	50.62
D42C3	—	12.5	30	3.0	40	120	20 [1]		RED Power Tab	198,199,200	50.61
—	D43C3	12.5	—30	—3.0	40	120	20 [1]		GREEN Power Tab	198,199,200	50.62
D42C4	—	12.5	45	3.0	25	—	10		RED Power Tab	198,199,200	50.61
—	D43C4	12.5	—45	—3.0	25	—	10		GREEN Power Tab	198,199,200	50.62
D42C5	—	12.5	45	3.0	40	120	20		RED Power Tab	198,199,200	50.61
—	D43C5	12.5	—45	—3.0	40	120	20		GREEN Power Tab	198,199,200	50.62
D42C6	—	12.5	45	3.0	40	120	20 [1]		RED Power Tab	198,199,200	50.61
—	D43C6	12.5	—45	—3.0	40	120	20 [1]		GREEN Power Tab	198,199,200	50.62
D42C7	—	12.5	60	3.0	25	—	10		RED Power Tab	198,199,200	50.61
—	D43C7	12.5	—60	—3.0	25	—	10		GREEN Power Tab	198,199,200	50.62
D42C8	—	12.5	60	3.0	40	120	20		RED Power Tab	198,199,200	50.61
—	D43C8	12.5	—60	—3.0	40	120	20		GREEN Power Tab	198,199,200	50.62
D42C9	—	12.5	60	3.0	40	120	20 [1]		RED Power Tab	198,199,200	50.61
—	D43C9	12.5	—60	—3.0	40	120	20 [1]		GREEN Power Tab	198,199,200	50.62
D42C10	—	12.5	80	3.0	25	—	10		RED Power Tab	198,199,200	50.61
—	D43C10	12.5	—80	—3.0	25	—	10		GREEN Power Tab	198,199,200	50.62
D42C11	—	12.5	80	3.0	40	120	20		RED Power Tab	198,199,200	50.61
—	D43C11	12.5	—80	—3.0	40	120	20		GREEN Power Tab	198,199,200	50.62
D42C12	—	12.5	80	3.0	40	120	20 [1]		RED Power Tab	198,199,200	50.61
—	D43C12	12.5	—80	—3.0	40	120	20 [1]		GREEN Power Tab	198,199,200	50.62
D42C100	—	12.5	30	3.0	75	—	10		RED Power Tab	198,199,200	50.61
—	D43C100	12.5	—30	—3.0	75	—	10		GREEN Power Tab	198,199,200	50.62

TYPICAL APPLICATIONS
- Amplifier Output and Driver Stages
- Regulators: series, shunt, and switching
- Inverters Converters

FEATURES
- High Free Air Power Dissipation (2.1 Watts @ 25°C)
- Very Low Collector Saturation Voltage (0.5V Typ. @ 3.0A Ic)
- Excellent Linearity
- Fast Switching
- TO-5 or TO-66 Compatible
- Typical f_T, 50 MHz

[1] h_{FE} measured at I_C = 2A.


229
230

SILICON POWER TRANSISTORS COMPLEMENTARY—4 AMPERE

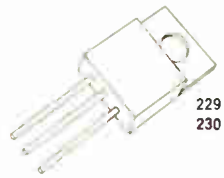
GE Type NPN	GE Type PNP	P_T $T_C = 25°C$ Max. (W)	V_{CEO} Min. (V)	I_C Cont. (A)	h_{FE} @ 1V, 200mA Min.	h_{FE} @ 1V, 200mA Max.	h_{FE} @ 1V, 1A Min.	Comments	Package Type	Package Outline No.	Specification Sheet No.
D44C1	—	30	30	4.0	25	—	10		RED Power Pac	229, 230	50.68
—	D45C1	30	—30	—4.0	25	—	10		GREEN Power Pac	229, 230	50.69
D44C2	—	30	30	4.0	40	120	20		RED Power Pac	229, 230	50.68
—	D45C2	30	—30	—4.0	40	120	20		GREEN Power Pac	229, 230	50.69
D44C3	—	30	30	4.0	40	120	20[1]		RED Power Pac	229, 230	50.68
—	D45C3	30	—30	—4.0	40	120	20[1]		GREEN Power Pac	229, 230	50.69
D44C4	—	30	45	4.0	25	—	10		RED Power Pac	229, 230	50.68
—	D45C4	30	—45	—4.0	25	—	10		GREEN Power Pac	229, 230	50.69
D44C5	—	30	45	4.0	40	120	20		RED Power Pac	229, 230	50.68
—	D45C5	30	—45	—4.0	40	120	20		GREEN Power Pac	229, 230	50.69
D44C6	—	30	45	4.0	40	120	20[1]		RED Power Pac	229, 230	50.68
—	D45C6	30	—45	—4.0	40	120	20[1]		GREEN Power Pac	229, 230	50.69
D44C7	—	30	60	4.0	25	—	10		RED Power Pac	229, 230	50.68
—	D45C7	30	—60	—4.0	25	—	10		GREEN Power Pac	229, 230	50.69
D44C8	—	30	60	4.0	40	120	20		RED Power Pac	229, 230	50.68
—	D45C8	30	—60	—4.0	40	120	20		GREEN Power Pac	229, 230	50.69
D44C9	—	30	60	4.0	40	—	20		RED Power Pac	229, 230	50.68
—	D45C9	30	—60	—4.0	40	—	20		GREEN Power Pac	229, 230	50.69
D44C10	—	30	80	4.0	25	—	10		RED Power Pac	229, 230	50.68
—	D45C10	30	—80	—4.0	25	—	10		GREEN Power Pac	229, 230	50.69
D44C11	—	30	80	4.0	40	120	20		RED Power Pac	229, 230	50.68
—	D45C11	30	—80	—4.0	40	120	20		GREEN Power Pac	229, 230	50.69
D44C12	—	30	80	4.0	40	120	20[1]		RED Power Pac	229, 230	50.68
—	D45C12	30	—80	—4.0	40	120	20[1]		GREEN Power Pac	229, 230	50.69

TYPICAL APPLICATIONS
- Amplifier Outputs
- Regulators; series, shunt, and switching
- Inverters/Converters

FEATURES
- Low Collector Saturation Voltage (0.5V Typ. @ 3.0A Ic)
- Excellent Linearity
- Fast Switching
- Round Leads
- TO-66 Compatible
- Typical f_T, 50 MHz

[1] h_{FE} measured at $I_C = 2A$.

SILICON POWER TRANSISTORS COMPLEMENTARY - 10 AMPERE



GE Type NPN	GE Type PNP	P_T $T_C = 25°C$ Max. (W)	V_{CEO} Min. (V)	I_C Cont. (A)	h_{FE} @ 1V, 2A Min.	h_{FE} @ 1V, 4A Min.	Comments	Package Outline No.	Specification Sheet No.
D44H1	—	50	30	10	35	20	RED Power Tab	229, 230	50.71
—	D45H1	50	—30	—10	35	20	GREEN Power Tab	229, 230	50.72
D44H2	—	50	30	10	60	40	RED Power Tab	229, 230	50.71
—	D45H2	50	—30	—10	60	40	GREEN Power Tab	229, 230	50.72
D44H4	—	50	45	10	35	20	RED Power Tab	229, 230	50.71
—	D45H4	50	—45	—10	35	20	GREEN Power Tab	229, 230	50.72
D44H5	—	50	45	10	60	40	RED Power Tab	229, 230	50.71
—	D45H5	50	—45	—10	60	40	GREEN Power Tab	229, 230	50.72
D44H7	—	50	60	10	35	20	RED Power Tab	229, 230	50.71
—	D45H7	50	—60	—10	35	20	GREEN Power Tab	229, 230	50.72
D44H8	—	50	60	10	60	40	RED Power Tab	229, 230	50.71
—	D45H8	50	—60	—10	60	40	GREEN Power Tab	229, 230	50.72
D44H10	—	50	80	10	35	20	RED Power Tab	229, 230	50.71
—	D45H10	50	—80	—10	35	20	GREEN Power Tab	229, 230	50.72
D44H11	—	50	80	10	60	40	RED Power Tab	229, 230	50.71
—	D45H11	50	—80	—10	60	40	GREEN Power Tab	229, 230	50.72

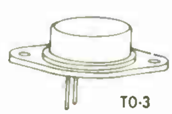
TYPICAL APPLICATIONS

- Amplifier Outputs
- Regulators; Series, Shunt and Switching
- Inverters/Converters

FEATURES

- Low Collector Saturation Voltage (0.24V Typ. @ 3.0A I_C
- Excellent Linearity
- Fast Switching
- Round Leads
- TO-66 Compatible
- Typical F_T, 50 MHz

SINGLE DIFFUSED HERMETIC 3-20 AMPS



GE Type NPN	P_T $T_C = 25°C$ Max. (W)	V_{CEO} Min. (V)	I_C Cont. (A)	h_{FE} Min	h_{FE} Max.	h_{FE} @ I_C(A)	Package Type
2N3441	25	140	3	25	100	.5	TO-66
2N3054	25	55	4	25	100	.5	TO-66
2N4347	100	120	5	15	60	2	TO-3
2N4348	120	120	10	15	60	5	TO-3
2N3442	117	140	10	20	70	3	TO-3
2N3055	115	60	15	20	70	4	TO-3
2N3773	150	140	16	15	60	8	TO-3
2N3772	150	60	20	15	60	10	TO-3

SILICON SIGNAL DIODES
100 MA TYPES

Part Number	BV @ 100µA Min. (V)	I_R @ 25°C Max. (nA)	@ V_R(V)	V_F Max (V)	@ I_F (mA)	C @ 0V (pf)	t_{rr} (nsec)	Package Type	Package Outline No	Specification Sheet No.
1N251	35	100	10	1.00	5	—	—	D07	37	—
1N252	25	100	5	1.00	10	—	—	D07	37	—
1N904	30	100	30	1.00	10	—	—	D07	37	—
1N914	100	25	20	1.00	10	4	4	D035	38	75 28
1N914A	100	25	20	1.00	20	4	4	D035	38	75.28
1N914B	100	25	20	1.00	100	4	4	D035	38	75 28
1N916	100	25	20	1.00	10	2	4	D035	38	75 28
1N916A	100	25	20	1.00	20	2	4	D035	38	75 28
1N916B	100	25	20	1.00	30	2	4	D035	38	75 28
1N3062	75	100	50	1.00	20	1	4	D07	37	—
1N3063	75	100	50	.850	10	2	2	D07	37	75.20
1N3064	75	100	50	1.00	10	2	4	D07	37	75.25
1N3065	75	100	50	1.00	20	1.5	4	D07	37	75.25
1N3067	30	100	20	1.00	5	4	4	D07	37	—
1N3604	75	50	50	1.00	50	2	2	D07	37	75.25
1N3605	40	50	30	.880	20	2	2	D07	37	75.25
1N3606	75	50	50	.880	20	2	2	D07	37	75.25
1N4009	35	100	25	1.00	30	4	2	D07	37	75 28
1N4148 *	100	25	20	1.00	10	4	4	D035	38	75.28
1N4149	100	25	20	1.00	10	2	4	D035	38	75 28
1N4151	75 [1]	50	50	1.00	50	2	2	D035	38	75.25
1N4152	40	50	30	.880	20	2	2	D035	38	75.25
1N4153 *	75	50	50	.880	20	2	2	D035	38	75.25
1N4154	35	100	25	1.00	30	4	2	D035	38	75 25
1N4305	75	100	50	.850	10	2	2	D035	38	75 20
1N4444	70	50	50	1.00	100	2	7	D035	38	75.37
1N4446	100	25	20	1.00	20	4	4	D035	38	75.28
1N4447	100	25	20	1.00	20	2	4	D035	38	75.28
1N4448	100	25	20	1.00	100	4	4	D035	38	75.28
1N4449	100	25	20	1.00	30	2	4	D035	38	75.28
1N4454 *	75	100	50	1.00	10	2	2	D035	38	75.25
1N4531 *	100	25	20	1.00	10	4	4	D034	39	75.28
1N4532	75	100	50	1.00	10	2	2	D034	39	75.25
1N4533	40	50	30	.880	20	2	2	D034	39	75.25
1N4534	75	50	50	.880	20	2	2	D034	39	75.25
1N4536	35	100	25	1.00	30	4	2	D034	39	75 28
1N4727	30	100	20	.850	10	4	4	D035	38	75.45
1N4863	70	50	50	1.20	100	2	7	D035	38	75.40
1N4864	125	100	80	1.10	100	1.3	4	D035	38	75.40
DA1701	100	30	30	1.00	50	1	4	D035	38	75 21
DA1702	75	30	30	1.00	50	1	4	D035	38	75.21
DA1703	40	50	30	1.00	50	2	4	D035	38	75.21
DA1704	25	100	20	1.00	30	3	4	D035	38	75.21
MA1701	100	30	30	1.00	50	1	4	D034	39	75.22
MA1702	75	30	30	1.00	50	1	4	D034	39	75.22
MA1703	40	50	30	1.00	50	2	4	D034	39	75.22
MA1704	25	100	20	1.00	30	3	4	D034	39	75.22
SS321	40	2	30	.880	10	4	—	D07	37	75.63
SS322	—	.2	20	.880	10	4	—	D07	37	75 63
SS324	—	.1	20	1 0	50	6	—	D07	37	75 63
SS325	—	.25	20	1.0	50	6	—	D07	37	75 63
SS334	40	1	30	.880	10	4	—	D07	37	75.63
SS337	—	2	50	.880	10	4	—	D07	37	75.63
SE708	40	.02	20	1	50	4	—	D07	37	75.58
DZ800	2	2000	2	.800	10	—	—	D035	38	75.57
DZ805	15	2000	12	.8[illegible]	10	—	—	D035	38	75.57
DZ806	25	2000	22	.800	10	—	—	D035	38	75.57

* JAN and JANTX types available   [1] Measured at 5µA

100-200 MA TYPES

1N4150 *	50	100	50	1.00	200	2.5	4	D035	38	75.25
1N4450	30	50	30	1.00	200	4	4	D035	38	75.36
1N4606	85	100	50	1.00	200	2.5	4	D035	38	75.44

200-400 MA TYPES

1N4451	40	50	30	1.00	300	6	10	D035	38	75.36
1N4607	85	100	50	1.00	400	4	10	D035	38	75.44
1N4608	85	100	50	.96	400	4	10	D035	38	75.44
DT230C	300	1000	300	1.20	250	5	300	D035	38	130.25
DT230H	250	1000	250	1.00	200	5	300	D035	38	130.25
DT230HI	250	1000	250	1.10	250	5	300	D035	38	130.25
DT230B	200	1000	200	1.10	250	5	300	D035	38	130.25
DT230G	150	1000	150	1.10	250	5	300	D035	38	130.25
DT230A	100	1000	100	1.10	250	5	300	D035	38	130.25
DT230F	50	1000	50	1.10	250	5	300	D035	38	130.25

* JAN and JANTX types available

SILICON SIGNAL DIODES
MULTIPELLET AND MATCHED TYPES

MULTIPELLET TYPES

Part Number	BV @ 5µA (V)	I_R @ 25°C Max. (nA)	@ V_R(V)	V_F Max. (V)	@ I_F(mA)	Co @ 0V Max. (pf)	t_{rr} (nsec)	Package Type	Package Outline No.	Specification Sheet No.
1N4156	30	50	20	1.58	10	25	—	D035	42	75.42
1N4157	30	50	20	2.32	10	20	—	D035	41	75.42
1N4453	30	50	20	.800	10	30	—	D035	38	75.42
1N4828	30	100	20	.830	10	35	—	D035	38	—
1N4829	30 [1]	100	20	1.61	10	25	—	D035	42	75.42
1N4830	30 [1]	100	20	2.35	10	20	—	D035	41	75.42
1N5179	30	50	20	3.20	10	20	—	D035	40	75.42
1N4156	30	50	20	1.58	10	25	—	D035	42	75.42
1N4157	30	50	20	2.32	10	20	—	D035	41	75.42
1N4453	30	50	20	.800	10	30	—	D035	38	75.42
1N4828	30	100	20	.830	10	35	—	D035	38	—
1N4829	30 [1]	100	20	1.61	10	25	—	D035	42	75.42
1N4830	30 [1]	100	20	2.35	10	20	—	D035	41	75.42
1N5179	30	50	20	3.20	10	20	—	D035	40	75.42
MPD200	70	30	30	1.54	10	15	—	D035	42	75.42
MPD201	50	50	20	1.57	10	15	—	D035	42	75.42
MPD202	50	90	20	1.60	10	15	—	D035	42	75.42
MPD203	50	90	20	1.51	10	15	—	D035	42	75.42
STB567	50	500	20	1.61	10	15	—	D035	42	75.46
MPD300	100	30	30	2.33	10	10	—	D035	41	75.42
MPD301	60	40	20	2.32	10	10	—	D035	41	75.42
MPD302	60	90	20	2.32	10	10	—	D035	41	75.42
STB568	60	500	20	2.31	10	10	—	D035	41	75.46
MPD400	120	30	30	3.07	10	7	—	D035	40	75.46
MPD401	75	50	20	3.01	10	7	—	D035	40	75.46
MPD402	75	90	20	3.01	10	7	—	D035	40	75.46
STB569	75	500	20	3.01	10	7	—	D035	40	75.46

MATCHED PAIRS AND QUADS

1N4306	75	50	50	10mV Match	2	2	—	43	75.50
MP-2	40	100	30	10mV Match	2	2	—	43	75.50
1N4307	75	50	50	10mV Match	2	2	—	43	75.50
MQ-2	40	100	30	10mV Match	2	2	—	43	75.50

[1] Measured @ 100µA

TUNNEL DIODES
MICROWAVE

Type[1]	I_P Peak Current Typ. (mA)	V_P Peak Voltage Typ. (mV)	V_V Valley Voltage Typ. (mV)	V_{FP} Forward Peak Voltage Typ. (mV)	(I_P/I_V) Peak to Valley Ratio Typ.	—R Negative Resistance (Ω)	R_S Series Resistance Max. (Ω)	C_J Junction Capacitance @ —R[2] Typ (pF)	f_{RO} Resistive Cutoff Freq. Min (GHz)
TD-401	1.85	65	350	520	8	60-80	3	2.0	5
TD-402	1.85	67	360	540	8	60-80	4	1.0	10
TD-403	1.85	70	380	550	8	60-80	5	0.65	15
TD-404	1.85	72	380	560	8	60-80	5	0.46	20
TD-405	1.85	74	390	570	8	60-80	6	0.36	25
TD-406	1.85	75	390	570	8	60-80	6	0.25	30
TD-407	1.85	76	400	580	8	60-80	6	0.18	40
TD-408	1.85	77	400	580	8	60-80	7	0.13	50
TD-409	1.85	78	400	580	8	60-80	8	0.09	65
TD-411	2.35	65	350	520	8	50-60	3	2.3	5
TD-412	2.35	67	360	540	8	50-60	4	1.2	10
TD-413	2.35	70	380	550	8	50-60	5	0.75	15
TD-414	2.35	72	380	560	8	50-60	5	0.53	20
TD-415	2.35	74	390	570	8	50-60	6	0.41	25
TD-416	2.35	75	390	570	8	50-60	6	0.30	30
TD-417	2.35	76	400	580	8	50-60	6	0.22	40
TD-418	2.35	77	400	580	8	50-60	7	0.15	50
TD-419	2.35	78	400	580	8	50-60	8	0.11	65
TD-421	2.85	65	350	520	8	40-50	3	2.6	5
TD-422	2.85	67	360	540	8	40-50	4	1.3	10
TD-423	2.85	70	380	550	8	40-50	5	0.84	15
TD-424	2.85	72	380	560	8	40-50	5	0.58	20
TD-425	2.85	74	390	570	8	40-50	6	0.46	25
TD-426	2.85	75	390	570	8	40-50	6	0.34	30
TD-427	2.85	76	400	580	8	40-50	6	0.24	40
TD-428	2.85	77	400	580	8	40-50	7	0.16	50
TD-429	2.85	78	400	580	8	40-50	8	0.12	65
TD-431	3.7	65	350	520	8	30-40	3	0.32	5
TD-432	3.7	67	360	540	8	30-40	4	1.6	10
TD-433	3.7	70	380	550	8	30-40	4	1.0	15
TD-434	3.7	72	380	560	8	30-40	5	0.70	20
TD-435	3.7	74	390	570	8	30-40	5	0.55	25
TD-436	3.7	75	390	570	8	30-40	5	0.38	30
TD-437	3.7	76	400	580	8	30-40	6	0.27	40
TD-438	3.7	77	400	580	8	30-40	6	0.18	50
TD-439	3.7	78	400	580	8	30-40	7	0.13	65

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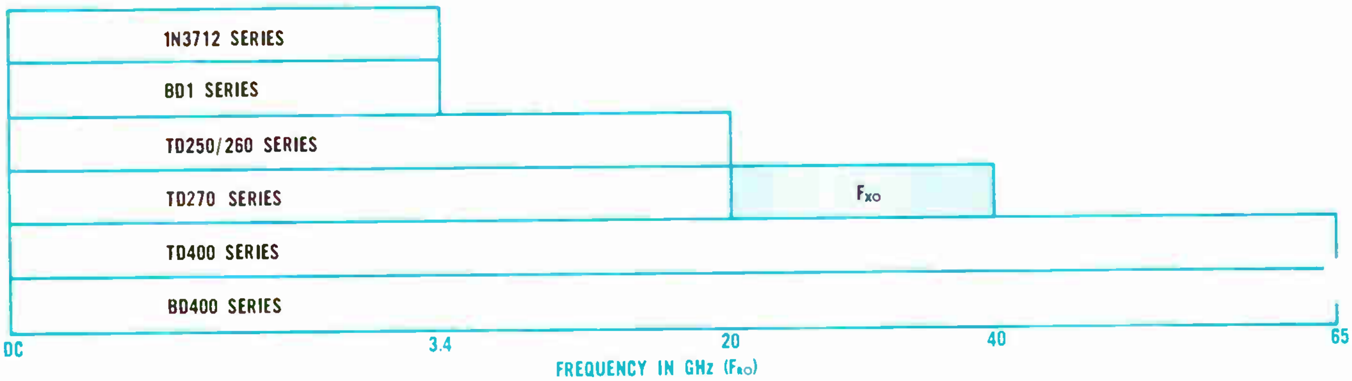
[1]The 400 Series high performance Microwave Tunnel Diodes are available in the pill package—Outline 49 Series Inductance, L_S, = 0.15 nH typical. C_P = .25 pF.

[2]C_J @ —R = 0.75 of the junction capacitance measured at V_V.



Advertisement

TUNNEL DIODES GENERAL PURPOSE

For Switching, Oscillators, Amplifiers, Converter Circuits and Threshold Detectors.

GE TYPE +100°C Operation TD-1 (1)	GE TYPE +100°C Subminiature Package TD-200 (2)	I_P Peak Point Current (mA)	I_V Valley Point Current Max. (mA)	C Capacitance Max. (pF)	V_P Peak Point Voltage Typ. (mV)	V_V Valley Voltage Typ. (mV)	V_{FP} Forward Peak Voltage Typ. (mV)	R_S Series Resist. Max. (Ohms)	—G Negative Conductance (mhos × 10^{-3})	f_{RO} Resistive Cutoff Frequency Typical (GHz)
1N3712	TD-201	1.0 ± 10%	0.18	10	65	350	500	4.0	8 Typ.	2.3
1N3713 [3]	TD-201A	1.0 ± 2.5%	0.14	5	65	350	510	4.0	8.5 ± 1	3.2
1N3714	TD-202	2.2 ± 10%	0.48	25	65	350	500	3.0	18 Typ.	2.2
1N3715 [3]	TD-202A	2.2 ± 2.5%	0.31	10	65	350	510	3.0	19 ± 3	3.0
1N3716	TD-203	4.7 ± 10%	1.04	50	65	350	500	2.0	40 Typ.	1.8
1N3717 [3]	TD-203A	4.7 ± 2.5%	0.60	25	65	350	510	2.0	41 ± 5	3.4
1N3718	TD-204	10.0 ± 10%	2.20	90	65	350	500	1.5	80 Typ.	1.6
1N3719 [3]	TD-204A	10.0 ± 2.5%	1.40	50	65	350	510	1.5	85 ± 10	2.8
1N3720	TD-205	22.0 ± 10%	4.80	150	65	350	500	1.0	180 Typ.	1.6
1N3721 [3]	TD-205A	22.0 ± 2.5%	3.10	100	65	350	510	1.0	190 ± 30	2.6
TD-9	TD-206	0.5 ± 10%	0.10	5	60	—	—	6.0	4.0 Typ.	1.3

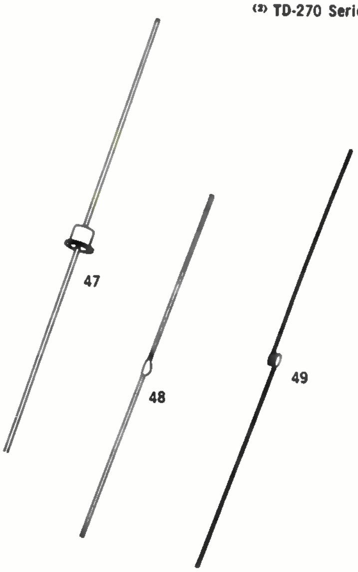
(1) TD-1 Series in Miniature Axial Pkg.—Outline No. 47 Nominal Series Inductance L_S = 0.5 nH.
(2) TD-200 Series in Sandwich Pkg.—Outline No. 48.
(3) Mil Versions Available.

TUNNEL DIODES ULTRA HIGH SPEED SWITCHING

For High Speed Memory Circuits, Pulse Generators and Threshold Detectors.

GE TYPE L_S = 1.5 nH +75°C Operation TD-250 (1)	GE TYPE L_S = 1.5 nH +100°C Operation TD-260 (1)	GE TYPE L_S = .15 nH +100°C Low Inductance TD-270 (2)	I_P Peak Point Current (mA)	I_V Valley Point Current Max. (mA)	C Capacitance Max. (pF)	V_P Peak Point Voltage Typical (mV)	V_V Valley Voltage Typical (mV)	V_{FP} Forward Voltage @ $I_F = I_P$ Typ. (mV)	R_S Series Resist. Typical (Ω)	t_r Rise Time Typical (psec.)
TD-251	TD-261	TD-271	2.2 ± 10%	0.31	3.0	70	390	500-700	5.0	430
TD-251A	TD-261A	TD-271A	2.2 ± 10%	0.31	1.0	80	390	500-700	7.0	160
TD-252	TD-262	TD-272	4.7 ± 10%	0.60	6.0	80	390	500-700	3.5	320
TD-252A	TD-262A	TD-272A	4.7 ± 10%	0.60	1.0	90	400	500-700	4.0	74
TD-253	TD-263	TD-273	10.0 ± 10%	1.40	9.0	75	400	500-700	1.7	350
TD-253A	TD-263A	TD-273A	10.0 ± 10%	1.40	5.0	80	410	520-700	2.0	190
TD-253B	TD-263B	TD-273B	10.0 ± 10%	1.40	2.0	90	420	550-700	2.5	68
TD-254	TD-264	TD-274	22.0 ± 10%	3.80	18.0	90	425	600 Typ.	1.8	185
TD-254A	TD-264A	TD-274A	22.0 ± 10%	3.80	4.0	100	425	550-700	2.0	64
TD-255	TD-265	TD-275	50.0 ± 10%	8.50	25.0	110	425	625 Typ.	1.4	100
TD-255A	TD-265A	TD-275A	50.0 ± 10%	8.50	5.0	130	425	640 Typ.	1.5	35
TD-256	TD-266	TD-276	100 ± 10%	17.50	35.0	150	450	650 Typ.	1.1	57
TD-256A	TD-266A	TD-276A	100 ± 10%	17.50	6.0	180	450	660 Typ.	1.2	22

(1) TD-250 & 260 Series in SandwichPkg.—Outline No. 48.
(2) TD-270 Series in Pill Pkg. with Leads—Package Outline No. 49.



TD PUBLICATIONS AVAILABLE

See back page for ordering instructions.

Product Specifications

70.09 TD-401-439 Microwave Tunnel Diodes
70.20 1N3712-3721 General Purpose Tunnel Diodes
70.22 TD-9 General Purpose Tunnel Diodes
70.26 TD251-256, 251A-256A, 253B Ultra High Speed Switching Tunnel Diodes
70.28 TD261/270 Ultra High Speed Switching Tunnel Diodes
70.32 1N4090 Mixer Tunnel Diode
70.51 BD1-7 General Purpose Back Diodes

Application Notes

90.42 Tunnel Diode UHF-TV Tuner
90.43 A Tunnel Diode R.F. Radiation Detector
90.44 Practical Tunnel Diode Converter Circuit Considerations
90.45 Tunnel Diode Sinewave Oscillators
90.66 Application for the Low Cost 1N3712 Series Tunnel Diodes

TUNNEL DIODE CIRCUITS are also detailed in Chapter 14 of the GE Transistor Manual, Pub. 450.37. Price: $2.00. Available from your local GE authorized semiconductor distributor.

GENERAL PURPOSE BACK DIODES

For Mixers, Detectors and Switching Circuits

GE Type[1]	I_P Peak Point Current Max. (mA)	C Total Capacitance Max. (pF)	Reverse Voltage Min. V_{R_1} @ $I_R = I_P$ max (mV)	Reverse Voltage Min. V_{R_2} @ 1 mA (mV)	I_{F_1} Forward Current @ $V_{F_1} = 90 \pm 10$ mV (mA)	V_{F_2} Forward Voltage @ $I_{F_2} = 3\ I_{F_1}$ Typical (mV)	t_r Rise Time Typical (psec.)
BD-1	1.0	20	440	440	10.0	120	1.0
BD-2	0.5	10	420	465	5.0	130	0.7
BD-3	0.2	10	400	465	2.0	170	0.5
BD-4	0.1	10	380	465	1.0	170	0.4
BD-5	0.05	10	350	465	0.5	160	0.4
BD-6	0.02	10	330	465	0.2	160	0.4
BD-7	0.01	10	300	465	0.1	160	0.4

(1) Miniature Axial Package—Outline No. 47 Series Inductance, $L_S = 1.5$ nH.

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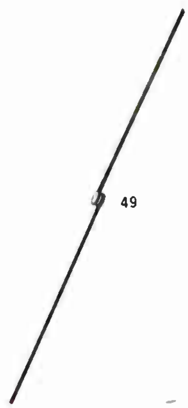
BACK DIODES MICROWAVE

For High Frequency Detectors, Mixers, and Switching Circuits

GE Type[1]	I_P Peak Point Current Max. (mA)	C Total Capacitance Max. (pF)	Reverse Voltage Min. V_{R_1} @ $I_R = I_P$ max (mV)	Reverse Voltage Min. V_{R_2} @ $I_R = 1$ mA (mV)	I_{F_1} Forward Current @ $V_{F_1} = 90 \pm 10$ mV (mA)	V_{F_2} Forward Voltage Typical @ $I_{F_2} = 3\ I_{F_1}$ (mV)
BD-402	0.5	3	420	465	5.0	138
BD-403	0.2	1	400	465	2.0	170
BD-404	0.1	1	380	465	1.0	170
BD-405	0.05	1	350	465	0.5	160
BD-406	0.02	1	330	465	0.2	160
BD-407	0.01	1	330	465	0.1	160

(1) Pill Pack—Package Outline No. 49. Series Inductance, $L_S = 0.1$ nH.



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GERMANIUM SIGNAL TRANSISTORS

PNP Alloy

GE Type	h_{FE} @ 1V, 20mA	f_{hfb} Typical (MHz)	BV_{CBO} Min. @ 400 µA 10KΩ (V)	I_{CBO} Max. @ V_{CB} (µA)	I_{CBO} Max. @ V_{CB} (V)	P_T Max. (mW)	Comments	Package Outline No.	Specification Sheet No.
2N319	25-42	2.0	20	16	25	225	Audio driver and audio output.	282	80.24
2N320	34-65	2.5	20	16	25	225		282	80.24
2N321	53-121	3.0	20	16	25	225		282	80.24
2N322	34-65	3.0	18	16	16	200		282	80.25
2N323	53-121	3.5	18	16	16	200		282	80.25
2N324	72-198	4.0	18	16	16	200		282	80.25
2N461	32-199[2]	4.0	35	15	45	200	General purpose—2N525 recommended.	282	20.25
2N508	100-200	4.5	18	7	16	200	High gain, low noise preamplifiers.	282	80.28
2N508A	100-200	4.5	25	7	25	200		282	80.28
2N524	25-42	2.5	30	10	30	225	Military/industrial—Audio amplifiers and medium speed switch. Specified h_{FE} hold-up, high temperature I_{CO}, and low temperature h_{FE}. Guaranteed reliability index.	282	20.30
2N525	34-65	3.0	30	10	30	225		282	20.30
2N526	53-90	3.5	30	10	30	225		282	20.30
2N527	72-121	4.0	30	10	30	225		282	20.30
2N1175	70-140	4.0	25	12	30	200	General purpose industrial and consumers preamplifier.	282	20.35
2N1175A	70-140	4.0	25	12	30	200	General purpose industrial and consumer, high gain, low noise preamplifiers. Guaranteed noise figure.	282	20.35
2N1413	25-42	3.2	25	12	30	200	General purpose industrial and consumer audio amplifier and medium speed switch.	282	20.70
2N1414	34-65	3.6	25	12	30	200		282	20.70
2N1415	53-90	4.0	25	12	30	200		282	20.70
2N1924	34-65	3.0	40	10	45	225	Military/industrial audio amplifier and medium speed switch. High voltage, specified h_{FE} hold-up, low temperature h_{FE}, and high temperature I_{CO}. Guaranteed reliability index.	282	20.80
2N1925	53-90	3.5	40	10	45	225		282	20.80
2N1926	72-121	4.0	40	10	45	225		282	20.80

[1] Also available as military types. [2] $V_{CE} = 1V$, $I_C = 10mA$. [3] $V_{CB} = 5V$, $I_E = 1mA$, $f = 1$ KHz [4] BV_{CEO}. [5] V_{RT} [6] $V_{RT} = 60V$

UNIJUNCTIONS, TRIGGERS AND SWITCHES

Since the introduction of the commercial silicon unijunction transistor in 1956, General Electric has continued developing an extensive line of negative resistance threshold and four-layer switch devices. Each of these devices can be used as a power thyristor trigger, and each offers a special advantage for a particular trigger function. In addition, each can be used for various non-trigger applications.

The features—both in design and characteristics—which you receive with these products are concisely defined for each series:

TYPES

CONVENTIONAL UNIJUNCTIONS 2N489-494—proved reliability, MIL spec version.
2N2646-47—low cost, proved hermetic sealed device.

PROGRAMMABLE UNIJUNCTION TRANSISTOR (PUT)—variable threshold, low cost, fast switching speed, and circuit adjustable electrical characteristics.

COMPLEMENTARY UNIJUNCTION TRANSISTOR—ultimate in temperature stability for timing and oscillator applications.

SILICON ASYMMETRICAL SWITCH (SAS)— asymmetrical voltage threshold, gate triggered

SILICON UNILATERAL SWITCH (SUS)—a stable fixed low voltage threshold, low cost, high performance "4-layer diode."

SILICON BILATERAL SWITCH (SBS)—low voltage triac trigger, two silicon unilateral switches connected back to back.

SILICON CONTROLLED SWITCH (SCS)—high triggering sensitivity, 4-lead capability for multiple loads or dv/dt suppression.

APPLICATIONS

	Device	Unijunctions				Triggers		
		Conventional		Complementary	Programmable			
	Use	2N489-94, 2N2417-22 2N1671, 2N2160	2N2646 2N2647	D5K1 D5K2	2N6027 2N6028	SUS 2N4983-90	SBS 2N4991-93	SAS D13H
Trigger for SCR's	DC, Lo Cost	P	F	P	E	E	E	E
	DC, Hi Perf.	F	F	F	E	F	F	F
	DC, Volt Regulator	P	P	F	F	E	E	E
	DC, Inverter	F	F	E	E	F	F	F
	DC, Hi ΔI/ΔT	P	P	P	E[1]	P	P	P
	AC, φ, Hi Perf.	F	F	E	E[1]	F	F	F
	AC, φ, Hi f	F	F	F	E	P	P	P
	AC, Lo RFI	P	P	F	F	E	E	E
	AC, φ, Lo Cost	P	F	P	E	E	E	E
Timers	>1 hr.	F[1]	P	F[1]	E[1]	N	N	N
	>1 min, Lo Cost	P	F	P	E	N	N	N
	>1 min, Stable	F	P	E	P	N	N	N
	<1 min, Lo Cost	P	F	P	E	F	F	F
	<1 min, Stable	F	P	E	P	F	N	N
	<10V	P	P	F	E	N	N	N
	10V-25V	E	E	E	E	F	F	F
	>25V	P	P	P	E	F	F	F
Oscillators	Stability	F	F	E	F	N	N	N
	Cost	P	F	P	E	N	N	N
	Adjust, Range	E	E	F	F[1]	N	N	N
Markets	Military	E	P	F	F[2]	P	P	P
	Hi-Rel	E	P	E	F[2]	F	F	P
	Economy	P	F	P	E	E	E	E
Trigger for Triac	SEE TRIAC SELECTOR GUIDE PAGE 67							

E = Excellent, F = Fair, P = Poor, N = Not Applicable
[1] With additional circuitry
[2] Hermetic version 2N6116-18

UNIJUNCTIONS
CONVENTIONAL

General Electric produces a very broad line of standard UJT's. The TO-5 ceramic disc bar structure device has been the workhorse of the unijunction industry for over 10 years. MIL versions are available on the 2N489-494 series. Equivalent types are available in TO-18 packages where small size is required.

The cube structure TO-18 series offers excellent value for those requiring proved, low cost units.

Applications

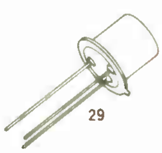
Oscillators
Timers
Sawtooth Generators

SCR Triggers
Frequency Divider
Stable Voltage Sensing

Structure	GE Type	R_{BBO} Interbase Resistance @ V_{BB} = 3V I_E = 0 (KΩ)	η Intrinsic Standoff Ratio @ V_{BB} = 10V	I_V Valley Current Min. (mA)	I_P Peak Point Emitter Current Max. (µA)	I_{EO} Emitter Reverse Current Max. (µA)	I_{EO} T_A = 25°C @ V_{B2E}	V_{OB1} Base One Peak Pulse Voltage Min. (V)	Comments	Package Outline No.	Specification Sheet No.
TO-5 Bar Structure	2N489 2N489A * 2N489B	4.7- 6.8	.51-.62	8	12 12 6	2 2 0.2	60 60 30	— 3 3	"A" versions are guaranteed in recommended circuit to trigger GE SCR's over range T_A = −55°C to 125°C. "B" versions in addition to SCR triggering guarantees lower I_{EO} and I_P for long timing periods with a smaller capacitor.	31	60.10
	2N490 2N490A * 2N490B 2N490C	6.2- 9.1	.51-.62	8	12 12 6 2	2 2 0.2 .02	60 60 30 30	— 3 3 3			60.10 60.11
	2N491 2N491A * 2N491B	4.7- 6.8	.56-.68	8	12 12 6	2 2 0.2	60 60 30	— 3 3		31	60.10
	2N492 2N492A * 2N492B 2N492C	6.2- 9.1	.56-.68	8	12 12 6 2	2 2 0.2 .02	60 60 30 30	— 3 3 3		31	60.10 60.11
	2N493 2N493A * 2N493B	4.7- 6.8	.62-.75	8	12 12 6	2 2 0.2	60 60 30	— 3 3		31	60.10
	2N494 2N494A * 2N494B 2N494C	6.2- 9.1	.62-.75	8	12 12 6 2	2 2 0.2 .02	60 60 30 30	— 3 3 3		31	60.10 60.11
	2N1671 2N1671A 2N1671B 2N1671C	4.7- 9.1	.47-.62	8	25 25 6 2	12 12 0.2 .02	30 30 30 30	— 3 3 3	Industrial types.	31	60.50
	2N2160	4.0-12.0	.47-.80	8	25	12	30	3	General purpose—low cost.	31	60.53
TO-18 Bar Structure	2N2417 2N2417A 2N2417B	4.7- 6.8	.51-.62	8	12 12 6	2 2 0.2	60 60 30	— 3 3	"A" versions are guaranteed in recommended circuit to trigger GE SCR's over range T_A = −55°C to 125°C. "B" versions in addition to SCR triggering guarantees lower I_{EO} and I_P for long timing periods with a smaller capacitor.	30	60.10
	2N2418 2N2418A 2N2418B	6.2- 9.1	.51-.62	8	12 12 6	2 2 0.2	60 60 30	— 3 3		30	60.10
	2N2419 2N2419A 2N2419B	4.7- 6.8	.56-.68	8	12 12 6	2 2 0.2	60 60 30	— 3 3		30	60.10
	2N2420 2N2420A 2N2420B	6.2- 9.1	.56-.68	8	12 12 6	2 2 0.2	60 60 30	— 3 3		30	60.10
	2N2421 2N2421A 2N2421B	4.7- 6.8	.62-.75	8	12 12 6	2 2 0.2	60 60 30	— 3 3		30	60.10
	2N2422 2N2422A 2N2422B	6.2- 9.1	.62-.75	8	12 12 6	2 2 0.2	60 60 30	— 3 3		30	60.10
	D5G514 D5G515 D5G516 —	4.7- 9.1	.47-.62	8	25 25 6 2	12 12 0.2 .02	30 30 30 30	— 3 3 3	TO-18 versions of 2N1671 industrial series.	30	—
TO-18 Cube Structure	2N2646	4.7- 9.1	.56-.75	4	5	12	30	3	General purpose.	29	60.62
	2N2647	4.7- 9.1	.68-.82	8	2	0.2	30	6	For long timing periods and triggering high current SCR's.	29	60.62
	D5E-43	4.7- 9.1	.68-.82	6	2	1	30	5	General purpose.	29	60.12
	D5E-44	4.7- 9.1	.68-.82	4	5	12	30	4	General purpose—low cost.	29	60.13
	2N2840	4.7- 9.1 [2]	.62 Typical	.2	10	1	30	—	For 1.5 volt applications.	29	60.56

* JAN & JANTX types available
[2] V_{BB} = 1.5V

See selector guide—Unijunctions, Triggers, Switches page 33.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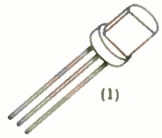
PROGRAMMABLE UNIJUNCTIONS (PUT—D13T SERIES)

The 2N6028 is specifically characterized for long interval timers and other applications requiring low leakage and low peak point current. The 2N6027 has been characterized for general use where the low peak point current of the 2N6028 is not essential.

Applications:

- SCR Trigger
- Pulse & Timing Circuits
- Oscillators
- Sensing Circuits
- Sweep Circuits



(1)

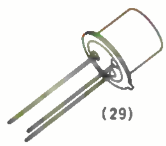
Outstanding Features of the PUT:

- Low Cost
- Low Leakage Current
- Low Peak Point Current
- Low Forward Voltage
- Fast, High Energy Trigger Pulse
- Programmable η
- Programmable R_{BB}
- Programmable I_p
- Programmable I_v
- Planar Passivated Structure

JEDEC Types	Gate to Anode Reverse Voltage Max. (V)	OC Anode Current Max. (mA)	Peak Anode Current 20 μsec. 1% O.C. Max. (A)	I_{GAO} Leakage Current @ 40V Max. (nA)	Pk. Point Current Max. @ R_G = 10 k (μA)	Pk. Point Current Max. @ R_G = 1 Meg. (μA)	I_V Valley Current Min. @ R_G = 10 k (μA)	V_O Output Voltage Min. (V)	t_r Pulse Rate of Rise Max. (nsec.)	Package	Specification Sheet No.
2N6027	40	150	2	10	5	2	70	6	80	1	60.20
2N6028	40	150	2	10	1	.15	25	6	80	1	60.20

[1] Hermetic version of 2N6027: 2N6116
[2] Hermetic version of 2N6028: 2N6118

COMPLEMENTARY UNIJUNCTIONS (D5K SERIES)

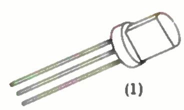


(29)

The D5K offers the ultimate in unijunction stability and uniformity. Low frequency oscillators and timers can be built using the D5K with better than 1.0% accuracy over extended temperature ranges. The D5K has characteristics like those of a standard unijunction except the currents and voltages applied to it are of opposite polarity than those of the standard devices.

GE Type	R_{BO} Interbase Resistance @ I_{B_2} = 0.1mA k Ω	η Intrinsic Standoff Ratio	I_V Valley Current Min. (mA)	I_P Peak Point Emitter Current Max. (μA)	I_{EO} Emitter Reverse Current Max. (nA)	V_O Peak Pulse Voltage Min. (V)	Operating Temp. Range Top (°C)	Frequency Stability from 25°C —55 to +150°C %	Package	Specification Sheet No.
D5K1	5.5-8.2	.58-.62	1	5	10	3.5	−55 to +150	1.0	29	60.15
D5K2	5-15	.58-.62	1	15	10	3.5	−55 to +100	2.0	29	60.16

SILICON ASYMMETRICAL SWITCH (SAS)

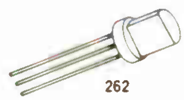


(1)

A Monolithic Integrated Switch for Bistable Application Where Stability of Switching Voltage is Required.

GE Type	V_{S2} Switching Voltage Min. (V)	V_{S2} Switching Voltage Max. (V)	V_{S1} Switching Voltage Min. (V)	V_{S1} Switching Voltage Max. (V)	I_{S2}, I_{S1} Switching Current Max. (μA)	V_{F2} Forward Voltage Drop @ 100 mA Max. (V)	V_{F1} Forward Voltage Drop @ 100 mA Min. (V)	V_{F1} Forward Voltage Drop @ 100 mA Max. (V)	Temperature Coefficient of V_S —55 to +125°C Typical	Package	Specification Sheet No.
D13H1	7	9	14	18	80	1.6	7	10	.03%/°C	1	65.34

SILICON UNILATERAL AND BILATERAL SWITCHES (SUS, SBS)



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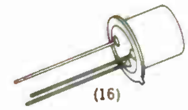


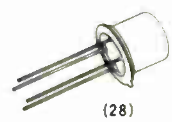
(16)

The General Electric SUS is a silicon, planar monolithic integrated circuit having thyristor electrical characteristics closely approximating those of an "ideal" four-layer diode. The device is designed to switch at 8 volts with a typical temperature coefficient of 0.02%/°C. A gate lead is provided to eliminate rate effect, obtain triggering at lower voltages, and to obtain transient-free waveforms.

The SBS is a bilateral version of the forward characteristics of the SUS. It provides excellently matched characteristics in both directions with the same low temperature coefficient.

	GE Type	V_{A} Reverse Voltage Max. (V)	I_F Continuous Forward Current Max. (mA)	I_F Peak Recurrent Forward Current @ 100°C, 10 μs, 1% duty cycle (A)	P Dissipation (mW)	T_C Temperature Coefficient of Switching Voltage (%/°C)	V_S Switching Voltage Min. (V)	V_S Switching Voltage Max. (V)	I_S Switching Current Max. (μA)	I_B Forward Blocking Current @ 5V (μA)	V_F Forward Voltage @ 200mA (V)	I_H Holding Current (mA)	V_O Peak Pulse Voltage Min. (V)	GE Package Outline	Specification Sheet No.
Unilateral	2N4987	30	175	1.0	300	—	6	10	500	1.0	1.5	1.5	3.5	262	65.26
	2N4988	30	200	1.0	350	±.05	7.5	9	150	0.1	1.5	.5	3.5		65.28
	2N4989	30	200	1.0	350	±.02	7.5	8.2	300	0.01	1.5	1.0	3.5		65.28
	2N4990	30	175	1.0	300	—	7	9	200	0.1	1.5	.75	3.5		65.26
	2N4983	30	175	1.0	300	—	6	10	500	1.0	1.5	1.5	3.5	16	65.25
	2N4984	30	200	1.0	350	±.05	7.5	9	150	0.1	1.5	.5	3.5		65.27
	2N4985	30	200	1.0	350	±.02	7.5	8.2	300	0.01	1.5	1.0	3.5		65.27
	2N4986	30	175	1.0	300	—	7	9	200	0.1	1.5	.75	3.5		65.25
Bilateral	2N4991	—	175	1.0	300	—	6	10	500	1.0	1.7	1.5	3.5	16	65.31
	2N4992	—	200	1.0	350	±.05	7.5	9	120	0.1	1.7	.5	3.5		65.32
	2N4993	—	175	1.0	300	—	6	10	500	1.0	1.7	1.5	3.5	262	65.30

SILICON CONTROL SWITCHES (SCS)



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High triggering sensitivity. 4 lead capability for multiple load or dv/dt suppression.

						Cutoff Characteristics	Conducting Characteristics		Max. Gate Ratings	Gate triggering Characteristics					
GE Type	V_{AK} Anode Voltage Blocking (V)	I_F Continuous DC Forward Current (mA)	Peak Recurrent Forward Current @ 100μsec (A)	Cathode Gate Peak Current (mA)	P (mW)	I_B @ V_{AK}, R_{GK} = 10K, 150°C (μA)	I_H R_{GK} = 10K (mA)	V_F I_F = 20 mA (V)	V_{GA} I_{GA} = 1 μA (V)	I_{GC} @ V_{AK} = 40V, R_L = 800 Ω, R_{GA} (μA)	V_{GC} (V)	I_{GTA} @ V_{AK} = 40V, R_L = 800 Ω, R_{GK} = 10K (mA)	V_{GTA} (V)	GE Package Outline	Specification Sheet No.
3N81	65	200	1.0	500	400	20	1.5	5	65	1.0	.4 to .65	1.5	−.4 to −.8	28	65.16
3N82	100	200	1.0	500	400	20	1.5	5	100	1.0	.4 to .65	1.5	−.4 to −.8	28	65.16
3N83	70	50	0.1	50	200	20 *	4.0 †	5	70	150 †	.4 to .80	—	—	28	65.17
3N84	40	175	0.5	100	320	20 *	2.0	5	40	10	.4 to .65	—	—	28	65.18
3N85	100	175	0.5	100	320	20 *	2.0	5	100	10	.4 to .65	—	—	28	65.18
3N86	65	200	1.0	500	400	20	0.2	5	65	1.0	.4 to .65	0.1	−.4 to −.8	28	65.19

* Measured @125°C. † Measured in special test circuit (See specification sheet).

ADDITIONAL REFERENCE PUBLICATIONS

ORDER BY PUBLICATION NUMBER

90.10 The Unijunction Transistor Characteristics and Applications

90.12 Unijunction Temperature Compensation

90.19 Unijunction Frequency Divider

90.70 The D13T—A Programmable Unijunction Transistor

90.72 Complementary Unijunction Transistors dvertisement

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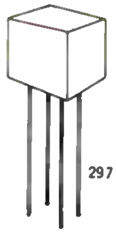

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PHOTON COUPLED ISOLATORS

PHOTO TRANSISTOR OUTPUT

GE Type	GE Package Outline	Isolation Voltage	Current Transfer Ratio Min.	I_D (nA)	BV_{CEO} (V)	Typical t_r (μSEC)	Typical t_f (μSEC)	$V_{CE(SAT)}$ MAX.	Spec. Pub. #
H10A1	289	1000	20%	100	40	3	3	.4	55.61
H11A1	296	2500	50%	50	30	2	2	.4	55.64
H11A2	296	1500	20%	50	30	2	2	.4	55.64
H11A3	296	2500	20%	50	30	2	2	.4	55.72
H11A4	296	1500	10%	50	30	2	2	.4	55.72
H15A1	297	4000	20%	100	30	3	3	.4	55.70
H15A2	297	4000	10%	100	30	3	3	.4	55.70

PHOTO DARLINGTON OUTPUT

GE Type	GE Package Outline	Isolation Voltage	Current Transfer Ratio Min.	I_D (nA)	BV_{CEO} (V)	Typical t_r (μSEC)	Typical t_f (μSEC)	$V_{CE(SAT)}$ MAX.	Spec. Pub. #
H10B1	289	1000	200%	100	25	125	100	1.2	55.62
H11B1	296	2500	500%	100	25	125	100	1.0	55.65
H11B2	296	1500	200%	100	25	125	100	1.0	55.65
H15B1	297	4000	400%	100	25	125	100	1.4	55.71
H15B2	297	4000	200%	100	25	125	100	1.4	55.71

PHOTO SCR

GE Type	GE Package Outline	Isolation Voltage	I_F to Trigger	I_D	Blocking Voltage	Typical Ton (μSEC)	Typical tf	V_F (V)	Spec. Pub. #
H10C1	289	1000	50mA	10μA	200	1		1.5	55.63
H11C1	296	2500	20mA	2μA	200			1.5	55.73
H11C2	296	1500	20mA	2μA	200			1.5	55.73

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PHOTON COUPLED INTERRUPTER MODULE

PHOTO TRANSISTOR OUTPUT

GE Type	GE Package Outline	Output Current		I_D (nA)	BV_{CEO} (V)	Typical Ton (μSEC)	Typical tf (μSEC)	$V_{CE(SAT)}$ MAX.	Spec. Pub. #
H13A1	295	I_F = 20mA	200μA	100	30	5	5	.4	55.68
H13A2	295	I_F = 20mA	50μA	100	30	5	5	.4	55.68

PHOTO DARLINGTON OUTPUT

GE Type	GE Package Outline	Output Current		I_D (nA)	BV_{CEO} (V)	Typical Ton (μSEC)	Typical tf (μSEC)	$V_{CE(SAT)}$ MAX.	Spec. Pub. #
H13B1	295	I_F = 10mA	1000μA	100	25	150	150	1.2	55.69
H13B2	295	I_F = 10mA	500μA	100	25	150	150	1.2	55.69

PHOTON COUPLED ISOLATOR INTERCHANGEABILITY GUIDE

Manufacture Type	*Closest GE Replacement Type	Isolation Voltage	Current Transfer Ratio Min.	Current Transfer Ratio Max.	Current Transfer Ratio @ I (mA)	I (nA)	B (V)	GE Package Outlines
CLAIREX								
CL1-2	H11A2	1500	30%	100%	10	25	50	274
CL1-3	H11A1	1500	100%	200%	10	25	50	274
CL1-5	H11A2	1500	20%	—	10	25	50	274
CL1-10	H11BX502	1500	600%	—	10	50	50	274
FAIRCHILD								
FC0810	H11A4	1500	10%	—	10	100	30	274
FCD811	H11A3	2500	20%	—	10	50	30	274
FCD820	H11A2	1500	20%	—	10	50	30	274
FPLA810	H11A4	1500	10%	—	10	50	30	274
FPLA820	H11A2	1500	20%	—	10	50	30	274
LITRONIX								
ISO-LIT1	H11A3	2500	20%	—	10	50	30	274
ISO-LIT12	H11A4	1000	2%	—	10	100	20	274
ISO-LIT16	H11A4	1500	6%	—	10	100	30	274
MONSANTO								
**MCT1	H15A1	2500	20%	—	10	75	30	275
MCT2	H11A2	1500	20%	100%	10	50	30	274
MCT26	H11A4	1500	6%	—	10	—	—	274
**MCS1	H11C1	2500	4 mA TYP	—	—	—	—	274
MCS2	H11C2	1500	—	14mA	—	—	—	274
MCA2-30	H11B2	1500	100%	—	10	100	30	274
MCA2-55	H11BX503	1500	100%	—	10	100	55	274
**MCA8	H13B1	—	I = 2mA	—	16	100	30	273
**MCA8-1	H13B2	—	I = 1.6mA	—	50	100	30	273
MOTOROLA								
MOC1000	H11A2	1500	20%	—	10	50	30	274
MOC1001	H11A3	2500	20%	—	10	50	30	274
MOC1002	H11A4	1500	10%	—	10	50	30	274
MOC1100	H11B2	1500	100%	—	10	—	—	274
T.I.								
**TIL102	H10A1	1000	25%	—	10	100	35	268
**TIL103	H10A1	1000	100%	—	10	100	35	268
TIL111	H11A2	1500	12.5%	—	16	50	30	274
TIL112	H11A4	1500	2%	—	10	100	20	274
**TIXL109	H15A2	5000	7%	—	35	500	15	275
TIXL113	H11B2	1500	100%	—	2.5	100	30	274
**TIL138	H13A1	—	I = 1.6mA min.	—	35	25	50	273

*The suggested replacements represent what we believe to be equivalents for the products listed. GE assumes no responsibility and does not guarantee that the replacements are exact, but only that the replacements will meet the terms of its applicable published written product warranties. The pertinent GE product specification sheets should be used as the key tool for actual replacements.

**Check package for compatability

DETECTORS

PHOTO TRANSISTORS

GE Type	Package Outline	Sensitivity (ma/mw/cm²) Min.	Max.	BV_{CEO} (V)	BV_{CBO} (V)	I_D (nA) Max.	Switching Typ t_r (μSEC)	t_f (μSEC)	TYP $V_{CE}(SAT)$	Specs. Pub. #
L15AX601	270	.075	.15	50	—	25	2.5	25	.15	55.80
L15AX602	270	.125	.25	50	—	25	2.5	25	.15	55.80
L15AX603	270	.20	.4	50	—	25	2.5	25	.15	55.80
L15AX604	270	.35	—	50	—	25	2.5	25	.15	55.80
L15A600	270	.05	—	40	—	100	3	3	.15	55.58
L15E	289	.15	—	40	50	100	3	3	.15	55.56
L14A502	54	.3	—	45	50	100	5	5	.15	55.45
L14E1	263	.005	.03	50	50	100	6	6	.2	55.47
L14E2	263	.01	.07	50	50	100	15	10	.2	55.47
L14E3	263	.04	.1	50	—	100	20	15	.2	55.47
L14E4	263	.005	—	50	45	10	20	15	.2	55.47
L14C1	54A	.1	—	45	45	10	5	5	.15	55.81
L14G1	54	.6	—	45	45	100	5	5	.15	55.82
L14G2	54	.3	—	45	45	100	5	5	.15	55.82

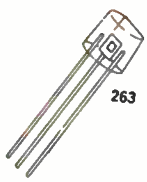
PHOTO DARLINGTONS

GE Type	Package Outline	Sensitivity (ma/mw/cm²) Min.	Max.	BV_{CEO} (V)	BV_{CBO} (V)	I_D (nA) Max.	Switching Typ t_r (μSEC)	t_f (μSEC)	TYP $V_{CE}(SAT)$	Specs. Pub. #
2N5777	263	.25	—	25	25	100	75	50	.8	55.46
2N5778	263	.25	—	40	40	100	75	50	.8	55.46
2N5779	263	1.0	—	25	25	100	75	50	.8	55.46
2N5780	263	1.0	—	40	40	100	75	50	.8	55.46
L14F	54	15	—	25	25	100	75	50	.8	55.49

PHOTO SWITCHES

GE Type	Package Outline	Irradiance To Trigger (mw/cm²)		Blocking Voltage	I_D (nA) Max.	V_F (V)	Specs. Pub. #
L1V	263	—	10	40	1μA	2.0	55.41
L14T1	263	—	.2	40	100	1.6	55.54
L14T2	263	—	.2	40	100	1.6	55.54
L14T3	263	—	.2	40	100	1.6	55.54
L14T4	263	—	.2	40	100	1.6	55.54
L14T5	263	—	.2	40	100	1.6	55.54
L8	101	—	4.2	25-200	10μA	1.4	190.10
L9	101	—	10	25-200	10μA	1.4	190.10

101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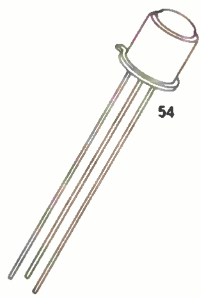
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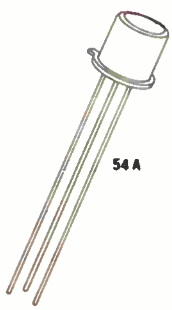
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DETECTOR INTERCHANGEABILITY GUIDE

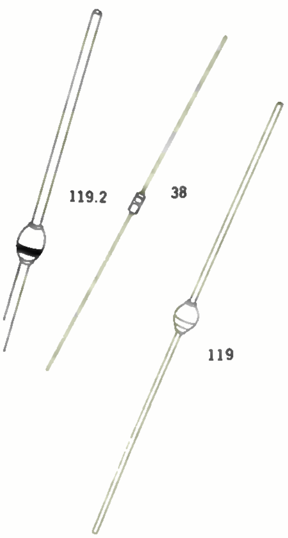
Manufacturer Type	**GE Equivalent Type	Light Current Min. (mA)	Light Current Max. (mA)	@ H = mw/cm²	Dark Current Max. (nA)	@ V_{CE} = Volts	BV_{CEO} Min. (V)	@ I_C = (μA)	BV_{CBO} Min. (V)	I_C = (μA)	BV_{ECO} *BV_{EBO} Min. (V)	I_C = (μA)	GE Package Outline
CLAIREX													
CLT2010	L14CX2010	.2	.6	5	25	10	50	100	80	100	*5	100	54A
CLT2020	L14CX2020	.4	1.2	5	25	10	30	100	60	100	*5	100	54A
CLT2030	L14CX2030	1.0	3.0	5	25	10	30	100	60	100	*5	100	54A
CLT2130	L14AX2130	.6	1.8	5	25	10	50	100	80	100	*5	100	54
CLT2140	L14AX2140	1.2	3.6	5	25	10	40	100	80	100	*5	100	54
CLT2150	L14AX2150	2.4	7.2	5	25	10	40	100	80	100	*5	100	54
CLT2160	L14AX2160	4.0	12.0	5	25	10	30	100	80	100	*5	100	54
CLR2050	L14FX2050	.6	1.8	.2	50	10	40	100	80	100	*10	100	54A
CLR2060	L14FX2060	1.4	4.0	.2	50	10	40	100	80	100	*10	100	54A
CLR2170	L14FX2170	.2	.5	.02	50	10	40	100	80	100	*10	100	54
CLR2180	L14FX2180	.4	.8	.02	50	10	40	100	80	100	*10	100	54
CLR3160	L15AX506	1.0	3.0	20	10	10	50	100			5	100	270
CLR3170	L15AX507	2.0	5.0	20	10	10	40	100			5	100	270
MONSANTO													
MT1	L14C1	.4	—	5	20	5	30	100	80	100	7	100	54A
MT2	L14A502	1.0	—	5	20	5	30	100	80	100	7	100	54
MOTOROLA													
MRD200	L15AX508	1.25	—	5	25	20	50	100	—	—	7	100	270
MRD210	L15AX509	.25	—	5	25	20	50	100	—	—	7	100	270
MRD250	L15AX510	.5	—	5	25	20	50	100	—	—	7	100	270
MRD300	L14AX300	4.0	—	5	25	20	50	100	80	100	7	100	54
MRD310	L14AX310	1.0	—	5	25	20	50	100	80	100	7	100	54
MRD600	L15A600	.8	—	20	25	30	50	100	—	—	7	100	270
MRD810	L14CX810	1.0	—	5	50	20	35	100	—	—	5	100	54A
MRD3050	L14AX3050	.1	—	5	100	20	40	100	30	100	5	100	54
MRD3051	L14AX3051	.2	—	5	100	20	40	100	30	100	5	100	54
MRD3052	L14AX3052	.1	.4	5	100	20	40	100	30	100	5	100	54
MRD3053	L14AX3053	.25	1.0	5	100	20	40	100	30	100	5	100	54
MRD3054	L14AX3054	.6	2.5	5	100	20	40	100	30	100	5	100	54
MRD3055	L14AX3055	1.5	—	5	100	20	40	100	30	100	5	100	54
MRD3056	L14AX3056	2.0	—	5	100	20	40	100	30	100	5	100	54
OPTRON													
OP600	L15A600	.8	—	20	25	30	50	100	—	—	7	100	270
OP601	L15AX601	1.5	3.0	20	25	30	50	100	—	—	7	100	270
OP602	L15AX602	2.5	5.0	20	25	30	45	100	—	—	7	100	270
OP603	L15AX603	4.0	8.0	20	25	30	40	100	—	—	7	100	270
OP604	L15AX604	6.0	12.0	20	25	30	40	100	—	—	7	100	270
SPECTRONICS													
SD2440	L15A600	.8	—	20	25	30	50	100	—	—	7	100	270
SD2440-1	L15A600	.5	—	20	25	30	50	100	—	—	7	100	270
SD2440-2	L15AX601	1.6	—	20	25	30	50	100	—	—	7	100	270
SD2440-3	L15AX602	2.4	—	20	25	30	50	100	—	—	7	100	270
SD2440-4	L15AX604	4.8	—	20	25	30	50	100	—	—	7	100	270
SD3440-1	L14CX502	.25	—	20	25	30	50	100	50	100	7	100	54A
SD3440-2	L14CX503	.8	—	20	25	30	50	100	50	100	7	100	54A
SD3440-3	L14CX504	1.2	—	20	25	30	50	100	50	100	7	100	54A
SD3440-4	L14CX505	2.4	—	20	25	30	50	100	50	100	7	100	54A
SD5440-1	L14AX545	2.4	—	20	25	30	50	100	50	100	7	100	54
SD5440-2	L14AX546	2.0	—	20	25	30	50	100	50	100	7	100	54
SD5440-3	L14AX547	4.0	—	20	25	30	50	100	50	100	7	100	54
SD5440-4	L14AX548	8.0	—	20	25	30	50	100	50	100	7	100	54
SD5440-5	L14AX548	8.0	—	20	25	30	50	100	50	100	7	100	54
SD5410-1	L14FX518	2.0	—	.2	250	5	30	100	30	100	7	100	54
SD5410-3	L14FX519	6.0	—	.2	250	5	30	100	30	100	7	100	54
SD5410-2	L14FX520	8.0	—	.2	250	5	30	100	30	100	7	100	54
T.I.													
LS600	L15A600	.8	—	20	25	30	50	100	—	—	7	100	270
TIL601	L15AX601	.5	3.0	20	25	30	50	100	—	—	7	100	270
TIL602	L15AX602	2.0	5.0	20	25	30	50	100	—	—	7	100	270
TIL603	L15AX603	4.0	8.0	20	25	30	50	100	—	—	7	100	270
TIL604	L15AX604	7.0	—	20	25	30	50	100	—	—	7	100	270
TIL81	L14GX502	5.0	—	5	100	10	30	100	50	100	7	100	54

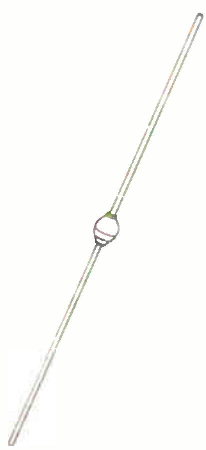
** The suggested replacements represent what we believe to be the nearest GE equivalents for the products listed and in most instances are exact replacements. However, GE assumes no responsibility and does not guarantee that the replacements are exact, but only that the replacements will meet the terms of its applicable published written product warranties. The pertinent GE product specification sheets should be used as the key tool for actual replacements.

SILICON RECTIFIERS .25 TO 3 AMPERES

JEDEC	—	—	—	—	1N5059-62	1N4245-49	—	—	1N5624-27	—	—
GE TYPE	DT230	MPR10-15	A14PD	A114PD2	A14A-P	—	GER4001-7	A114A-M	—	A15A-N	A115A-M
SPECIFICATIONS											
$I_{FM(AV)}$ (A)	.25	.5	1	1	1	1	1	1	3	3	3
@ T_A(°C)	50	100	75	75	100	55	75	55	70	70	55
$V_{RM(rep)}$ — Max. repetitive peak reverse voltage (V)											
50	DT230F	—	—	—	A14F	—	GER4001	A114F	—	A15F	A115F
100	DT230A	—	—	—	A14A	—	GER4002	A114A	—	A15A	A115A
150	DT230G	—	—	—	—	—	—	—	—	—	—
200	DT230B	—	—	—	1N5059	1N4245 *	GER4003	A114B	1N5624	A15B	A115B
250	DT230H	—	—	—	—	—	—	—	—	—	—
300	—	—	—	—	A14C	—	—	A114C	—	A15C	A115C
400	—	—	—	—	1N5060	1N4246 *	GER4004	A114D	1N5625	A15D	A115D
500	—	—	—	—	A14E	—	—	A114E	—	A15E	A115E
600	—	—	—	—	1N5061	1N4247 *	GER4005	A114M	1N5626	A15M	A115M
800	—	—	—	—	1N5062	1N4248 *	GER4006	A114N	1N5627	A15N	—
1000	—	MPR10	—	—	A14P [1]	1N4249	GER4007	—	—	—	—
1200	—	MPR12	—	—	—	—	—	—	—	—	—
1400	—	—	A14PD	A114PD2	—	—	—	—	—	—	—
1500	—	MPR15	—	—	—	—	—	—	—	—	—
$I_{FM(surge)}$ Max. peak one cycle, non-recurrent surge current (60 Hz sine wave, 1 phase operation) @ max. rated load conditions (A)	5	25	40	40	50	25	30	40	125	125	110
I^2t Max. non-repetitive for 8.3 msec. (A^2sec)	—	3	3.5	3.5	4	4	—	3.5	25	25	20
T_J Operating junction temperature range (°C)	−65 to 150	−65 to 175	−65 to 150	−65 to 150	−65 to 175 [1]	−65 to 160	−65 to 175	−65 to 125	−65 to 175	−65 to 175	−65 to 150
T_{stg} Storage temperature range (°C)	−65 to 200	−65 to 175	−65 to 175	−65 to 175	−65 to 175	−65 to 200	−65 to 175	−65 to 175	−65 to 200	−65 to 175	−65 to 175
V_{FM} Max. peak forward voltage drop @ rated $I_{F(AV)}$ (1 phase operation)	1.1	1.8	1.1	1.1	1.0	1.2@ +55°C	1.1	1.1	1.0	1.0	1.0
t_{rr} Max. reverse recovery time (μsec)	0.3	5	—	20	6	5	—	0.2	5	5	0.2
PACKAGE OUTLINE NO.	38	119	119	119	119	119	119	119	119.2	119.2	119.2
SPECIFICATION SHEET NO.	130.25	130.53	Contact Factory		130.55	130.56	130.66	130.63 130.64	130.59	130.58 130.59	130.67 130.68

NOTE:
[1] Average forward current 1 amp. @ T_A=90°C. Junction, operating and storage temperature range −65 to +165°C.
* JAN & JANTX types available





The best way to assure reliability in a low-current rectifier pellet is to put it in a package that really protects it. Protects it from shock, humidity, vibration and temperature.

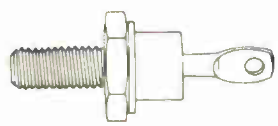
And that's just what we do with General Electric's glassivated 1-amp (A14) and 3-amp (A15) rectifiers. Solid glass provides passivation and protection of the silicon pellet's P-N junction—no organic material is present within the hermetically sealed package. In addition, rigid mechanical support and excellent thermal characteristics are provided by the dual heat sink construction.

For high-frequency applications, GE offers a fast-recovery rectifier, the 1-amp A114, with a 200 nsec. max. reverse recovery.

SILICON RECTIFIERS
5 TO 12 AMPERES

JEDEC		1N1612-16	1N1341A-48A	1N3987-90	1N3879-83	1N1199A-1206A 1N3670A-73A 1N5331	1N3889-93			1N4510-11
GE TYPES		—	—	—	—	—	—	A28F-D	A129E-PB	—
SPECIFICATIONS										
$I_{F(AV)}$	(A)	5	6	6	6	12	12	12	12	12
	@ T_C (°C)	150	150	150	100	150	100	135	65	135
V_{RRM}	— Max. repetitive peak reverse voltage (V)	—	—	—	—	—	—	—	—	—
	50	1N1612	1N1341A	—	1N3879	1N1199A	1N3889	A28F	—	—
	100	1N1613	1N1342A	—	1N3880*	1N1200A	1N3890*	A28A	—	—
	150	—	1N1343A	—	—	1N1201A	—	—	—	—
	200	1N1614*	1N1344A	—	1N3881*	1N1202A*	1N3891*	A28B	—	—
	300	—	1N1345A	—	1N3882	1N1203A	1N3892	A28C	—	—
	400	1N1615*	1N1346A	—	1N3883*	1N1204A*	1N3893*	A28D	—	—
	500	—	1N1347A	—	—	1N1205A	—	—	A129E	—
	600	1N1616*	1N1348A	—	—	1N1206A*	—	—	A129M	—
	700	—	—	1N3987	—	1N3670A	—	—	—	—
	800	—	—	1N3988	—	1N3671A	—	—	A129N	—
	900	—	—	1N3989	—	1N3672A	—	—	—	—
	1000	—	—	1N3990	—	1N3673A*	—	—	A129P	1N4510
	1200	—	—	—	—	1N5331	—	—	A129PB	1N4511
$I_{FM(surge)}$	Max. peak one cycle, non-recurrent surge current (60 Hz sine wave, 1 phase operation) @ max. rated load conditions (A)	150	150	150	75	240	150	240	150	240
I^2t	Max. non repetitive for 8.3 msec (A^2sec)	25	25	25	—	60	—	67	38	67
T_J	Operating junction temperature range (°C)	−65 to +190	−65 to +200	−65 to +200	−65 to +150	−65 to +200	−65 to +200	−65 to +175	−40 to +125	−65 to +175
T_{stg}	Storage temperature range (°C)	−65 to +200	−65 to +200	−65 to +200	−65 to +175	−65 to +200	−65 to +200	−65 to +175	−40 to +125	−65 to +200
$R_{\theta JC}$	Max. thermal resistance, junction to case (°C/W)	7.0	4.25	4.25	2.5	2.5	2.0	2.0	3.25	2.0
V_{FM}	Max. peak forward voltage drop @ rated $I_{F(AV)}$ (1 phase operation) (V)	1.1	1.1	1.1	1.4	1.1	1.4	1.1	1.4	1.4
	@ T_C (°C)	25	25	25	25	25	25	25	25	135
t_{rr}	Max. reverse recovery time (nsec)	—	—	—	200	—	200	100	500	—
PACKAGE OUTLINE NO.		120	120	120	120	120	120	120	120	120
SPECIFICATION SHEET NO.		140.15	140.10	—	140.12	140.20	140.22	140.23	140.25	140.24

*JAN & JANTX types available



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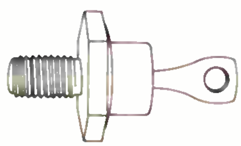
SILICON RECTIFIERS 20 TO 40 AMPERES

JEDEC		1N248B-50B	1N1195A-98A	1N2154-60	1N1183-90 1N3765-68 1N5332	1N1183A-90A	1N3899-3903	1N3909-13	1N4529-30	1N3208-14		
GE TYPE										A40F-M	A44F-M	A139
SPECIFICATIONS												
$I_{F(AV)}$	Max. average forward current (1 phase operation) (A)	20	20	25	35	40	20	30	35	20	20	25
	@ T_C=(°C)	150	150	145	140	150	100	100	115	110	110	75
$V_{RM(rep)}$	—Max. repetitive peak reverse voltage (V)											
	50	1N248B	—	1N2154	1N1183	1N1183A	1N3899	1N3909*	—	1N3208 A40F	A44F	—
	100	1N249B*	—	1N2155	1N1184*	1N1184A	1N3900	1N3910*	—	1N3209 A40A	A44A	—
	150	—	—	—	1N1185	1N1185A	—	—	—	—	—	—
	200	1N250B*	—	1N2156	1N1186*	1N1186A	1N3901	1N3911*	—	1N3210 A40B	A44B	—
	300	—	1N1195A	1N2157	1N1187	1N1187A	1N3902	1N3912*	—	1N3211 A40C	A44C	—
	400	—	1N1196A	1N2158	1N1188*	1N1188A	1N3903	1N3913*	—	1N3212 A40D	A44D	—
	500	—	1N1197A	1N2159	1N1189	1N1189A	—	—	—	1N3213 A40E	A44E	A139E
	600	—	1N1198A	1N2160	1N1190	1N1190A	—	—	—	1N3214 A40M	A44M	A139M
	700	—	—	—	1N3765	—	—	—	—	—	—	—
	800	—	—	—	1N3766	—	—	—	—	—	—	A139N
	900	—	—	—	1N3767	—	—	—	—	—	—	—
	1000	—	—	—	1N3768	—	—	—	1N4529	—	—	A139P
	1200	—	—	—	1N5332	—	—	—	1N4530	—	—	A139PB
$I_{FM(surge)}$	Max. peak one cycle, non-recurrent surge current (60 Hz sine wave, 1 phase operation) @ max. rated load conditions (A)	350	350	400	500	800	225	300	500	300	300	400
I^2t	Max. I^2t rating (non-repetitive for 8.3 msec.) A^2 sec	—	—	250	500	—	—	—	500	100	100	500
T_J	Operating junction temperature range (°C)	−65 to +175	−65 to +175	−65 to +200	−65 to +200	−65 to +200	−65 to +150	−65 to +150	−65 to +175	−65 to +175	−65 to +175	−40 to +125
T_{stg}	Storage temperature range (°C)	−65 to +175	−65 to +175	−65 to +200	−65 to +200	−65 to +200	−65 to +175	−65 to +175	−65 to +200	−65 to +175	−65 to +175	−40 to +200
θ_{J-C}	Max. thermal resistance, junction-to-case (°C/W)	1.2	1.2	1.4	1.0	1.0	1.5	1.0	1.0	1.5 Typical	1.5 Typical	1.0
V_{FM}	Max. peak forward voltage drop @ rated $I_{F(AV)}$ (1 phase operation) (V)	—	—	—	1.7	1.3	1.4	1.4	1.4	1.35 Typical	1.35 Typical	1.85
	@ T_C=(°C)	150	150	145	140	25	25	25	115	25	25	75
T_{rr}	Max. reverse recovery time (nsec)	—	—	—	—	—	200	200	—	—	—	500
PACKAGE OUTLINE NO.		123	123	123	123	123	123	123	123	125	126	126
SPECIFICATION SHEET NO.		140.28	140.30	140.40	140.50	140.50	140.47	140.48	140.37	140.32	140.33	140.26

* JAN & JANTX types available



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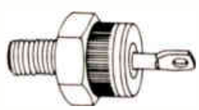

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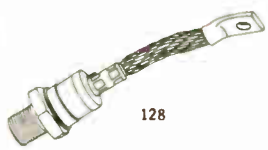
126

SILICON RECTIFIERS
100 TO 275 AMPERES

JEDEC TYPE		1N3289-96	1N3260-73	1N3735-42			1N4044-56
GE TYPE		A70B-PB		A90A-P8	A96A-P	A291PC-PM	
SPECIFICATIONS							
$I_{FM(AV)}$	Max. average forward current (1 phase operation)	100	160	250	250	250	275
	@ T_C = (°C)	130	125	130	70	135	120
$V_{RM(rep)}$	— Max. repetitive peak reverse voltage (V)	—	—	—	—	—	—
	50	—	1N3260	—	—	—	1N4044
	100	—	1N3261	A90A, 1N3735	A96A	—	1N4045
	150	—	1N3262	—	—	—	1N4046
	200	A70B, 1N3289	1N3263	A90B, 1N3736	A96B	—	1N4047
	250	—	1N3264	—	—	—	1N4048
	300	A70C, 1N3290	1N3265	A90C, 1N3737	A96C	—	1N4049
	350	—	1N3266	—	—	—	—
	400	A70D, 1N3291	1N3267	A90D, 1N3738	A96D	—	1N4050
	500	A70E, 1N3292	1N3268	A90E, 1N3739	A96E	—	1N4051
	600	A70M, 1N3293	1N3269	A90M, 1N3740	A96S	—	1N4052
	700	A70S	1N3270	A90S	A96M	—	1N4053
	800	A70N, 1N32[illegible]	1N3271	A90N, 1N3741	A96N	—	1N4054
	900	A70T	1N3272	A90T	A96T	—	1N4055
	1000	A70P, 1N3295	1N3273	A90P, 1N3742	A96P	—	1N4056
	1100	—	—	A90PA	—	—	—
	1200	A70PB, 1N3296	—	A90PB	—	—	—
	1300	—	—	—	—	A291PC	—
	1400	—	—	—	—	A291PD	—
	1500	—	—	—	—	A291PE	—
	1600	—	—	—	—	A291PM	—
$I_{FM(surge)}$	Max. peak one cycle, non-recurrent surge current (60 Hz sine wave, 1 phase operation) @ max. rated load conditions (A)	1600	2000	4500	3300	4500	5000
I^2t	Max. non-repetitive for 8.3 msec. (A^2sec)	[illegible]	16,000	84,000	43,000	84,000	100,000
T_J	Operating junction temperature range (°C)	−40 to +200	−55 to +190	−40 to +200	−40 to +125	−40 to +200	−65 to +190
T_{stg}	Storage temperature range (°C)	−40 to +200	−55 to +190	−40 to +200	−40 to +125	−40 to +200	−65 to +190
$R_{\theta JC}$	Max. thermal resistance, junction-to-case (°C/W)	[illegible]	.3	.18	.18	.15	.18
V_{FM}	Max. peak forward voltage drop @ rated $I_{F(AV)}$ (1 phase operation)	1.15	1.6	1.3	1.25	1.0	1.35
	@ T_J = (°C)	25	125	130	25	25	120
Q_{RR}	Max. reverse recovered charge (μC)	—	—	—	19	—	—
PACKAGE OUTLINE NO.		127	128	128	128	129	128
SPECIFICATION SHEET NO.		140.15	145.28	145.30	145.55	145.58	145.30


127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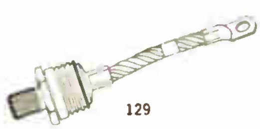
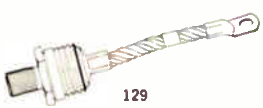

129

SILICON RECTIFIERS 400 TO 1500 AMPERES

GE TYPE	A396A-P	A390A-PB	A295A-PN	A500P-LP	A540PA-L	A570A-P
SPECIFICATIONS						
$I_{FM(AV)}$ Max. average forward current (1 phase operation) (A)	400	400	500	740	1000	1500
@ T_C = (°C)	70	145	130	100	100	80
$V_{RM(rep)}$ — Max. repetitive peak reverse voltage (V)						
100	A396A	A390A	—	—	A540A	A570A
200	A396B	A390B	A295B	—	A540B	A570B
300	A396C	A390C	A295C	—	A540C	A570C
400	A396D	A390D	A295D	—	A540D	A570D
500	A396E	A390E	A295E	—	A540E	A570E
600	A396M	A390M	A295M	—	A540M	A570M
700	A396S	A390S	A295S	—	A540S	A570S
800	A396N	A390N	A295N	—	A540N	A570N
900	A396T	A390T	A295T	—	A540T	A570T
1000	A396P	A390P	A295P	A500P	A540P	A570P
1100	—	A390PA	A295PA	A500PA	A540PA	—
1200	—	A390PB	A295PB	A500PB	A540PB	—
1300	—	—	A295PC	A500PC	A540PC	—
1400	—	—	A295PD	A500PD	A540PD	—
1500	—	—	A295PE	A500PE	A540PE	—
1600	—	—	A295PM	A500PM	A540PM	—
1700	—	—	A295PS	A500PS	A540PS	—
1800	—	—	A295PN	A500PN	A540PN	—
1900	—	—	—	A500PT	A540PT	—
2000	—	—	—	A500L	A540L	—
2100	—	—	—	A500LA	—	—
2200	—	—	—	A500LB	—	—
2300	—	—	—	A500LC	—	—
2400	—	—	—	A500LD	—	—
2500	—	—	—	A500LE	—	—
2600	—	—	—	A500LM	—	—
2700	—	—	—	A500LS	—	—
2800	—	—	—	A500LN	—	—
2900	—	—	—	A500LT	—	—
3000	—	—	—	A500LP	—	—
$I_{FM(surge)}$ Max. peak one cycle, non-recurrent surge current (60 Hz sine wave, 1 phase operation) @ max. rated load conditions (A)	3,300	4500	7000	8400	10,000	15,000
I^2t Max. non-repetitive for 8.3 msec (A^2sec)	43,000	84,000	200,000	270,000	400,000	920,000
T_J Operating junction temperature range (°C)	−40 TO +125	−40 TO +200	−40 TO +200	−40 TO +200	−40 TO +200	−40 TO +200
T_{stg} Storage temperature range (°C)	−40 TO +125	−40 TO +200	−40 TO +200	−40 TO +200	−40 TO +200	−40 TO +200
θ_{J-C} Max. thermal resistance, junction-to-case (°C/W)	.18	.15	.12	.06	.06	.053
V_{FM} Max. peak forward voltage drop @ rated $I_{F(AV)}$ (1 phase operation)	1.25	1.15	1.1	1.25	1.15	1.0
@ T_C = (°C)	25	25	25	25	150	25
PACKAGE NO.	109.1	109.1	129	182	182	182
SPECIFICATION SHEET NO.	145.71	145.70	145.60	145.78	145.80	145.85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109.1


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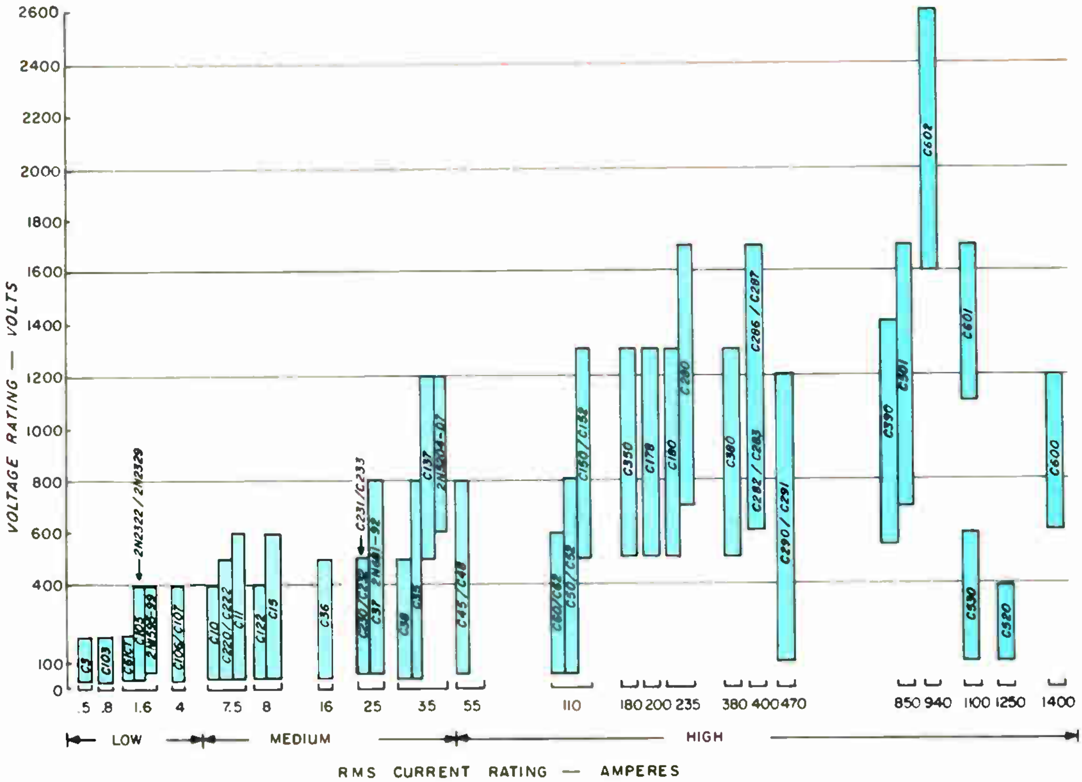
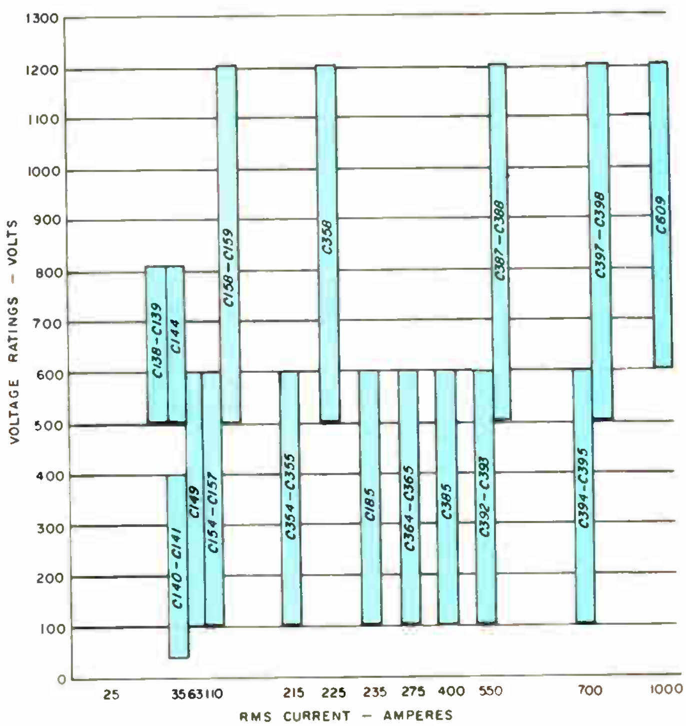
SELECTOR GUIDE PHASE CONTROL SCR's



SELECTOR GUIDE INVERTER SCR's



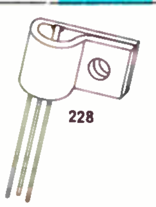
PHASE CONTROL SCR's .5 TO 4.0 AMPERES

GE TYPE		C3	C103	C6	C7	C5	—	C106	C107
JEDEC		2N877-81	—	—	2N2344-48	2N2322-29 *	2N1595-99	—	—
ELECTRICAL SPECIFICATIONS									
VOLTAGE RANGE		30-200	30-200	25-400	25-200	25-400	50-400	15-400	15-400
FORWARD CONDUCTION									
$I_{T(RMS)}$	Max. RMS on-state current (A)	0.50	0.80	1.60	1.60	1.60	1.60	4.00	4.00
$I_{T(AV)}$	Max. average on-state current @ 180° conduction (A) @ T_C	0.32 @ 75°C	0.50 @ 25°C	1.0 @ 85°C	1.0 @ 55°C	1.0 @ 85°C	1.0 @ 110°C	2.5 @ 30°C	2.5 @ 20°C
I_{TSM}	Max. peak one cycle, non-repetitive surge current (A)	7	8.0	—	15	15	15	20	15
I^2t	Max. I^2t for fusing for <1.5 msec (A^2 sec)	—	—	0.5	—	0.5	0.5	0.5	0.5
V_{TM}	Max. peak on-state voltage @ 25°C, 180° conduction, rated $I_{T(AV)}$ (V)	1.6	1.5	1.4	2.0	2.2	2.0	2.2	2.5
$R_{\theta JC}$	Max. internal thermal resistance, dc, junction-to-case (°C/W)	80	125	18	18	18	18	10	10
I_H	Typical holding current @ 25°C (mA)	1.7	5.0	1.0	1.0	2.0	0.5	1.0	1.0
t_q	Typical turn-off time (μsec) Maximum Turn-off Time (μsec)	15 —	15 —	40 —	20 —	40 —	40 —	40 100	40 100
$t_d + t_r$	Typical turn-on time (μsec)	1.0	—	1.4	1.4	1.4	1.2	1.2 [2]	1.2 [2]
di/dt	Max. rate-of-rise turned-on current (A/μsec)	—	—	—	—	50	—	50	50
T_J	Junction operating temperature range (°C)	−65 to 125	−65 to 125	−40 to 125	−65 to 100	−65 to 125	−65 to 150	−40 to 110	−40 to 110
BLOCKING									
dv/dt	Typical critical rate-of-rise of off-stage voltage, exponential to rated V_{DRM} @ max. rated T_J (V/μsec)	40	20	20	20	20	20	8	8
FIRING									
I_{GT}	Max. required gate current to trigger (μA) @ −65°C	300	500	—	75	350	—	—	—
	@ −40°C	—	—	—	—	—	—	500	—
	@ 25°C	200	200	1.0 [1]	20	200	10	200	500
	@ 125°C	100	—	—	—	—	—	—	—
V_{GT}	Max. required gate voltage to trigger (V) @ −65°C	1.0	1.0	—	1.0	1.0	—	—	—
	@ −40°C	—	—	1.0	—	—	—	1.0	—
	@ 25°C	0.8	0.8	0.8	0.8	0.8	3.0	0.8	0.8
V_{GT}	Min. required gate voltage to trigger (V) @ 110°C	—	—	—	—	—	—	0.2	0.2
	@ 125°C	0.05	0.1	0.1	0.1	0.1	—	—	—
VOLTAGE TYPES									
Repetitive Peak Forward and Reverse Voltages									
	15							C106Q1-4	C107Q1-4
	25	—	—	C6U	2N2344	2N2322	—	—	—
	30	2N877	C103Y	—	—	—	—	C106Y1-4	C107Y1-4
	50	—	—	C6F	2N2345	2N2323 *	2N1595	C106F1-4	C107F1-4
	60	2N878	C103YY	—	—	—	—	—	—
	100	2N879	C103A	C6A	2N2346	2N2324 *	2N1596	C106A1-4	C107A1-4
	150	2N880	—	C6G	2N2347	2N2325	—	—	—
	200	2N881	C103B	C6B	2N2348	2N2326 *	2N1597	C106B1-4	C107B1-4
	250	—	—	—	—	2N2327	2N1598	—	—
	300	—	—	C6C	—	2N2328 *	2N1599	C106C1-4	C107C1-4
	400	—	—	C6D	—	2N2329 *	—	C106D1-4	C107D1-4
PACKAGE OUTLINE NO.		112	195.1 228	102.1	101	102.1	101	232	232
SPECIFICATION SHEET NO.		150.5	150.7	150.8	150.11	150.10	150.15	150.9	150.13

* JAN & JANTX types available
[1] Units = mA
[2] Maximum turn-on time
[3] Junction to ambient


112


195.1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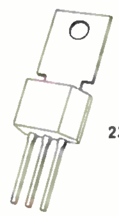
102.1


101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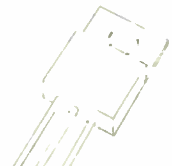
PHASE CONTROL SCR's
7.5 TO 25 AMPERES

GE TYPE		C10	C11	C15	C122	C220-2	C36	C230-2	C231-3	C37
JEDEC		2N1770A-77A*	2N1770-78	—	—	—	2N1842-50	—	—	—
ELECTRICAL SPECIFICATIONS										
VOLTAGE RANGE		25-400	25-600	25-600	25-400	25-500	25-500	25-500	25-500	25-800
FORWARD CONDUCTION										
$I_{T(RMS)}$	Max. RMS on-state current (A)	7.40	7.40	8.0	8.0	7.40	16.0	25.0	25.0	25.0
$I_{T(AV)}$	Max. average on-state current @ 180° conduction (A) @ T_C	4.7 @ 106°C	4.7 @ 105°C	5.1 @ 50°C	—	—	10.0 @ 35°C	16.0 @ 70°C	16.0 @ 70°C	16.0 @ 35°C
I_{TSM}	Max. peak one cycle, non-repetitive surge current (A)	60	60	60	80	90	125	250	250	125
I^2t	Max. I^2t for fusing for ≥ 1.5 msec (A^2 sec)	.5	.5	—	—	27	—	260	260	40
V_{TM}	Max. peak on-state voltage @ 25°C, 180° conduction, rated $I_{T(AV)}$ (V)	1.8	1.8	1.85	2.2	2.0	2.9	1.5	1.5	2.25
$R_{\theta JC}$	Max. internal thermal resistance, dc, junction-to-case (°C/W)	3.1	3.1	3.1	2.0	—	2.5	1.0	1.0	1.5
I_H	Max. holding current @ 25°C (mA)	25	8.0	30	30	30	20	50	50	10
t_q	Typical turn-off time (µsec) @ 100°C 125°C	— 40	— 40	— —	—	—	15	—	—	—
$t_d + t_r$	Typical turn-on time (µsec)	1.0	1.0	1.0	—	2.5	3	3	3	3
di/dt	Max. rate-of-rise turned-on current (A/µsec)	60	40 [3]	40 [3]	100	100	20	20	20	20
T_J	Junction operating temperature range (°C)	−65 to 150	−65 to 125	−65 to 105	−40 to 100	−40 to 100	−40 to 100	−40 to 100	−40 to 100	−40 to 105
BLOCKING										
dv/dt	Typical critical rate-of-rise of off-stage voltage, exponential to rated V_{DRM} @ max. rated T_J (V/µsec)	20	20	20	50	40	20	40	40	40
FIRING										
I_{GT}	Max. required gate current to trigger (mA) @ −65°C	30	30	50	—	—	—	—	—	—
	@ −40°C	—	—	—	—	40	150	40	20	150
	@ 25°C	15	15	35	25	25	80	25	9	80
	@ 100°C	—	—	—	—	40	50	2	1	40
	@ 125°C	7 [1]	7	—	—	—	—	—	—	—
V_{GT}	Max. required gate voltage to trigger (V) @ −65°C	2	2	2.5	—	—	—	—	—	—
	@ −40°C	—	—	—	—	30	3.5	2.0	2.0	3.5
	@ 25°C	1.35	1.35	—	1.5	1.5	—	1.5	1.5	—
V_{GD}	Min. required gate voltage to trigger (V) @ 150°C	—	—	0.3	0.2	0.5	0.3	0.2	0.2	0.25
	@ 125°C	0.2 [2]	0.3	—	—	—	—	—	—	—
VOLTAGE TYPES										
	Repetitive Peak Forward and Reverse Voltages									
25		2N1770A * C10U	2N1770 C11U	C15U	—	C220U C222U	2N1842 C36U	C230U C232U	C231U C233U	C37U
50		2N1771A * C10F	2N1771 C11F	C15F	C122F	C220F C222F	2N1843 C36F	C230F C232F	C231F C233F	C37F
100		2N1772A * C10A	2N1772 C11A	C15A	—	C220A C222A	2N1844 C36A	C230A C232A	C231A C233A	C37A
150		2N1773A C10G	2N1773 C11G	C15G	—	—	2N1845 C36G	—	—	—
200		2N1774A * C10B	2N1774 C11B	C15B	C122B	C220B C222B	2N1846 C36B	C230B C232B	C231B C233B	C37B
250		2N1775A C10H	2N1775 C11H	C15H	—	—	2N1847 C36H	C230H C232H	—	—
300		2N1776A * C10C	2N1776 C11C	C15C	—	C220C C222C	2N1848 C36C	C230C C232C	C231C C233C	C37C
400		2N1777A * C10D	2N1777 C11D	C15D	C122D	C220D C222D	2N1849 C36D	C230D C232D	C231D C233D	C37D
500		—	2N1778 C11E	C15E	C122E	C220E C222E	2N1850 C36E	C230E C232E	C231E C233E	C37E
600		—	2N2619 C11M	C15M	—	—	—	—	—	C37M
700		—	—	—	—	—	—	—	—	C37S
800		—	—	—	—	—	—	—	—	C37N
PACKAGE OUTLINE NO.		104.1	104	104.1	173.1	241 to 243	107.2	241 to 243	241 to 243	107.1
SPEC SHEET NO.		150.20	150.21	150.22	150.35	150.36	160.21	160.27	160.27	160.23

* JAN & JANTX types available [1] Specified 6 mA max @ 150°C [2] Specified 0.2 V min @ 150°C [3] Typical Value

PHASE CONTROL SCR's
25 TO 35 AMPERES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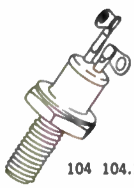
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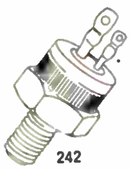
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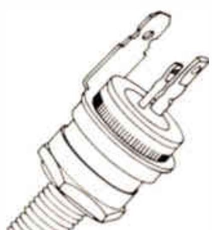
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107 . 107.1

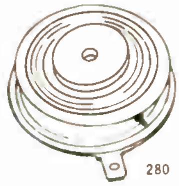
GE TYPE		—	C35	C38	C137	—
JEDEC		2N681-92	—	—	—	2N5204-07
ELECTRICAL SPECIFICATIONS						
VOLTAGE RANGE		25-800	25-800	25-800	500-1200	600-1200
FORWARD CONDUCTION						
$I_{T(RMS)}$	Max. RMS on-state current (A)	25.0	35.0	35.0	35	35
$I_{T(AV)}$	Max. average on-state current @ 180° conduction (A) @ T_C(°C)	16.0 @ 65°C	22.3 @ 35°C	22.5 @ 70°C	22.3 @ 40°C	22.3 @ 40°C
I_{TSM}	Max. peak one cycle, non-repetitive surge current (A)	150	150	150	360	300
I^2t	Max. I^2t for fusing for 5 to 8.3 msec (A^2 sec)	100	100	100	460	320
V_{TM}	Peak on-state Voltage @ 125°C, 180° conduction, rated $I_{T(AV)}$ (V)	2.0	2.0	2.0	2.3	2.3
$R_{\theta JC}$	Max. internal thermal resistance, dc, junction-to-case (°C/W)	1.7	1.7	1.5	1.0	1.5
I_H	Max. holding current @ 25°C (mA)	100	100	80	100	100
$t_d + t_r$	Typical turn-on time (μsec)	1.6	1.6	1.6	1.6	1.6
t_q	Turn-off time (μsec) (MAX)	75	75	25 Typ.	75	—
di/dt	Max. rate-of-rise turned-on current (A/μsec)	80	80	80	150	150
T_J	Junction operating temperature range (°C)	—65 to 125	—65 to 125	—65 to 150	—65 to 125	—40 to 125
BLOCKING						
dv/dt	Min. critical rate-of-rise of off-stage voltage, exponential @ max. rated T_J (V/μsec)	20	20 Typ.	20	100	100
FIRING						
I_{GT}	Max. required gate current to trigger (mA) @ —65°C	80	80	80	120	—
	@ —40°C	—	—	—	80	80
	@ 25°C	40	40	40	40	40
	@ 100°C	—	—	—	—	—
	@ 125°C	10	10	—	15	15
	@ 150°C	—	—	20	—	—
V_{GT}	Max. required gate voltage to trigger (V) @ —65°C	3.0	3.0	3.0	3.0	—
	@ —40°C	—	—	—	3.0	3.0
	@ 25°C	3.0	3.0	3.0	3.0	3.0
V_{GT}	Min. required gate voltage to trigger (V) @ 125°C	0.25	0.25	—	0.25	0.25
	@ 150°C	—	—	0.15	—	—
VOLTAGE TYPES						
Repetitive Peak Forward and Reverse Voltages						
	25	2N681	C35U	C38U	—	—
	50	2N682 *	C35F	C38F	—	—
	100	2N683 *	C35A	C38A	—	—
	150	2N684	C35G	C38G	—	—
	200	2N685 *	C35B	C38B	—	—
	250	2N686 *	C35H	C38H	—	—
	300	2N687 *	C35C	C38C	—	—
	400	2N688 *	C35D	C38D	—	—
	500	2N689 *	C35E	C38E	C137E	—
	600	2N690	C35M		C137M	2N5204
	700	2N691	C35S		C137S	—
	800	2N692	C35N		C137N	2N5205
	900				C137T	—
	1000				C137P	2N5206
	1100				C137PA	—
	1200				C137PB	2N5207
PACKAGE OUTLINE NO.		107.1	107.1	107.1	107.1	107.1
SPECIFICATION SHEET NO.		160.22	160.20	160.30	160.45	160.46

* JAN & JANTX types available

PHASE CONTROL SCR's
55 TO 200 AMPERES


108


109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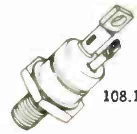
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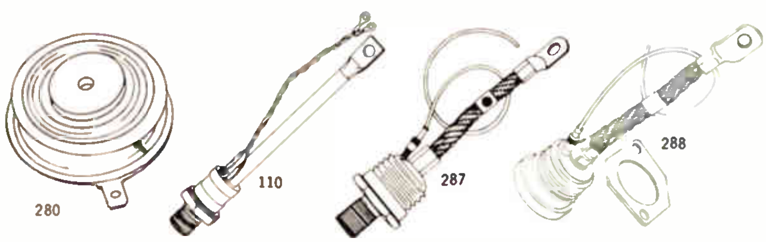
		C45, 46	C147	C50, 52	C150, 152	C60, 62	C350
GE TYPE		C45, 46	C147	C50, 52	C150, 152	C60, 62	C350
JEDEC				2N1909-16 2N1792-98		2N2023-30	
ELECTRICAL SPECIFICATIONS							
VOLTAGE RANGE		25-800	100-1200	25-800	500-1300	25-600	500-1300
FORWARD CONDUCTION							
$I_{T(RMS)}$	Max. RMS on-state current (A)	55	63	110	110	110	180
$I_{T(AV)}$	Max. average on-state current @ 180° conduction (A) @ T_C	35 @ 87°C	40 @ 102°C	70 @ 62°C	70 @ 80°C	70 @ 88°C	110 @ 90°C
$I_{T(AV)}$	Max. average on-state current for 3 conduction (A) @ T_C	32 @ 90°C	36 @ 101°C	62 @ 65°C	52 @ 80°C	62 @ 92°C	95 @ 85°C
I_{TSM}	Max. peak one cycle, non-repetitive surge current (A)	700	1000	1000	1500	1000	1500
I^2t	Max. I^2t for fusing for 5 to 8.3 msec (A^2 sec)	2000	4150	4000	7000	4000	10,000
V_{TM}	Peak on-state voltage @ 125°C, 180° conduction, rated $I_{T(AV)}$ (V)	2.1	1.4	1.8	2.0	1.8	2.5
$R_{\theta JC}$	Max. internal thermal resistance, dc, junction-to-case (°C/W)	.4	.35	.4	.3	.4	.135
t_q	Typical turn-off time (μsec)	30	—	30	100	50	125
$t_d + t_r$	Typical turn-on time (μsec)	5	5	5	8	5	8
di/dt	Rate-of-rise turned-on current (A/μsec)	30	100	30	50-75	30	50-100
T_J	Junction operating temperature range (°C)	—40 to 125°C	—40 to 125°C	—40 to 125°C	—40 to 125°C	—65 to 150°C	—40 to 125°C
BLOCKING							
dv/dt	Min. critical rate-of-rise of off-stage voltage, exponential @ max. rated T_J (V/μsec)	30 TYP.	200	30 TYP.	200	30 TYP.	200
FIRING							
I_{GT}	Max. required gate current to trigger (mA) @ −40°C	125	300	125	200	125	200
	@ 125°C	40	125	40	125	40	125
V_{GT}	Max. required gate voltage to trigger (V) @ −40°C	3	3.5	3	3	3	3
V_{GT}	Min. required gate voltage to trigger (V) @ 125°C	.25	.25	.25	.15	.25	.15
VOLTAGE TYPES							
	Repetitive Peak Forward and Reverse Voltages						
	25	C45U C46U	C147U	2N1909 C52U	CONSULT FACTORY	2N2023 C62U	—
	50	C45F C46F	C147F	2N1910 2N1792		2N2024 C62F	—
	100	C45A C46A	C147A	2N1911 2N1793		2N2025 C62A	C350A
	150	C45G C46G	C147G	2N1912 2N1794		2N2026 C62G	—
	200	C45B C46B	C147B	2N1913 2N1795		2N2027 C62B	C350B
	250	C45H C46H	C147H	2N1914 2N1796		2N2028 C62H	—
	300	C45C C46C	C147C	2N1915 2N1797		2N2029 C62C	C350C
	400	C45D C46D	C147D	2N1916 2N1798		2N2030 C62D	C350D
	500	C45E C46E	C147E	C50E C52E	C150E C152E	C60E C62E	C350E
	600	C45M C46M	C147M	C50M C52M	C150M C152M	C60M C62M	C350M
	700	C45S C46S	C147S	C50S C52S	C150S C152S	C60S C62S	C350S
	800	C45N C46N	C147N	C50N C52N	C150N C152N	C60N C62N	C350N
	900		C147T		C150T C152T		C350T
	1000		C147P		C150P C152P		C350P
	1100		C147PA		C150PA C152PA		C350PA
	1200		C147PB		C150PB C152PB		C350PB
	1300				C150PC C152PC		C350PC
PACKAGE TYPE		½″ STUD	¼″ STUD	½″ STUD	½″ STUD	½″ STUD	½″ PRESS PAK
PACKAGE OUTLINE NO.		108, 109	108.1	108, 109	108, 109	108, 109	280
SPECIFICATION SHEET NO.		170.17	170.19	170.20	170.23	170.26	170.54

PHASE CONTROL SCR's 235 TO 470 AMPERES

GE TYPE		C180	C280	C380	C282, 283	C286, 287	C290, 291
ELECTRICAL SPECIFICATIONS							
VOLTAGE RANGE		500-1300	700-1700	500 - 1300	600 - 1700	600 - 1700	100 - 1200
FORWARD CONDUCTION							
$I_{T(RMS)}$	Max. RMS on-state current (A)	235	235	380	400	400	470
$I_{T(AV)}$	Max. average on-state current @ 180° conduction (A) @ T_C	150 @ 88°C	150 @ 90°C	235 @ 80°C	200 @ 80°C	225 @ 80°C	300 @ 76°C
$I_{T(AV)}$	Max. average on-state current for 3φ conduction (A) @ T_C	135 @ 80°C	125 @ 80°C	180 @ 80°C	175 @ 80°C	200 @ 80°C	250 @ 80°C
I_{TSM}	Max. peak one cycle, non-repetitive surge current (A)	3500	3500	3500	4500	5000	5500
I^2t	Max. I^2t for fusing for 5 to 8.3 msec (A^2 sec)	50,000	50,000	50,000	85,000	100,000	120,000
V_{TM}	Peak on-state voltage @ 125°C, 180° conduction, rated $I_{T(AV)}$ (V)	1.7	1.36	1.8	1.3	1.3	1.4
$R_{\theta JC}$	Max. internal thermal resistance, dc, junction-to-case (°C/W)	.14	.18	.095	.136	.136	.118
t_q	Typical turn-off time (μsec)	125	250	125	250	250	250
t_d+t_r	Typical turn-on time (μsec)	8	10	8	10	10	10
di/dt	Rate-of-rise turned-on current (A/μsec)	50-100	50	50-100	50	50	50
T_J	Junction operating temperature range(°C)	—40 to 125°C	—40 to 125°C	—40 to 125°C	—40 to 120°C	—40 to 125°C	—40 to 125°C
BLOCKING							
dv/dt	Min. critical rate-of-rise of off-stage voltage, exponential @ max. rated T_J (V/μsec)	200	100	200	100	100	100
FIRING							
I_{GT}	Max. required gate current to trigger (mA) @ —40°C	200	200	200	300	300	300
	@ 125°C	125	125	125	100	100	100
V_{GT}	Max. required gate voltage to trigger (V) @ —40°C	3	3	3	3.5	3.5	3.5
V_{GT}	Min. required gate voltage to trigger (V) @ 125°C	.15	.15	.15	.15	.15	.15
VOLTAGE TYPES							
	Repetitive Peak Forward and Reverse Voltages						
	100	CONSULT FACTORY		C380A	CONSULT FACTORY	CONSULT FACTORY	C290A, C291A
	200			C380B			C290B, C291B
	300			C380C			C290C, C291C
	400			C380D			C290D, C291D
	500	C180E		C380E			C290E, C291E
	600	C180M		C380M	C282M, C283M	C286M, C287M	C290M, C291M
	700	C180S	C280S	C380S	C282S, C283S	C286S, C287S	C290S, C291S
	800	C180N	C280N	C380N	C282N, C283N	C286N, C287N	C290N, C291N
	900	C180T	C280T	C380T	C282T, C283T	C286T, C287T	C290T, C291T
	1000	C180P	C280P	C380P	C282P, C283P	C286P, C287P	C290P, C291P
	1100	C180PA	C280PA	C380PA	C282PA, C283PA	C286PA, C287PA	C290PA, C291PA
	1200	C180PB	C280PB	C380PB	C282PB, C283PB	C286PB, C287PB	C290PB, C291PB
	1300	C180PC	C280PC	C380PC	C282PC, C283PC	C286PC, C287PC	
	1400		C280PD		C282PD, C283PD	C286PD, C287PD	
	1500		C280PE		C282PE, C283PE	C286PE, C287PE	
	1600		C280PM		C282PM, C283PM	C286PM, C287PM	
	1700		C280PS		C282PS, C283PS	C286PS, C287PS	
PACKAGE TYPE		¾" STUD	¾" STUD	½" PRESS PAK	¾" STUD	¾" STUD	¾" STUD
PACKAGE OUTLINE NO.		110	287, 288	280	287, 288	287, 288	287, 288
SPECIFICATION SHEET NO.		170.52	170.58	170.56	CONTACT FACTORY	CONTACT FACTORY	170.60



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PHASE CONTROL SCR's 850 TO 1400 AMPERES

GE TYPE		C390	C501	C530	C520	C600	C601	C602
ELECTRICAL SPECIFICATIONS								
VOLTAGE RANGE		500-1300	700-1700	100-600	100-400	500-1200	1100-1700	1600-2600
FORWARD CONDUCTION								
$I_{T(RMS)}$	Max. RMS on-state current (A)	850	850	1100	1250	1400	1100	940
$I_{T(AV)}$	Max. average on-state current @ 180° conduction (A) @ T_C	550 @ 65°C	550 @ 67°C	700 @ 80°C	800 @ 75°C	900 @ 72°C	750 @ 72°C	600 @ 72°C
$I_{T(AV)}$	Max. average on-state current for 3θ conduction (A) @ T_C	500 @ 65°C	525 @ 70°C	600 @ 75°C	680 @ 75°C	720 @ 80°C	620 @ 80°C	510 @ 80°C
I_{TSM}	Max. peak one cycle, non-repetitive surge current (A)	8000	7000	10,000	10,000	13,000	11,000	6500
I^2t	Max. I^2t for fusing for 5 to 8.3 msec (A^2 sec)	200,000	200,000	415,000	415,000	700,000	516,000	176,000
V_{TM}	Peak on-state voltage @ 125°C, 180° conduction, rated $I_{T(AV)}$ (V)	1.75	1.9	1.4	1.6	1.6	2.0	2.3
$R\theta_{JC}$	Max. internal thermal resistance, dc, junction-to-case (°C/W)	.059	.059	.054	.054	.041	.041	.041
t_q	Typical turn-off time (μsec)	125	250	150	150	200	275	300
t_d+t_r	Typical turn-on time (μsec)	5	4	4	4	5	5	5
di/dt	Rate-of-rise turned-on current (A/μsec)	500	30-75	75	75	150	80-150	35-75
T_J	Junction operating temperature range (°C)	—40 to 125°C	—40 to 125°C	—40 to 125°C	—40 to 150°C	—40 to 125°C	—40 to 125°C	—40 to 125°C
BLOCKING								
dv/dt	Min. critical rate-of-rise of off-stage voltage, exponential @ rated T_J (V/μsec)	200	100	50 TYP	50 TYP	100	100	100
FIRING								
I_{GT}	Max. required gate current to trigger (mA) @ —40°C	300	225	300	300	—	—	—
	@ 125°C	125	75	125	125	75	—	75
V_{GT}	Max. required gate voltage to trigger (V) @ —40°C	5	6.5	4	4	6.5	—	6.5
V_{GT}	Min. required gate voltage to trigger (V) @ 125°C	.35	.15	.15	.15	.3	—	.3
VOLTAGE TYPES								
Repetitive Peak Forward and Reverse Voltages								
100		CONSULT FACTORY	CONSULT FACTORY	C530A	C520A	CONSULT FACTORY		
200				C530B	C520B			
300				C530C	C520C			
400				C530D	C520D			
500		C390E		C530E		C600E		C602 SERIES VOLTAGE CAPABILITY 1600 THRU 2600 VOLTS
600		C390M	C501M	C530M		C600M		
700		C390S	C501S			C600S		
800		C390N	C501N			C600N		
900		C390T	C501T			C600T		
1000		C390P	C501P			C600P		
1100		C390PA	C501PA			C600PA	C601PA	
1200		C390PB	C501PB			C600PB	C601PB	SEE DETAILED SPECIFICATION
1300		C390PC	C501PC				C601PC	
1400			C501PD				C601PD	
1500			C501PE				C601PE	
1600			C501PM				C601PM	
1700			C501PS				C601PS	
PACKAGE TYPE			1" PRESS PAK	1" PRESS PAK	1" PRESS PAK	1" PRESS PAK	1" PRESS PAK	1" PRESS PAK
PACKAGE OUTLINE NO.		276	185	185	185	276	276	276
SPECIFICATION SHEET NO.		170.62	170.70	170.82	170.81	170.84	170.85	170.86

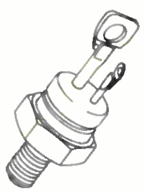
185

276

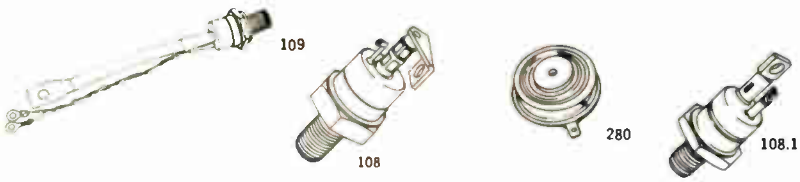
INVERTER SCR's
25 TO 35 AMPERES

		C140	C141	C138	C139	C144
GE TYPE		C140	C141	C138	C139	C144
JEDEC		2N3649-53	2N3654-58	—	—	—
ELECTRICAL SPECIFICATIONS						
VOLTAGE RANGE		50-400	50-400	500-800	500-800	500-1000
FORWARD CONDUCTION						
$I_{T(RMS)}$	Max. RMS on-state current @ T_C=65°C, 50% duty, (A)	35	35	35 [1]	35	35
	1KHz	26	26	26	26	35
	5KHz	26	26	22	22	32
	10KHz	20	20	18	18	30
I_{TSM}	Max. peak one cycle, non-repetitive surge current (A)	200	200	200	200	200
I^2t	Max. I^2t for fusing @ < 1.5 msec (A^2sec)	165	165	165	165	165
$R_{\theta J\text{-}C}$	Max. internal thermal resistance, dc, junction-to-case (°C/W)	1.7	1.7	1.0	1.0	1.0
$t_d + t_r$	Typical turn-on time (μsec)	3.1	3.1	3.1	3.1	3.1
t_q	Max. turn-off time @ rated voltage and T_J (μsec) 20V/μsec reapplied	—	—	—	—	—
	@ 200V/μsec reapplied	15	10	10	10	30
di/dt	Critical rate-of-rise of on-state current (A/μsec)	400	400	100	100	100
T_J	Junction operating temperature range (°C)	−65 to 120	−65 to 120	−65 to 125	−65 to 125	−65 to 125
BLOCKING						
dv/dt	Min. critical rate-of-rise of off-state voltage exponential to rated V_{DRM} @ Max. rated T_J (V/μsec)	200	200	200	200	200
FIRING						
I_{GT}	Max. required gate current to trigger (mA) @ −65°C	500	500	500	500	450
	@ −40°C	—	—	—	—	—
	@ 25°C	180	180	180	180	150
V_{GT}	Max. required voltage to trigger (V) @ −65°C	4.5	4.5	4.5	4.5	4.0
	@ −40°C	—	—	—	—	—
	@ 25°C	3.0	3.0	3.0	3.0	2.5
V_{GT}	Min. required voltage to trigger (V) @ 100°C	—	—	—	—	—
	@ 125°C	0.25	0.25	0.25	0.25	0.3
VOLTAGE TYPES						
	Repetitive Peak Forward & Reverse Voltage					
	25					
	50	C140F 2N3649	C141F 2N3654			
	100	C140A 2N3650	C141A 2N3655			
	200	C140B 2N3651	C141B 2N3656			
	300	C140C 2N3652	C141C 2N3657			
	400	C140D 2N3653	C141D 2N3658			
	500			C138E1, 2	C139E1, 2	C144E
	600			C138M1, 2	C139M1, 2	C144M
	700			C138S1, 2	C139S1, 2	C144S
	800			C138N1, 2	C139N1, 2	C144N
	900					
	1000					
PACKAGE OUTLINE NO.		107.1	107.1	107.1	107.1	107.1
SPECIFICATION SHEET NO.		160.35	160.35	160.47	160.47	160.49

[1] V_{RRM}=50 volts

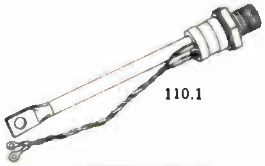


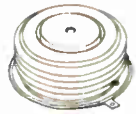
107.1



INVERTER SCR's
63 TO 180 AMPERES

GE TYPE	C149	C151, C153	C154, 156	C155, 157	C158, 159	C354	C355	C358
CONSTRUCTION	ALL DIFFUSED	ALL DIFFUSED	ALL DIFFUSED	ALL DIFFUSED	AMPLIFYING GATE	ALL DIFFUSED	ALL DIFFUSED	AMPLIFYING GATE
ELECTRICAL SPECIFICATIONS								
VOLTAGE RANGE	100-600	500-1000	100-600	100-600	500-1200	100-600	100-600	500-1200
FORWARD CONDUCTION								
$I_{T(RMS)}$ Max. forward conduction sinusoidal @ T_C = 65°C, 50% duty (A)								
@ 60 Hz	63	110	110	110	110	180	180	180
@ 400 Hz	63	—	105	105	110	170	170	180
@ 1200 Hz	63	—	102	102	110	160	160	180
@ 2500 Hz	63	—	85	85	100	140	140	160
@ 5000 Hz	63	—	65	65	90	120	120	140
I_{TSM} Max. peak one cycle, non-repetitive surge current (A)	1000	1000	1200	1200	1600	1200	1200	1600
I^2t Max. I^2t for fusing for 5 to 8.3 msec (A^2sec)	4000	4000	6000	6000	10,500	6000	6000	10,500
$R_{\theta JC}$ Max. thermal impedance (°C/W)	.35	.3	.3	.3	.3	.13	.13	.135
$t_d + t_r$ Typical turn-on time (µsec)	2	8	2	2	5	2	2	5
t_q Turn-off time @ rated voltage & T_J, V_R = 50 volts min (µsec) @ 20V/µsec reapplied	10	30	10	20	30	10	20	30
@ 100V/µsec reapplied	15	—	15	25	35	15	25	35
@ 200V/µsec reapplied	20	—	20		40	20		40
di/dt Critical rate-of-rise of on-state current (A/µsec)	100	75	100	100	800	100	100	800
T_J Junction operating temperature range (°C)		40 to 125°C				40 to 125°C		
BLOCKING								
dv/dt Min. critical rate-of-rise off state voltage exponential to rated V_{DRM} @ Max. T_J (V/µsec)	200	200	200	100	200	200	200	200
FIRING								
I_{GT} Max. required gate current to trigger (mA) @ −40°C	300	200	200	200	300	200	200	300
@ 125°C	120	125	120	120	125	120	120	125
V_{GT} Min. required voltage to trigger (V) @ −40°C	3	3	3	3	5	3	3	5
@ 125°C	.15	.15	.15	.15	.15	.15	.15	.15
PACKAGE TYPE	¼" STUD	½" STUD	½" STUD	½" STUD	½" STUD	½" PRESS PAK	½" PRESS PAK	½" PRESS PAK
VOLTAGE TYPES								
Repetitive Peak Forward & Reverse Voltage								
100	C149A	—	C154A C156A	C155A C157A		C354A	C355A	
150	C149G	—	C154G C156G	C155G C157G		C354G	C355G	
200	C149B	—	C154B C156B	C155B C157B		C354B	C355B	
300	C149C	—	C154C C156C	C155C C157C		C354C	C355C	
400	C149D	—	C154D C156D	C155D C157D		C354D	C355D	
500	C149E	C151E C153E	C154E C156E	C155E C157E	C158E C159E	C354E	C355E	C358E
600	C149M	C151M C153M	C154M C156M	C155M C157M	C158M C159M	C354M	C355M	C358M
700		C151S C153S			C158S C159S			C358S
800		C151N C153N			C158N C159N			C358N
900		C151T C153T			C158T C159T			C358T
1000		C151P C153P			C158P C159P			C358P
1100		—			C158PA C159PA			C358PA
1200		—			C158PB B159PB			C358PB
PACKAGE OUTLINE NO.	108.1	109, 108	109,108	109,108	109, 108	280	280	280
SPECIFICATION SHEET NO.	170.22	170.23	170.35	170.35	170.36	170.37	170.37	170.38





INVERTER SCR's
235 TO 550 AMPERES

GE TYPE		C185	C364	C365	C385	C387	C388
CONSTRUCTION		ALL DIFFUSED	AMPLIFYING GATE	AMPLIFYING GATE	ALL DIFFUSED	AMPLIFYING GATE	AMPLIFYING GATE
ELECTRICAL SPECIFICATIONS							
VOLTAGE RANGE		100-600	100-600	100-600	100-600	500-1300	500-1300
FORWARD CONDUCTION							
$I_{T(RMS)}$	Max. forward conduction sinusoidal @ T_C = 65°C, 50% duty (A)						
	@ 60 Hz	235	300	300	380	550	550
	@ 400 Hz	235	300	300	320	530	530
	@ 1000 Hz	210	270	270	275	455	455
	@ 2000 Hz	180	230	230	215	225	225
	@ 5000 Hz	115	150	150	170	120	120
I_{TSM}	Max. peak one cycle, non-repetitive surge current (A)	3500	1600	1600	3500	5500	550
I^2t	Max. I^2t for fusing for 5 to 8.3 msec (A^2sec)	50,000	10,500	10,500	50,000	120,000	120,000
$R_{\theta JC}$	Max. thermal impedance (°C/W)	.14	.135	.135	.095	.06	.06
$t_d + t_r$	Typical turn-on time (μsec)	2	2.0	2.0	2	2	2
t_q	Turn-off time @ rated voltage & T_J, V_R = 50 volts min. (μsec) @ 20V/μsec reapplied	20	< 10	15	20	30	20
	@ 100V/μsec reapplied	25	< 10	—	25	35	25
	@ 200V/μsec reapplied		10	20		40	30
di/dt	Critical rate-of-rise of on-state current (A/μsec)	100	800	800	100	800	800
T_J	Junction operating temperature range (°c)			—40° to 125°C			
BLOCKING							
dv/dt	Min. critical rate-of-rise off-state voltage exponential to rated V_{DRM} @ Max. T_J (V/μsec)	200	500	500	200	200	200
FIRING							
I_{GT}	Max. required gate current to trigger (mA) @ —40°C	500	400	400	500	300	300
	@ 125°C	250	175	175	250	125	125
V_{GT}	Min. required voltage to trigger (V) @ —40°C	3	5	5	3	3	3
	@ 125°C	.15	3	3	.15	.15	.15
PACKAGE TYPE		3/4" STUD	1/2" PRESS PAK	1/2" PRESS PAK	1/2" PRESS PAK	1" PRESS PAK	1" PRESS PAK
VOLTAGE TYPES							
Repetitive Peak Forward & Reverse Voltage							
100		C185A	C364A	C365A	C385A		
150		C185G			C385G		
200		C185B	C364B	C365B	C385B		
300		C185C	C364C	C365C	C385C		
400		C185D	C364D	C365D	C385D		
500		C185E	C364E	C365E	C385E	C387E	6388E
600		C185M	C364M	C365M	C385M	C387M	C388M
700						C387S	C388S
800						C387N	C388N
900						C387T	C388T
1000						C387P	C388P
1100						C387PA	C388PA
1200						C387PB	C388PB
1300						C387PC	C388PC
PACKAGE OUTLINE NO.		110.1	280	280	280	276	276
SPECIFICATION SHEET NO.		170.53	170.39	170.39	170.57	170.44	170.44

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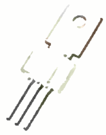
INVERTER SCR's
700 TO 1000 AMPERES

		C397	C398	C392	C393	C394	C395	C609
GE TYPE		C397	C398	C392	C393	C394	C395	C609
CONSTRUCTION		AMPLIFYING GATE	AMPLIFYING GATE	AMPLIFYING GATE	AMPLIFYING GATE	AMPLIFYING GATE	AMPLIFYING GATE	AMPLIFYING GATE
ELECTRICAL SPECIFICATIONS								
VOLTAGE RANGE		500-1300	500-1300	100-600	100-600	100-600	100-600	700-1200
FORWARD CONDUCTION								
$I_{T(RMS)}$	Max. forward conduction sinusoidal @ T_C = 65°C, 50% duty (A)							
	@ 60 Hz	700	700	500	500	700	700	1000
	@ 400 Hz	650	650	450	450	650	650	1000
	@ 1200 Hz	550	550	400	400	550	550	1000
	@ 2500 Hz	275	275	210	210	275	275	950
	@ 5000 Hz	150	150	145	145	150	150	700
I_{TSM}	Max. peak one cycle, non-repetitive surge current (A)	7500	7500	5,500	5,500	8000	8000	10,000
I^2t	Max. I²t for fusing for 5 to 8.3 msec (A²sec)	230,000	230,000	100,000	100,000	250,000	250,000	415,000
$R_{\theta JC}$	Max. thermal impedance (°C/W)	.06	.06	.06	.06	.06	.06	.04
$t_d + t_r$	Typical turn-on time (µsec)	2	2	2	2	2	2	2.5
t_q	Turn-off time @ rated voltage & T_J, V_R = 50 V min. (µsec) @ 20V/µsec reapplied	40	30	10	15	10	15	
	@ 100V/µsec reapplied	50	35	12	18	12	18	
	@ 200V/µsec reapplied	60	40	14	20	14	20	40
di/dt	Critical rate of rise of on-state current (A/µsec)	800	800	800	800	800	800	800
T_J	Junction operating temperature range (°C)	−40 to +125°C	−40 to +125°C	−40 to +125°C	−40 to +125°C	−40 to +125°C	−40 to +125°C	−40 to +125°C
BLOCKING								
dv/dt	Min. critical rate-of-rise off-state voltage exponential to rated V_{DRM} @ Max. T_J (V/µsec)	200	200	200	200	200	200	400
FIRING								
I_{GT}	Max. required gate current to trigger (mA) @ −40°C	300	300	400	400	400	400	350
	@ 125°C	125	125	150	150	150	150	100
V_{GT}	Min. required voltage to trigger (V) @ −40°C	3	3	5	5	5	5	5
	@ 125°C	.15	.15	.15	.15	.15	.15	.15
PACKAGE TYPE		1" PRESS PAK	1" PRESS PAK	1" PRESS PAK	1" PRESS PAK	1" PRESS PAK	1" PRESS PAK	1" PRESS PAK
VOLTAGE TYPES								
Repetitive Peak Forward & Reverse Voltage								
	100			C392A		C394A	C395A	
	200			C392B		C394B	C395B	
	300			C392C		C394C	C395C	
	400			C392D		C394D	C395D	
	500	C397E	C398E	C392E		C394E	C395E	
	600	C397M	C398M	C392M		C394M	C395M	
	700	C397S	C398S		C393A			C609S
	800	C397N	C398N		C393B			C609N
	900	C397T	C398T		C393C			C609T
	1000	C397P	C398P		C393D			C609P
	1100	C397PA	C398PA		C393E			C609PA
	1200	C397PB	C398PB		C393M			C609PB
	1300	C397PC	C398PC					
	1400							
PACKAGE OUTLINE NO.		276	276	276	276	276	276	276
SPECIFICATION SHEET NO.		170.45	170.45	170.42	170.42	170.42	170.42	170.93

General purpose 3 ampere TRIACS.



POWER TAB
173.2

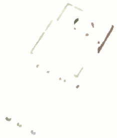
SPECIFICATION SHEET
SC136

TRIACS
3 AMPERES RMS

GE Type	Package Type	V_{DRM} Repetitive Pk Off-State Voltage @ T 40 to 100 C (V)	Igt DC Gate Trigger Current @ 6V, 25 C Max. (mA)				Vgt DC Gate Trigger Voltage @ 6V, 25 C Max. (V)				dv/dt Static @ 110 C Rated V_{DRM} Gate Open Typical (V/μsec)	dv/dt Commutating @ 65 C Rated V_{DRM} and I_T Gate Open Min. (V/μsec)	I_{DRM} Leakage Current @ 25 C Max. (μA)	I_{TSM} Surge Current @ 60 Hz One Cycle Non-repetitive Max. (A)
			MT2 + / Gate +	+ / −	− / −	− / +	MT2 + / Gate +	+ / −	− / −	− / +				
SC136B	Power Tab	200	25	25	25	—	2.0	2.0	2.0	—	50	5.0 [1]	10	30
SC136D	Power Tab	400	25	25	25	—	2.0	2.0	2.0	—	50	5.0 [1]	10	30

[1] Commutating di/dt = 1.6 A/msec

General purpose 6 ampere TRIACS with **POWER GLAS**™ passivated pellets in 4 different package configurations including a silicone encapsulated **POWER PAC** series.




POWER PAC 173.1 — PRESS FIT 241 — STUD 242 — ISOLATED STUD 243

SPECIFICATION SHEET NO.
SC240/241—175.25
SC141—175.15

TRIACS
6 AMPERES RMS

	GE Type	Package Type	V_{DRM} Repetitive Pk Off-State Voltage @T_C = −40 to 100°C (V)	Igt DC Gate Trigger Current @ 12V, 25°C Max. (mA)				Vgt DC Gate Trigger Voltage @ 12V, 25°C Max. (V)				dv/dt Static @ 100°C Rated V_{DRM} Gate Open Typical (V/μsec)	dv/dt Commutating @ 75°C Rated V_{DRM} and I_T Gate Open Min. (V/μsec)	I_{DRM} Leakage Current @ 25°C Max. (mA)	I_{TSM} Surge Current @ 60 Hz One Cycle Non-repetitive Max. (A)
				MT2 + / Gate +	+ / −	− / −	− / +	MT2 + / Gate +	+ / −	− / −	− / +				
Standard	SC241B	Press Fit	200	50	50	50	—	2.5	2.5	2.5	—	20	4.0 [2]	0.1	80
	SC240B	Stud	200	50	50	50	—	2.5	2.5	2.5	—	20	4.0 [2]	0.1	80
	SC240B2	Isolated Stud	200	50	50	50	—	2.5	2.5	2.5	—	20	4.0 [2]	0.1	80
	SC141B	Power Pac	200	50	50	50	—	2.5	2.5	2.5	—	20	4.0 [2]	0.1	80
	SC241D	Press Fit	400	50	50	50	—	2.5	2.5	2.5	—	20	4.0 [2]	0.1	80
	SC240D	Stud	400	50	50	50	—	2.5	2.5	2.5	—	20	4.0 [2]	0.1	80
	SC240D2	Isolated Stud	400	50	50	50	—	2.5	2.5	2.5	—	20	4.0 [2]	0.1	80
	SC141D	Power Pac	400	50	50	50	—	2.5	2.5	2.5	—	20	4.0 [2]	0.1	80
	SC241E	Press Fit	500	50	50	50	—	2.5	2.5	2.5	—	20	4.0 [2]	0.1	80
	SC240E	Stud	500	50	50	50	—	2.5	2.5	2.5	—	20	4.0 [2]	0.1	80
	SC240E2	Isolated Stud	500	50	50	50	—	2.5	2.5	2.5	—	20	4.0 [2]	0.1	80
Zero Voltage Switch	SC241B12	Press Fit	200	—	30 [1]	30 [1]	—	—	2.0 [1]	2.0 [1]	—	20	4.0 [2]	0.1	80
	SC240B12	Stud	200	—	30 [1]	30 [1]	—	—	2.0 [1]	2.0 [1]	—	20	4.0 [2]	0.1	80
	SC240B22	Isolated Stud	200	—	30 [1]	30 [1]	—	—	2.0 [1]	2.0 [1]	—	20	4.0 [2]	0.1	80
	SC241D12	Press Fit	400	—	30 [1]	30 [1]	—	—	2.0 [1]	2.0 [1]	—	20	4.0 [2]	0.1	80
	SC240D12	Stud	400	—	30 [1]	30 [1]	—	—	2.0 [1]	2.0 [1]	—	20	4.0 [2]	0.1	80
	SC240D22	Isolated Stud	400	—	30 [1]	30 [1]	—	—	2.0 [1]	2.0 [1]	—	20	4.0 [2]	0.1	80
	SC241E12	Press Fit	500	—	30 [1]	30 [1]	—	—	2.0 [1]	2.0 [1]	—	20	4.0 [2]	0.1	80
	SC240E12	Stud	500	—	30 [1]	30 [1]	—	—	2.0 [1]	2.0 [1]	—	20	4.0 [2]	0.1	80
	SC240E22	Isolated Stud	500	—	30 [1]	30 [1]	—	—	2.0 [1]	2.0 [1]	—	20	4.0 [2]	0.1	80
Selected Gate	SC241B13	Press Fit	200	25	25	25	25	2.0	2.0	2.0	2.0	20	4.0 [2]	0.1	80
	SC240B13	Stud	200	25	25	25	25	2.0	2.0	2.0	2.0	20	4.0 [2]	0.1	80
	SC240B23	Isolated Stud	200	25	25	25	25	2.0	2.0	2.0	2.0	20	4.0 [2]	0.1	80
	SC241D13	Press Fit	400	25	25	25	25	2.0	2.0	2.0	2.0	20	4.0 [2]	0.1	80
	SC240D13	Stud	400	25	25	25	25	2.0	2.0	2.0	2.0	20	4.0 [2]	0.1	80
	SC240D23	Isolated Stud	400	25	25	25	25	2.0	2.0	2.0	2.0	20	4.0 [2]	0.1	80
	SC241E13	Press Fit	500	25	25	25	25	2.0	2.0	2.0	2.0	20	4.0 [2]	0.1	80
	SC240E13	Stud	500	25	25	25	25	2.0	2.0	2.0	2.0	20	4.0 [2]	0.1	80
	SC240E23	Isolated Stud	500	25	25	25	25	2.0	2.0	2.0	2.0	20	4.0 [2]	0.1	80
400 Hz Operation	SC241B14	Press Fit	200	50	50	50	—	2.5	2.5	2.5	—	20	4.0 [3]	0.1	173 @ 400Hz
	SC240B14	Stud	200	50	50	50	—	2.5	2.5	2.5	—	20	4.0 [3]	0.1	173 @ 400Hz
	SC240B24	Isolated Stud	200	50	50	50	—	2.5	2.5	2.5	—	20	4.0 [3]	0.1	173 @ 400Hz
	SC241D14	Press Fit	400	50	50	50	—	2.5	2.5	2.5	—	20	4.0 [3]	0.1	173 @ 400Hz
	SC240D14	Stud	400	50	50	50	—	2.5	2.5	2.5	—	20	4.0 [3]	0.1	173 @ 400Hz
	SC240D24	Isolated Stud	400	50	50	50	—	2.5	2.5	2.5	—	20	4.0 [3]	0.1	173 @ 400Hz
	SC241E14	Press Fit	500	50	50	50	—	2.5	2.5	2.5	—	20	4.0 [3]	0.1	173 @ 400Hz
	SC240E14	Stud	500	50	50	50	—	2.5	2.5	2.5	—	20	4.0 [3]	0.1	173 @ 400Hz
	SC240E24	Isolated Stud	500	50	50	50	—	2.5	2.5	2.5	—	20	4.0 [3]	0.1	173 @ 400Hz

[1] Pulse Condition Vo = 3V, Gate Pulse Width = 50 μsec [2] Commutating di/dt = 3.2 A/msec [3] Commutating di/dt = 21.5 A/msec TM Trademark of General Electric Company

General purpose 8 ampere ISOLATED TRIACS with POWER GLAS™ passivated pellets in silicone encapsulated POWER PAC series.

TRIACS 8 AMPERES RMS ISOLATED

SPECIFICATION SHEET NO. SC142

POWER PAC

GE Type	Package Type	V_{DRM} Repetitive Pk Off-Stage Voltage @ T_C = −40 to 100 C (V)	Igt DC Gate Trigger Current @ 12V, 25 C Max. (mA) MT2 + Gate +	Igt MT2 + Gate −	Igt MT2 − Gate −	Igt MT2 − Gate +	Vgt DC Gate Trigger Voltage @ 12V, 25 C Max. (V) MT2 + Gate +	Vgt MT2 + Gate −	Vgt MT2 − Gate −	Vgt MT2 − Gate +	dv/dt Static @ 100 C Rated V_{DRM} Gate Open Typical (V/μsec)	dv/dt Commutating @ 75 C Rated V_{DRM} and I_T Gate Open Min. (V/μsec)	I_{DRM} Leakage Current @ 25 C Max (mA)	I_{TSM} Surge Current @ 60 Hz One Cycle Non repetitive Max. (A)
SC142B	Power Pac	200	50	50	50	—	2.5	2.5	2.5	—	50	4.0 [1]	.1	80
SC142D	Power Pac	400	50	50	50	—	2.5	2.5	2.5	—	50	4.0 [1]	.1	80
SC142E	Power Pac	500	50	50	50	—	2.5	2.5	2.5	—	50	4.0 [1]	.1	80

[1] Commutating di/dt = 4.3 A/msec

TRIACS 10 AMPERES RMS

POWER PAC 173.1

PRESS FIT 241

STUD 242

ISOLATED STUD 243

General Purpose 10 ampere TRIACS with POWER GLAS™ passivated pellets in 4 different package configurations including a silicone encapsulated POWER PAC series.

SPECIFICATION SHEET NO.
SC245/246—175.26
SC146—175.15

	GE Type	Package Type	V_{DRM} Repetitive Pk Off-State Voltage @T_C = −40 to 100°C (V)	Igt DC Gate Trigger Current @ 12V, 25°C Max. (mA) MT2 + Gate +	Igt MT2 + Gate −	Igt MT2 − Gate −	Igt MT2 − Gate +	Vgt DC Gate Trigger Voltage @ 12V, 25°C Max. (V) MT2 + Gate +	Vgt MT2 + Gate −	Vgt MT2 − Gate −	Vgt MT2 − Gate +	dv/dt Static @ 100°C Rated V_{DRM} Gate Open Typical (V/μsec)	dv/dt Commutating @ 75°C Rated V_{DRM} and I_T Gate Open Min (V/μsec)	I_{DRM} Leakage Current @ 25°C Max. (mA)	I_{TSM} Surge @ 60 Hz Current One Cycle Non repetitive Max (A)
Standard	SC24[illegible]	Press Fit	200	50	50	50	—	2.5	2.5	2.5	—	20	4.0 [2]	0.1	100
	SC[illegible]5[illegible]	Stud	200	50	50	50	—	2.5	2.5	2.5	—	20	4.0 [2]	0.1	100
	SC245B2	Isolated Stud	200	50	50	50	—	2.5	2.5	2.5	—	20	4.0 [2]	0.1	100
	SC1[illegible]	Power Pac [4]	200	50	50	50	—	2.5	2.5	2.5	—	20	4.0 [2]	0.1	80
	[illegible]D	Press Fit	400	50	50	50	—	2.5	2.5	2.5	—	20	4.0 [2]	0.1	100
	SC24[illegible]0	Stud	400	50	50	50	—	2.5	2.5	2.5	—	20	4.0 [2]	0.1	100
	SC24502	Isolated Stud	400	50	50	50	—	2.5	2.5	2.5	—	20	4.0 [2]	0.1	100
	SC1[illegible]D	Power Pac [4]	400	50	50	50	—	2.5	2.5	2.5	—	20	4.0 [2]	0.1	80
	[illegible]E	Press Fit	500	50	50	50	—	2.5	2.5	2.5	—	20	4.0 [2]	0.1	100
	[illegible]	Stud	500	50	50	50	—	2.5	2.5	2.5	—	20	4.0 [2]	0.1	100
	[illegible]2	Isolated Stud	500	50	50	50	—	2.5	2.5	2.5	—	20	4.0 [2]	0.1	100
Zero Voltage Switch	SC246B12	Press Fit	200	—	30 [1]	30 [1]	—	—	2.0 [1]	2.0 [1]	—	20	4.0 [2]	0.1	100
	SC245B12	Stud	200	—	30 [1]	30 [1]	—	—	2.0 [1]	2.0 [1]	—	20	4.0 [2]	0.1	100
	[illegible]D22	Isolated Stud	200	—	30 [1]	30 [1]	—	—	2.0 [1]	2.0 [1]	—	20	4.0 [2]	0.1	100
	[illegible]12	Press Fit	400	—	30 [1]	30 [1]	—	—	2.0 [1]	2.0 [1]	—	20	4.0 [2]	0.1	100
	[illegible]12	Stud	400	—	30 [1]	30 [1]	—	—	2.0 [1]	2.0 [1]	—	20	4.0 [2]	0.1	100
	SC245D22	Isolated Stud	400	—	30 [1]	30 [1]	—	—	2.0 [1]	2.0 [1]	—	20	4.0 [2]	0.1	100
	SC246D12	Press Fit	500	—	30 [1]	30 [1]	—	—	2.0 [1]	2.0 [1]	—	20	4.0 [2]	0.1	100
	SC245E12	Stud	500	—	30 [1]	30 [1]	—	—	2.0 [1]	2.0 [1]	—	20	4.0 [2]	0.1	100
	SC245E22	Isolated Stud	500	—	30 [1]	30 [1]	—	—	2.0 [1]	2.0 [1]	—	20	4.0 [2]	0.1	100
Selected Gate	[illegible]B13	Press Fit	200	25	25	25	25	2.0	2.0	2.0	2.0	20	4.0 [2]	0.1	100
	SC[illegible]13	Stud	200	25	25	25	25	2.0	2.0	2.0	2.0	20	4.0 [2]	0.1	100
	SC[illegible]D23	Isolated Stud	200	25	25	25	25	2.0	2.0	2.0	2.0	20	4.0 [2]	0.1	100
	SC[illegible]D13	Press Fit	400	25	25	25	25	2.0	2.0	2.0	2.0	20	4.0 [2]	0.1	100
	SC[illegible]5D13	Stud	400	25	25	25	25	2.0	2.0	2.0	2.0	20	4.0 [2]	0.1	100
	SC245D23	Isolated Stud	400	25	25	25	25	2.0	2.0	2.0	2.0	20	4.0 [2]	0.1	100
	SC[illegible]E13	Press Fit	500	25	25	25	25	2.0	2.0	2.0	2.0	20	4.0 [2]	0.1	100
	[illegible]13	Stud	500	25	25	25	25	2.0	2.0	2.0	2.0	20	4.0 [2]	0.1	100
	SC245E23	Isolated Stud	500	25	25	25	25	2.0	2.0	2.0	2.0	20	4.0 [2]	0.1	100
400 Hz Operation	SC246B14	Press Fit	200	50	50	50	—	2.5	2.5	2.5	—	20	4.0 [3]	0.1	187 @ 400Hz
	SC245B24	Stud	200	50	50	50	—	2.5	2.5	2.5	—	20	4.0 [3]	0.1	187 @ 400Hz
	SC245B24	Isolated Stud	200	50	50	50	—	2.5	2.5	2.5	—	20	4.0 [3]	0.1	187 @ 400Hz
	[illegible]	Press Fit	400	50	50	50	—	2.5	2.5	2.5	—	20	4.0 [3]	0.1	187 @ 400Hz
	[illegible]	Stud	400	50	50	50	—	2.5	2.5	2.5	—	20	4.0 [3]	0.1	187 @ 400Hz
	[illegible]	Isolated Stud	400	50	50	50	—	2.5	2.5	2.5	—	20	4.0 [3]	0.1	187 @ 400Hz
	[illegible]14	Press Fit	500	50	50	50	—	2.5	2.5	2.5	—	20	4.0 [3]	0.1	187 @ 400Hz
	[illegible]14	Stud	500	50	50	50	—	2.5	2.5	2.5	—	20	4.0 [3]	0.1	187 @ 400Hz
	SC245E24	Isolated Stud	500	50	50	50	—	2.5	2.5	2.5	—	20	4.0 [3]	0.1	187 @ 400Hz

[1] Pulse Conditions V_D = 3V, Gate Pulse Width = 50 μsec [2] Commutating di/dt = 5.4 A/msec [3] Commutating di/dt = 36 A/msec ™ Trademark of General Electric Company.

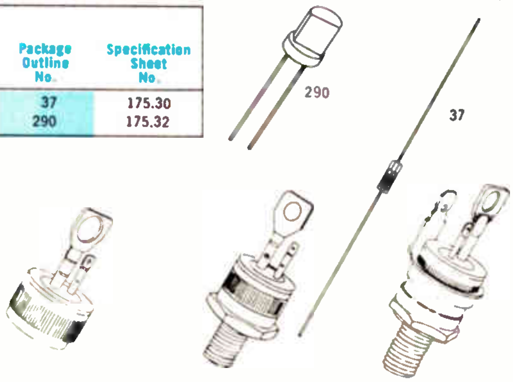
TRIAC TRIGGERS

The ST2 (diac) is a silicon bi-directional diode which may be used for triggering triacs or SCR's. It has a three layer structure with negative resistance switching characteristics in both directions.

The ST4 is an asymmetrical AC trigger integrated circuit for use in triac phase control applications. This device reduces the snap-on effects that are present in conventional trigger circuits by eliminating control circuit hysteresis. This performance is possible with a single RC time constant where as a symmetrical circuit of comparable performance would require at least three more passive components.

GE Type	V_{S2} Switching Voltage Min. (V)	V_{S2} Switching Voltage Max. (V)	V_{S1} Switching Voltage Min. (V)	V_{S1} Switching Voltage Max. (V)	I_{S2}, I_{S1} Switching Current Max. (μA)	Pulse Output Min. (V)	Package Outline No.	Specification Sheet No.
ST2	28 [1]	36 [1]	28 [1]	36 [1]	200	3.0	37	175.30
ST4	7	9	14	18	80	3.5	290	175.32

[1] For ST2, $V_{S2} = V_{S1} \pm 10\%$



PRESS FIT 241 | STUD 242 | ISOLATED STUD 243

General purpose 15 amperes TRIACS with **POWER GLAS**™ passivated pellets for reliability.

TRIACS 15 AMPERES RMS

SPECIFICATION SHEET NO. 175.18

	GE Type	Package Type	V_{DRM} Repetitive Pk Off-State Voltage @Tc = −40 to 115°C (V)	Igt DC Gate Trigger Current @ 12V, 25°C Max. (mA): MT2 + / Gate +	Igt: MT2 + / Gate −	Igt: MT2 − / Gate −	Igt: MT2 − / Gate +	Vgt DC Gate Trigger Voltage @ 12V, 25°C Max. (V): MT2 + / Gate +	Vgt: MT2 + / Gate −	Vgt: MT2 − / Gate −	Vgt: MT2 − / Gate +	dv/dt Static @ 115°C Rated V_{DRM} Gate Open Typical (V/μsec)	dv/dt Commutating @ 80°C Rated V_{DRM} and I_T Gate Open Min. (V/μsec)	I_{DRM} Leakage Current @ 25°C Max. (mA)	I_{TSM} Surge Current @ 60 Hz One Cycle Non-repetitive Max. (A)
Standard	SC251B	Press Fit	200	50	50	50	—	2.5	2.5	2.5	—	20	4.0 [2]	0.1	100
	SC250B	Stud	200	50	50	50	—	2.5	2.5	2.5	—	20	4.0 [2]	0.1	100
	SC250B2	Isolated Stud	200	50	50	50	—	2.5	2.5	2.5	—	20	4.0 [2]	0.1	100
	SC251D	Press Fit	400	50	50	50	—	2.5	2.5	2.5	—	20	4.0 [2]	0.1	100
	SC250D	Stud	400	50	50	50	—	2.5	2.5	2.5	—	20	4.0 [2]	0.1	100
	SC250D2	Isolated Stud	400	50	50	50	—	2.5	2.5	2.5	—	20	4.0 [2]	0.1	100
	SC251E	Press Fit	500	50	50	50	—	2.5	2.5	2.5	—	20	4.0 [2]	0.1	100
	SC250E	Stud	500	50	50	50	—	2.5	2.5	2.5	—	20	4.0 [2]	0.1	100
	SC250E2	Isolated Stud	500	50	50	50	—	2.5	2.5	2.5	—	20	4.0 [2]	0.1	100
Zero Voltage Switch	SC251B12	Press Fit	200	—	30 [1]	30 [1]	—	—	2.0 [1]	2.0 [1]	—	20	4.0 [2]	0.1	100
	SC250B12	Stud	200	—	30 [1]	30 [1]	—	—	2.0 [1]	2.0 [1]	—	20	4.0 [2]	0.1	100
	SC250B22	Isolated Stud	200	—	30 [1]	30 [1]	—	—	2.0 [1]	2.0 [1]	—	20	4.0 [2]	0.1	100
	SC251D12	Press Fit	400	—	30 [1]	30 [1]	—	—	2.0 [1]	2.0 [1]	—	20	4.0 [2]	0.1	100
	SC250D12	Stud	400	—	30 [1]	30 [1]	—	—	2.0 [1]	2.0 [1]	—	20	4.0 [2]	0.1	100
	SC250E12	Isolated Stud	400	—	30 [1]	30 [1]	—	—	2.0 [1]	2.0 [1]	—	20	4.0 [2]	0.1	100
	SC251E12	Press Fit	500	—	30 [1]	30 [1]	—	—	2.0 [1]	2.0 [1]	—	20	4.0 [2]	0.1	100
	SC250E12	Stud	500	—	30 [1]	30 [1]	—	—	2.0 [1]	2.0 [1]	—	20	4.0 [2]	0.1	100
	SC250E22	Isolated Stud	500	—	30 [1]	30 [1]	—	—	2.0 [1]	2.0 [1]	—	20	4.0 [2]	0.1	100
Selected Gate	SC251B13	Press Fit	200	25	25	25	25	2.0	2.0	2.0	2.0	20	4.0 [2]	0.1	100
	SC250B13	Stud	200	25	25	25	25	2.0	2.0	2.0	2.0	20	4.0 [2]	0.1	100
	SC250B23	Isolated Stud	200	25	25	25	25	2.0	2.0	2.0	2.0	20	4.0 [2]	0.1	100
	SC251D13	Press Fit	400	25	25	25	25	2.0	2.0	2.0	2.0	20	4.0 [2]	0.1	100
	SC250D13	Stud	400	25	25	25	25	2.0	2.0	2.0	2.0	20	4.0 [2]	0.1	100
	SC250D23	Isolated Stud	400	25	25	25	25	2.0	2.0	2.0	2.0	20	4.0 [2]	0.1	100
	SC251E13	Press Fit	500	25	25	25	25	2.0	2.0	2.0	2.0	20	4.0 [2]	0.1	100
	SC250E13	Stud	500	25	25	25	25	2.0	2.0	2.0	2.0	20	4.0 [2]	0.1	100
	SC250E23	Isolated Stud	500	25	25	25	25	2.0	2.0	2.0	2.0	20	4.0 [2]	0.1	100
400 Hz Operation	SC251B14	Press Fit	200	50	50	50	—	2.5	2.5	2.5	2.0	20	4.0 [3]	0.1	187 @ 400Hz
	SC250B14	Stud	200	50	50	50	—	2.5	2.5	2.5	2.0	20	4.0 [3]	0.1	187 @ 400Hz
	SC250B24	Isolated Stud	200	50	50	50	—	2.5	2.5	2.5	2.0	20	4.0 [3]	0.1	187 @ 400Hz
	SC251D14	Press Fit	400	50	50	50	—	2.5	2.5	2.5	2.0	20	4.0 [3]	0.1	187 @ 400Hz
	SC250D14	Stud	400	50	50	50	—	2.5	2.5	2.5	2.0	20	4.0 [3]	0.1	187 @ 400Hz
	SC250D24	Isolated Stud	400	50	50	50	—	2.5	2.5	2.5	2.0	20	4.0 [3]	0.1	187 @ 400Hz
	SC251E14	Press Fit	500	50	50	50	—	2.5	2.5	2.5	2.0	20	4.0 [3]	0.1	187 @ 400Hz
	SC250E14	Stud	500	50	50	50	—	2.5	2.5	2.5	2.0	20	4.0 [3]	0.1	187 @ 400Hz
	SC250E24	Isolated Stud	500	50	50	50	—	2.5	2.5	2.5	2.0	20	4.0 [3]	0.1	187 @ 400Hz

(1) Pulse conditions V_D = 3V, gate pulse width = 50μsec. (2) Commutating di/dt = 8A/Msec. (3) Commutating di/dt = 54A/Msec. TM Trademark of General Electric Company

TRIACS
25 AMPERES RMS

General Purpose 25 ampere TRIACS with **POWER GLAS**™ Passivated Pellets for reliability.

SPECIFICATION SHEET NO. SC260

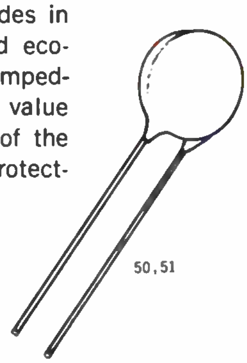
PRESS FIT	STUD	ISOLATED STUD
256	257	258

	GE Type	Package Type	V_{DRM} Repetitive Pk Off-State Voltage @ T_J = −40 to 115°C (V)	Igt DC Gate Trigger Current @ 12V, 25°C Max (mA) MT₂ + / Gate +	Igt MT₂ − / Gate +	Igt MT₂ − / Gate −	Igt MT₂ + / Gate −	Vgt DC Gate Trigger Voltage @ 12V, 25°C Max (V) MT₂ + / Gate +	Vgt MT₂ − / Gate +	Vgt MT₂ − / Gate −	Vgt MT₂ + / Gate −	dv/dt Static @ 100°C Rated V_{DRM} Gate Open Typical (V/μsec)	dv/dt Commutating @ 80°C Rated V_{DRM} and I_T Gate Open Min (V/μsec)	I_{DRM} Leakage Current @ 25°C Max (mA)	I_{TSM} Surge Current @ 60 Hz One Cycle Non-repetitive Max (A)
Standard	SC261B	Press Fit	200	50	50	50	—	2.5	2.5	2.5	—	100	5.0	0.5	250
	SC260B	Stud	200	50	50	50	—	2.5	2.5	2.5	—	100	5.0	0.5	250
	SC260B2	Isolated Stud	200	50	50	50	—	2.5	2.5	2.5	—	100	5.0	0.5	250
	SC261D	Press Fit	400	50	50	50	—	2.5	2.5	2.5	—	100	5.0	0.5	250
	SC260D	Stud	400	50	50	50	—	2.5	2.5	2.5	—	100	5.0	0.5	250
	SC260D2	Isolated Stud	400	50	50	50	—	2.5	2.5	2.5	—	100	5.0	0.5	250
	SC261E	Press Fit	500	50	50	50	—	2.5	2.5	2.5	—	100	5.0	0.5	250
	SC260E	Stud	500	50	50	50	—	2.5	2.5	2.5	—	100	5.0	0.5	250
	SC260E2	Isolated Stud	500	50	50	50	—	2.5	2.5	2.5	—	100	5.0	0.5	250
Zero Voltage Switch	SC261B12	Press Fit	200	—	30[1]	30[1]	—	—	2.0[1]	2.0[1]	—	100	5.0	0.5	250
	SC260B12	Stud	200	—	30[1]	30[1]	—	—	2.0[1]	2.0[1]	—	100	5.0	0.5	250
	SC260B22	Isolated Stud	200	—	30[1]	30[1]	—	—	2.0[1]	2.0[1]	—	100	5.0	0.5	250
	SC261D12	Press Fit	400	—	30[1]	30[1]	—	—	2.0[1]	2.0[1]	—	100	5.0	0.5	250
	SC260D12	Stud	400	—	30[1]	30[1]	—	—	2.0[1]	2.0[1]	—	100	5.0	0.5	250
	SC260D22	Isolated Stud	400	—	30[1]	30[1]	—	—	2.0[1]	2.0[1]	—	100	5.0	0.5	250
	SC261E12	Press Fit	500	—	30[1]	30[1]	—	—	2.0[1]	2.0[1]	—	100	5.0	0.5	250
	SC260E12	Stud	500	—	30[1]	30[1]	—	—	2.0[1]	2.0[1]	—	100	5.0	0.5	250
	SC260E22	Isolated Stud	500	—	30[1]	30[1]	—	—	2.0[1]	2.0[1]	—	100	5.0	0.5	250
Selected Gate	SC261B13	Press Fit	200	50	50	50	50	2.5	2.5	2.5	2.5	100	5.0	0.5	250
	SC260B13	Stud	200	50	50	50	50	2.5	2.5	2.5	2.5	100	5.0	0.5	250
	SC260B23	Isolated Stud	200	50	50	50	50	2.5	2.5	2.5	2.5	100	5.0	0.5	250
	SC261D13	Press Fit	400	50	50	50	50	2.5	2.5	2.5	2.5	100	5.0	0.5	250
	SC260D13	Stud	400	50	50	50	50	2.5	2.5	2.5	2.5	100	5.0	0.5	250
	SC260D23	Isolated Stud	400	50	50	50	50	2.5	2.5	2.5	2.5	100	5.0	0.5	250
	SC261E13	Press Fit	500	50	50	50	50	2.5	2.5	2.5	2.5	100	5.0	0.5	250
	SC260E13	Stud	500	50	50	50	50	2.5	2.5	2.5	2.5	100	5.0	0.5	250
	SC260E23	Isolated Stud	500	50	50	50	50	2.5	2.5	2.5	2.5	100	5.0	0.5	250
400 Hz Operation	SC261B14	Press Fit	200	50	50	50	—	2.5	2.5	2.5	—	100	5.0[1]	0.5	510 @ 400Hz
	SC260B14	Stud	200	50	50	50	—	2.5	2.5	2.5	—	100	5.0[3]	0.5	510 @ 400Hz
	SC260B24	Isolated Stud	200	50	50	50	—	2.5	2.5	2.5	—	100	5.0[3]	0.5	510 @ 400Hz
	SC261014	Press Fit	400	50	50	50	—	2.5	2.5	2.5	—	100	5.0[3]	0.5	510 @ 400Hz
	SC260D14	Stud	400	50	50	50	—	2.5	2.5	2.5	—	100	5.0[3]	0.5	510 @ 400Hz
	SC260D24	Isolated Stud	400	50	50	50	—	2.5	2.5	2.5	—	100	5.0[3]	0.5	510 @ 400Hz
	SC261E14	Press Fit	500	50	50	50	—	2.5	2.5	2.5	—	100	5.0[3]	0.5	510 @ 400Hz
	SC260E14	Stud	500	50	50	50	—	2.5	2.5	2.5	—	100	5.0[3]	0.5	510 @ 400Hz
	SC260E24	Isolated Stud	500	50	50	50	—	2.5	2.5	2.5	—	100	5.0[3]	0.5	510 @ 400Hz

[1] Pulse Condition V_D = 3V, Gate Pulse Width = 50 μsec
[2] Commutating di/dt = 13.5 A/msec
[3] Commutating di/dt = 89 A/msec

GE-MOV™ VARISTORS
ASSURE YOUR EQUIPMENT WILL ENDURE

General Electric **Metal Oxide Varistors** are voltage dependent, symmetrical resistors which perform in a manner similar to back-to-back zener diodes in circuit protective functions and offer advantages in performance and economics. When exposed to high energy voltage transients, the varistor impedance changes from a very high standby value to a very low conducting value thus clamping the line voltage to a safe level. The dangerous energy of the incoming high voltage pulse is absorbed by the GE-MOV varistor, thus protecting your voltage sensitive circuit components.



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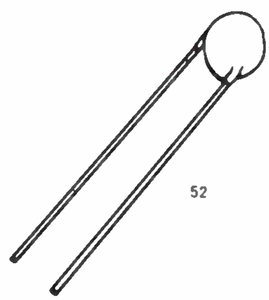
GE-MOV™

Model #	Max. RMS Input Voltage (V)	Max. DC Input Voltage (V)	Varistor Peak Voltage @ .1ma AC (V) Min.	Max.	Max. Energy Rating (Joules)	Average Power Dissipation Rating (W)	Capacitance Typical (pF)	Max. Thermal Resistance (°C/W)	Peak Current for Pulses ≤ 7 μsec. (A)	AC Max.* Clamp Ratio @ 10 A
VP95LA7	95	130	136	207	7	.50	1500	60	1000	2.0
VP130LA10	130	177	185	254	10	.50	900	60	1000	2.0
VP130LA20	130	177	185	254	20	.85	1800	37	2200	2.0
VP150LA10	150	197	212	282	10	.50	900	60	1000	2.0
VP150LA20	150	197	212	282	20	.85	1800	37	2200	2.0
VP250LA15	250	330	354	472	15	.60	600	50	750	2.2
VP250LA20	250	330	354	472	20	.60	600	50	1000	2.0
VP250LA40	250	330	354	472	40	.90	1200	35	2200	2.0
VP420LB20	420		595	800	20	.50	300	60	420	2.5
VP420LB40	420	560	595	800	40	.90	600	35	2200	2.0
VP460LB20	460		650	878	20	.50	300	60	420	2.5
VP460LB40	460	615	650	878	40	.90	600	35	2200	2.0
VP480LB20	480		680	914	20	.55	300	55	420	2.5
VP480LB40	480	640	680	914	40	.70	300	45	1000	2.0
VP480LB80	480	640	680	914	80	1.00	600	30	2200	2.0
VP510LB20	510		725	963	20	.55	300	55	420	2.5
VP510LB40	510	675	725	963	40	.70	300	45	1000	2.0
VP510LB80	510	675	725	963	80	1.00	150	30	2200	2.0
VP1000LB80	1000		1414	1900	80	.90	150	35	1000	2.0
VP1000LB160	1000		1414	1900	160	1.30	300	24	2200	2.0

* **DC Max. Clamp Ratio** = 2.2



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MINI-MOV™

Model #	Max. RMS Input Voltage (V)	Max. DC Input Voltage (V)	Varistor Peak Voltage @ .1ma AC (V) Min.	Max.	Max. Energy Rating (Joules)	Average Power Dissipation Rating (W)	Capacitance Typical (pF)	Max. Thermal Resistance (°C/W)	Peak Current for Pulses ≤ 7 μsec. (A)	AC Max.* Clamp Ratio @ 1 A
VP130LA1	130	177	185	254	1	.24	120	125	150	2
VP130LA2	130	177	185	254	2	.24	120	125	150	2
VP150LA1	150	197	212	287	1	.24	120	125	150	2
VP150LA2	150	197	212	287	2	.24	120	125	150	2
VP250LA2	250	330	354	479	2	.28	80	110	150	2
VP250LA4	250	330	354	479	4	.28	80	110	150	2

* **DC Max. Clamp Ratio** = 2.2

FOR APPLICATION INFORMATION WRITE FOR PUBLICATIONS #180.59, #200.62, & #180.66

SPECIAL SILICON PRODUCTS
SILICON SIGNAL DIODE CHIPS

Equivalent JEDEC Number	GE Type	Description	Chip Dwg.	Specification Sheet No.
1N914	M46P-X503	Designed for high-speed switching and general purpose applications.	1	35.88
1N914A				
1N914B	M46P-X510			35.90
1N3064	M46P-X507	Very high speed		35.89
1N3600	M79P-X506	High conductance and high-speed switching in logic, core, hammer driver circuits and general purpose applications.	2	35.97
1N3605	M46P-X516	High-speed switching: high conductance, fast recovery time, low leakage and low capacitance.	1	35.91
1N4150	M79P-X506	Similar to 1N3600 (Chip)	2	35.97
1N4152	M46P-X516	Similar to 1N3605 (Chip)	1	35.91
1N4551	M87PX500	High current, fast switching diode designed primarily for computer usage	2[1]	35.101
1N4454	M46P-X507	Similar to 1N3064 (Chip)	1	35.89
1N4532				
1N4533	M46P-X516	Similar to 1N3605 (Chip)		35.91
1N4606	M79P-X501	Similar to 1N3600 (Chip) except high voltage.	2	35.96

SILICON SIGNAL TRANSISTOR CHIPS

Equivalent JEDEC Number	GE Type	Description	Chip Dwg.	Specification Sheet No.
2N708	M82P-X500	NPN chip for high-speed switching. Also suitable as small signal device.	3	35.98
2N918	M63P-X503	NPN chip for high frequency	4	35.92
2N929	M26P-X531	NPN chip for low-level amplifiers.	5	35.79
2N930	M26P-X505			35.76
2N2219	M23P-X504	NPN chip for high-speed switching, amplifiers and core drivers.	6	35.71
2N2220				
2N2221				
2N2222				
2N2222A	M23PX503			
2N2369	M33PX504	NPN chip ideal for high speed switching	11	35.102
2N2484	M26P-X504	NPN chip for low-level, high gain preamplifiers in hybrid and micro-miniature circuits.	5	35.75
2N2604	M92PX500	PNP chip featuring high BV_{CEO} and low capacitance	11	35.103
2N2714	M24P-X502	NPN chip for general purpose.	8	35.74
2N2905	M67P-X504	PNP chip for amplifiers, drivers and general purpose switching. (Electrically similar to JEDEC series only.)	9	35.93
2N2906				
2N2907				
2N3414	M32P-X503	NPN chip suited for high-level linear amplifiers or medium-speed switching circuits.	7	35.84
2N3415	M32P-X509			35.87
2N3416	M32P-X506			35.85
2N3417	M32P-X508			35.86
2N3855A	M28P-X507	NPN chip for RF, IF and converters in AM and FM radio and TV video amplifiers.	5	35.82
2N3856A	M28P-X508			35.83
2N3859	M26P-X516	NPN chip for AM radio, IF and converters.		35.77
2N3860	M26P-X560			35.81
2N3975	M23P-X509	NPN chip for medium-speed switching and large signal RF amplifiers.	6	35.72
2N3976	M23P-X516			35.73
2N5172	M26P-X558	NPN chip for general purpose.	5	35.80
2N5232	M26P-X517	NPN chip for low noise preamp and small signal amplifier.		35.78
2N5306	M73P-X502	NPN darlington chip for preamp input stages.	10	35.95
2N5814	M86PX503	NPN chip for general purpose amplifier applications at audio and intermediate frequencies	12	35.104
2N5815	M85PX506	PNP chip—complement to M86PX503	12	35.104
	M22P2	NPN chip for general low signal levels.	8	35.70
	M22P3			
	M22P4			
	M73P1	NPN darlington chip for preamp input stages.	10	35.94

[1] Similar to chip drawing #2 except chip is 20 mils square with 12 mil diameter cathode dot

CHIP DRAWINGS

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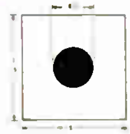

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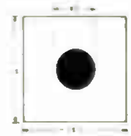

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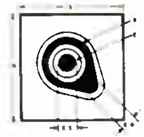

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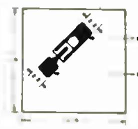

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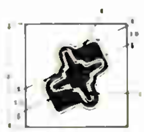

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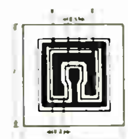

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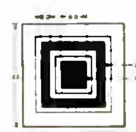

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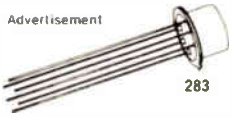
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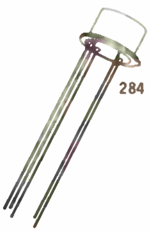
SPECIAL SILICON PRODUCTS
DIFFERENTIAL AMPLIFIERS

Differential Amplifiers—NPN

GE Type	V_{CEO} Min. (V)	h_{FE} @ 100μA Min.	h_{FE} @ 100μA Max.	h_{FE1}/h_{FE2} Match @ 100μA	h_{FE} @ 1mA Min.	h_{FE} @ 1mA Max.	h_{FE1}/h_{FE2} Match @ 1mA	Δ V_{BE} @ 10μA (mV)	Δ V_{BE} @ 1mA (mV)	I_{CBO} @ V_{CB} (V) Max. (nA)	I_{CBO} @ V_{CB} (V) Max. (V)	Package Outline No.	Specification Sheet No.
2N2060 [4]	60 [1]	30	—	0.9-1.0	40	—	—	—	5	2	80	283	35.42
2N2223	60	25	—	0.8-1.0	50 [2]	200	—	—	15 [3]	10	80	283	35.14
2N2223A	60	25	150	.9-1.0	50 [2]	200	—	—	5 [3]	10	80	283	35.14
2N2453 [5]	30	80 [1]	—	—	150	600	0.9-1.0	3	5	5	50	283	35.20
2N2453A [5]	50	—	—	—	150	600	.9-1.0	3	5	5	60	283	35.20
2N2480	40	20	—	0.8-1.0	30	350	0.8-1.0	—	10	50	60	283	35.25
2N2480A	40	35	—	0.8-1.0	50	200	0.8-1.0	—	5	20	60	283	35.25
2N2639 [5]	45	55	—	—	65	—	.9-1.0 [1]	5	—	10	45	283	35.61
2N2640 [5]	45	55	—	—	65	—	.8-1.0 [1]	10	—	10	45	283	35.61
2N2641 [5]	45	55	—	—	—	—	—	—	—	10	45	283	35.61
2N2642 [5]	45	110	—	—	130	—	.9-1.0 [1]	5	—	10	45	283	35.61
2N2643 [5]	45	110	—	—	130	—	.8-1.0 [1]	10	—	10	45	283	35.61
2N2644 [5]	45	110	—	—	—	—	—	—	—	10	45	283	35.61
2N2652	60	35	—	.85-1.0	50	200	0.85-1.0	—	3	10	50	283	35.32
2N2652A	60	35	—	0.9-1.0	50	200	0.9-1.0	—	3	2	50	283	35.32
2N2903	30	60 [1]	—	—	125	625	.8-1.0	10	—	—	—	283	—
2N2910	25	70	—	0.8-1.0	80	—	0.8-1.0	—	10	10	20	283	35.34
2N2913 [5]	45	100	—	—	150	—	—	—	—	10	45	283	35.36
2N2914 [5]	45	225	—	—	300	—	—	—	—	10	45	283	35.36
2N2915 [5]	45	100	—	0.9-1.0	150	—	—	5	5	10	45	283	35.36
2N2916 [5]	45	225	—	0.9-1.0	300	—	—	5	5	10	45	283	35.36
2N2917 [5]	45	100	—	0.8-1.0	150	—	—	10	10	10	45	283	35.36
2N2918 [5]	45	225	—	0.8-1.0	300	—	—	10	10	10	45	283	35.36
2N2919 [5]	60	100	—	0.9-1.0	150	—	—	5	5	2	45	283	35.36
2N2920 [5]	60	225	—	0.9-1.0	300	—	—	5	5	2	45	283	35.36
2N3521 [5]	45	155 [6]	500	0.8-1.0 [1]	200	600 [2]	0.8-1.0	5	10	5	50	283	35.31
2N3522	45	155 [6]	500	0.8-1.0 [1]	200	600 [2]	.8-1.0	5	10	10	50	285	35.31
012A8	30	30	—	0.6-1.0	—	—	—	—	15 [3]	25	30	283	35.27
D12E026	30	40	—	.6-1.0	60	—	—	—	—	25	20	283	35.24
D12E109	30	80 [1]	—	—	150	600	0.9-1.0	3	5	5	30	283	35.20
D12E126	30	40	—	0.6-1.0	60	—	—	—	—	25	20	285	35.24

[1] Ic = 10μA
[2] Ic = 10mA
[3] Ic = 100μA
[4] JAN & JANTX types available
[5] TO-18 packages available
[6] Ic = 5mA

CHOPPERS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	GE Type	V_O Offset Voltage @ $I_{B1} = I_{B2}$ = 1mA $I_{E1} = I_{E2}$ = 0 (μV)	V_{EEO} @ I_{E1E2} = 1mA $I_{B1} = I_{B2}$ (V)	R_s @ I_{B1} = 1mA I_{EE} = 0.1mA (Ω)	I_{CBO1} or I_{CBO2} @ 25V Max (nA)	Package Outline No.	Specification Sheet No.
Choppers NPN	2N2356	300 @ −55°C to +125°C	20	40	10	284	35.10
	2N2356A	50 @ −55°C to +125°C	20	40	10	284	35.10

DARLINGTONS


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	GE Type	V_{CEO} @ 30mA Min. (V)	h_{FE} @ 100mA Min.	h_{FE} @ 100mA Max.	h_{FE} @ 10mA Min.	h_{FE} @ 10mA Max.	h_{FE} @ 1mA Min.	I_{CBO} @ V_{CB} (V) Max. (nA)	I_{CBO} @ V_{CB} (V) Max. (V)	Package Outline No.	Specification Sheet No.
Darlingtons [2] NPN	2N997	40	7000	70,000	4000	—	—	10	60	286	35.11
	2N998	60	2000	—	1600	8000	800	10	90	286	35.12
	2N999	60	7000	70,000	4000	—	—	10	60	286	35.11
	2N2785	40 [1]	2000	20,000	1200	—	600	50	30	286	35.33

[1] Measured at 20mA

[2] For Plastic Encapsulated Darlington types see Silicon Signal Transistor Section Page 28

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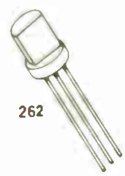
SPECIAL SILICON PRODUCTS
REFERENCE AMPLIFIERS

GE Type	Circuit Characteristics: $V_{CB}=3$ Volts, $I_C=0.5mA$, $I_Z=0$, $R_B=1K$ — Temperature Coefficient (%/°C)	Temperature Range (°C)	V_{REF} Min. (V)	V_{REF} Max. (V)	G_{MC} Minimum Trans-conductance (μMHO)	Transistor Characteristics: $V_{CE}=3V$, $I_C=.5mA$ — h_{FE} Min	h_{FE} Max	$V_{CB}=30V$ — I_{CBO} Typ. (μA)	I_{CBO} Max. (μA)	$V_{CB}=45V$ — I_{CBO} Typ. (μA)	I_{CBO} Max. (μA)	Package Outline No.	Specification Sheet No.
RA1 RA1A RA1B RA1C	.02 .005 .002 .001	0 to 70	6.3	7.7	3,000	10	120	.004	1.0			289	35.35
RA2 RA2A RA2B	.02 .005 .002	−55 to +150	6.65	7.35	6,000	40	120	.004	0.1				
RA3 RA3A RA3B	.02 .005 .002	−55 to +150 [1]	6.65 [1]	7.35 [1]	2,000 [1]	30 [2]	90 [2]			.006	0.1		

[1] $V_{CB}=3$ Volts, $I_C=0.1mA$, $I_Z=5mA$, $R_B=1K$
[2] At $V_{CE}=3V$, $I_C=.1mA$



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SPECIAL SILICON PRODUCTS
INTEGRATED VOLTAGE REGULATOR (IVR) D13V SERIES

The D13V is a monolithic integrated voltage regulator circuit. Designed for use as a shunt voltage regulating element, it can be utilized over wide voltage and current ranges. It also features a specified voltage temperature coefficient. It has a power dissipation rating of 500 MW or 1 watt with heatsink.

GE Type	Regulated Voltage Range (V)	T.C. of Regulated Voltage (%/°C)	Thevinin Impedance Max. (Ω)	Thevinin Reference Voltage Min. (V)	Thevinin Reference Voltage Max. (V)	Package Outline No.	Specification Sheet No.
D13V1	8.5-40	.03	20	7.0	8.5	262	35.65
D13V2	8.5-40	.03	10	7.5	7.8		
D13V3	8.0-80	.03	10	7.3	8.0		
D13V4	8.0-80	.03	10	7.6	7.9		

MILITARY TYPES AVAILABLE

Type	TX Type	Military Specification
JAN 1N93A		MIL-S-19500/293
JAN 1N249B, 250B		MIL-S-19500/134
JAN 1N1184, 6, 8	JANTX 1N1184, 6, 8	MIL-S-19500/297
JAN 1N1202A, 04A	JANTX 1N1202A, 04A	MIL-S-19500/260
JAN 1N1206A	JANTX 1N1206A	MIL-S-19500/260
JAN 1N1614, 15, 16		MIL-S-19500/162
JAN 1N3289, 91, 93, 94, 95		MIL-S-19500/246
JAN 1N3713, 15, 17, 19, 21		MIL-S-19500/269
JAN 1N3880, 81, 83		MIL-S-19500/266
JAN 1N3890, 91, 93	JANTX 1N3890, 91, 93	MIL-S-19500/304
JAN 1N3909, 10, 11, 12, 13		MIL-S-19500/308
JAN 1N4148	JANTX 1N4148	MIL-S-19500/116
JAN 1N4150	JANTX 1N4150	MIL-S-19500/231
JAN 1N4153	JANTX 1N4153	MIL-S-19500/337
JAN 1N4245		MIL-S-19500/286
JAN 1N4246, 7, 8		MIL-S-19500/286
JAN 1N4454	JANTX 1N4454	MIL-S-19500/144
JAN 1N4531	JANTX 1N4531	MIL-S-19500/116
JAN 1N4532		MIL-S-19500/144

Type	TX Type	Military Specification
JAN 2N461		MIL-S-19500/45
JAN 2N489A-94A	JANTX 2N489A-94A	MIL-S-19500/75
JAN 2N526		MIL-S-19500/60
JAN 2N682, 3, 5, 6, 7, 8, 9		MIL-S-19500/108
JAN 2N1771A, 2A, 4A, 6A, 7A	JANTX 2N1771A, 2A, 4A, 6A, 7A	MIL-S-19500/168
JAN 2N1792, 3, 5, 7, 8		MIL-S-19500/204
JAN 2N1910, 11, 13, 15, 16		MIL-S-19500/204
JAN 2N2031		MIL-S-19500/204
JAN 2N2060	JANTX 2N2060	MIL-S-19500/270
JAN 2N2323, 24, 26 &A	JANTX 2N2323, 24, 26 & A	MIL-S-19500/276

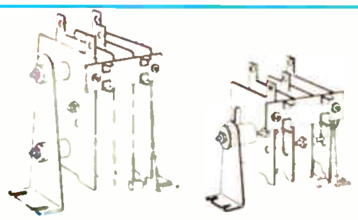
HIGH RELIABILITY SPECIFICATIONS

High Rel. Type	Commercial Type	Conservative Design Maximum Conditions				Estimated Maximum Failure Rate in Conservatively Designed Equipment %/1000 hrs.
		Io	T_{STG}, T_{JOP}	V_{DRM}, V_{RRM}	V_{RSM}	
A27BR1200	1N1202	12A	−65 to +100°C	100V	200V	.001
A27DR1200	1N1204	12A	−65 to +100°C	200V	400V	.001
A27MR1200	1N1206	12A	−65 to +100°C	400V	600V	.001
A28BR1200	A28B	12A	−65 to +100°C	100V	200V	.001
A28DR1200	A28D	12A	−65 to +100°C	200V	400V	.001
A28BR1201	1N3891	12A	−65 to +100°C	100V	200V	.001
A28DR1201	1N3893	12A	−65 to +100°C	200V	400V	.001
A38BR1200	1N2156	25A	−65 to +100°C	100V	200V	.001
A38DR1200	1N2158	25A	−65 to +100°C	200V	400V	.001
A38MR1200	1N2160	25A	−65 to +100°C	400V	600V	.001
A38BR1202	1N3911	30A	−65 to +100°C	100V	200V	.001
A38DR1202	1N3913	30A	−65 to +100°C	200V	400V	.001
C5AR1200	2N2324	1.6A	−65 to +85°C	50V	100V	.001
C5BR1200	2N2326	1.6A	−65 to +85°C	100V	200V	.001
C5DR1200	2N2329	1.6A	−65 to +85°C	200V	400V	.001
C10AR1200	2N1772A	4.7A	−65 to +100°C	50V	100V	.001
C10BR1200	2N1774A	4.7A	−65 to +100°C	100V	200V	.001
C10DR1200	2N1777A	4.7A	−65 to +100°C	200V	400V	.001
C11AR1200	2N1772	4.7A	−65 to +85°C	50V	100V	.001
C11BR1200	2N1774	4.7A	−65 to +85°C	100V	200V	.001
C11DR1200	2N1777	4.7A	−65 to +85°C	200V	400V	.001
C11MR1200	2N2619	4.7A	−65 to +85°C	300V	600V	.001
C35AR1200	2N683	16A	−65 to +85°C	50V	100V	.001
C35BR1200	2N685	16A	−65 to +85°C	100V	200V	.001
C35DR1200	2N688	16A	−65 to +85°C	200V	400V	.001
C35ER1200	2N689	16A	−65 to +85°C	250V	500V	.001
C35MR1200	2N690	16A	−65 to +85°C	300V	600V	.001
C38BR1200	2N685	16A	−65 to +100°C	100V	200V	.001
C38HR1200	2N686	16A	−65 to +100°C	125V	250V	.001
C38DR1200	2N688	16A	−65 to +100°C	200V	400V	.001
C137MR1200	2N5204	22.3A	−65 to +85°C	300V	600V	.001

SCR COMBINATION STACKS

General Electric's broad line of SCR's and rectifiers permits the offering of packaged SCR building blocks. This new concept in stack design includes SCR's, compatible rectifiers, heatsinks, interconnections and all required hardware in one package. Installation requires only mounting bolts and electrical connections for power and triggering signal.

C3512, 13
C4012, 13
C1012, 13
C1112, 13
C1212, 13

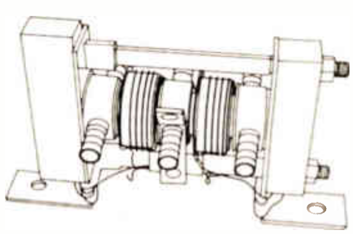


Up to 13.65A per fin free convection rating in 25°C ambient.
Up to 23.5A per fin forced cooling in 25°C ambient.
Two fin sizes (3" x 3", 5" x 5") and 5 SCR types permit an optimum designed assembly for each application. Stacks can be mounted in either vertical or horizontal plane. An almost limitless number of circuit configurations available. Will operate from −65°C up to +150°C.

C5014 C6014 C15014 C15414 C15514 C15814 C18015 C18515

Up to 102 amps per fin free convection rating in 30°C ambient: Aluminum extrusions designed specifically for maximum heat dissipation when used with any G-E high current SCR. Hundreds of configurations available.

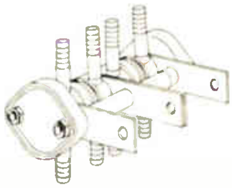
C350G6 C390G6 C380G6 C354G6 C355G6 C385G6 C398G6 C397G6 C388G6 C387G6



G6 Watercooled Heatsinks in single, doubler and AC Switch configurations for ½" Press Pak C350, C380, and A390 series as well as 1" Press Pak C398, C500 and A500 families. Data is available showing variance in sink to ambient thermal resistance for different flow rates as well as pressure drop and transient thermal curves. Ask for data and outlines available in Power Data Book TAB7, pp. 1-9. Package outline no. 277

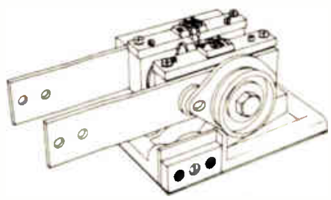
SCR COMBINATION STACKS (Continued)

C501G5, G8
C520G5, G8
C530G5, G8
A500G5, G8
A540G5, G8
A570G5, G8



G5, G8 Watercooled Heatsink assemblies especially designed for the C500 and A500 series for the maximum thermal efficiency available. Configurations include single and doubler with both the flat surface mounted G5 and straight tang model G8. See spec 170.72 where all C500 and A500 devices are characterized in average amps out for various water temperatures and conduction angles. Package outline no. 217

C501G7-A11
C501G10-A11



Solid State Watercooled AC Power Switch: Two SCR's, anti-parallel mounted between watercooled heat exchangers provide control up to 1400 A (RMS) at 50% duty. Blocking capability is 1700 volts peak repetitive in both directions. Other voltages down to 1000 volts blocking are available. Double side cooling gives 850 A (RMS) per pellet. One cycle (60 HZ) surge capability is 7000 amps. Required water flow is one GPM. Preliminary data sheets are available. Package outline no. 278

C501E7-A11
A540E7
A500E7
A570E7

CONSULT FACTORY

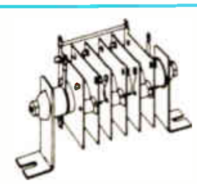
Air cooled AC Switch. Two SCR's anti-parallel mounted between forced air cooled heat exchanger provide up to 750 A (RMS) continuous at 40°C ambient and 1000 LFPM. Ask for information available in TAB7 of Power Data Book.

Half wave air cooled SCR or diode assembly also available. Ask for data in Tab 7 in Power Data Book for average current vs. various ambient temperatures, air flow rates, and conduction angles. Package outline no. 279

RECTIFIER DIODE BRIDGES AND STACKS

GERMANIUM
LOW CURRENT

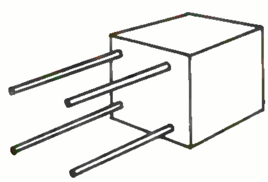
Up to 6 Amps @ 55°C
Up to 630 PRV



A211 Stacks: The industry's most widely-used semiconductor rectifier diode series. Hundred of thousands in use. May be arranged in stacks up to 12 fins to produce more than 160 various circuit configurations. Small, lightweight, excellent regulation.
Specification Sheet No. 120.20

SILICON
SINGLE PHASE RECTIFIER BRIDGES

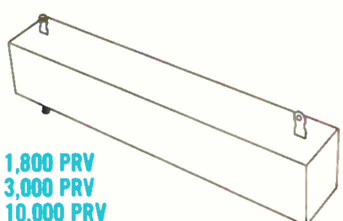
Up to 1.6 Amps @ 50°C
Up to 1000 PRV



GEB Bridges: The GEB 100 Series Rectifier offer a wide range of voltage grades for general purpose applications. Voltage ratings 50 to 1000 volts, Av Forward Current @ 50°C 1.6 amps. Bridge consists of A14 Glass hermetically sealed devices offering small size and high reliability.
Specification Sheet No. 130.96
Package Outline No. 271

POTTED
RECTIFIER DIODE CIRCUITS

A220	.4 Amp @ 55°C	Up to 1,800 PRV
A420	2.0 Amps @ 50°C	Up to 3,000 PRV
A421	.65 Amp @ 25°C	Up to 10,000 PRV
A422	1.5 Amps @ 25°C	Up to 2,000 PRV



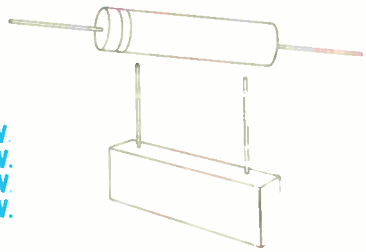
A220, A420-421-422 Series: Mounted in standard eight-pin tube base (A220-420 Series) or in rectangular design with solder lug connections (A221-421-422 Series). Available in a large number of circuit configurations. One to 20 cells may be potted in a single circuit. Individual cell specifications determine ratings. A220 Series utilize germanium 1N91-93 cells. A420-421-422 Series utilize silicon A14F-P cells. (See BASIC RECTIFIER-DIODE LISTING.)
Specification Sheet No. 130.95

Advertisement

RECTIFIER DIODE BRIDGES AND STACKS

CONTROLLED AVALANCHE RECTIFIER DIODES IN POTTED ASSEMBLIES

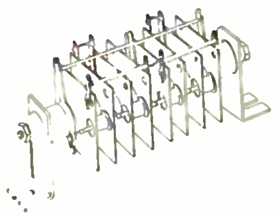
	Up to:	Up to:
1N1730	.1 amp @ 100°C amb.	5,000 PRV.
1N2382	.075 amp @ 100°C amb.	10,000 PRV.
A1425	.770 amp @ 100°C amb.	12,000 PRV.
A1423	1.0 amp @ 50°C amb.	12,000 PRV.



1N1730, 1N2382 and A1425 Series: Controlled Avalanche rectifier diodes potted in axial lead cartridge type assemblies.
A1423 Series: Potted block assemblies utilizing A14 Controlled Avalanche rectifier diodes. Available in half wave, center tap, voltage doublers, full-wave bridge, single phase or three phase.
Specification Sheet No. 130.95

SILICON LOW CURRENT

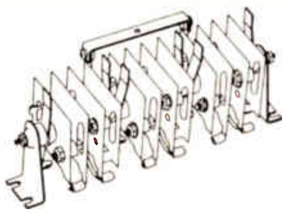
Up to 18 Amps @ 25°C
Up to 1800 PRV



A411 Stacks: Combine high temperature operation (up to 150°C) with increased ratings (up to 18 amps d-c). Hundreds of stack combinations to meet a variety of circuit conditions. High efficiency plus excellent regulation.
A1011 Stacks: Available in same mechanical and circuit configurations and featuring 45 amp, one cycle surge rating.
Specification Sheet No. 130.90, 130.91

SILICON MEDIUM CURRENT

Up to 65 Amps @ 55°C
Up to 1800 PRV



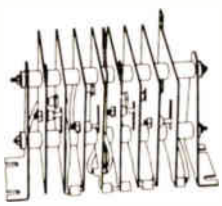
A2011 Stacks: Provide a wide range of power applications with d-c outputs up to 32 amps.

A2511 Stacks: Provide a wide range of power applications with d-c outputs up to 47 amps.

A3511 Stacks: Provide a wide range of power applications with d-c outputs up to 67 amps.

SILICON MEDIUM CURRENT

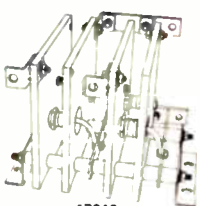
Up to 108 Amps @ 55°C
Up to 1800 PRV



A3512 Stacks: This 5" square fin assembly makes optimum use of the 1N2154 series 25 ampere cell. This stack provide a wide range of power applications with d-c outputs up to 108 amperes.

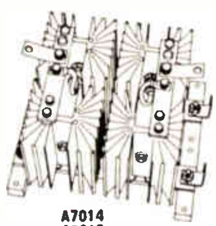
SILICON HIGH CURRENT

Up to 690 Amps @ 40°C
Up to 1000 PRV



A7013
A9013

A7012
A9016



A7014
A9015

A7011

A7011 3½" x 3½" x 2" Aluminum Extrusion Stacks: Particularly suitable for free convection applications. Plated copper terminals for all purchaser connections.

A7012, A7013 Stacks: Available with a choice of two heat sink sizes: the 5" x 5" x ⅛" flat copper fin (7012) and the 7" x 7" x ⅜" flat aluminum fin (7013). Lightweight units with outputs up to 165 amps DC.

A7014 Stacks: The A7014 stack line has been designed especially for free convection cooled applications where a maximum amount of current is required in a relatively small space. Fin size is 4" x 4" x 5" anodized aluminum. DC outputs up to 240 amps, free convection cooled in 40°C ambient.

A9013 Stacks: DC outputs up to 250 amps, per fin forced air cooled in 40°C ambient. Utilizes light-weight 7" x 7" x ⅜" aluminum fin. Heat dissipation abilities equal to 7" x 7" x ¼" nickel-plated copper, yet less than half the weight of copper fin stacks.

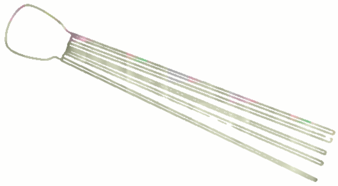
A9015 Aluminum Extrusion Stacks: Designed for maximum heat dissipation in free convection cooled applications. Plated copper terminals for all purchaser connections.

A9016 Stacks: Different rectifier diode configurations available on 5" x 5" nickel-plated copper flat fins. Fin thickness ⅛".
NOTE: Series and parallel configurations available in all High Current Stacks

SELENIUM RECTIFIER DIODES AND STACKS

General Electric's unique vacuum process provides highly reliable selenium cells, known for long life and high temperature operation. This Vac-U-Sel® process assures you of uniformity from cell to cell and excellent margins of safety.

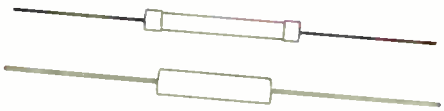
Capitalize on the low cost versatility of design inherent in quality selenium products. Typical G-E types are shown in a variety of voltages and cell sizes, finishes and mountings. Many other types to suit individual needs are available on request.



A complete line of low cost miniature selenium rectifier doides are now offered by General Electric. These rectifier diodes are epoxy-encapsulated and exhibit exceptional electrical and mechanical properties.

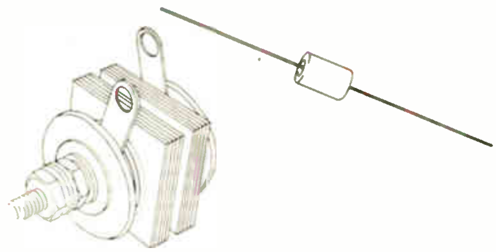
Because of the very high product value of these devices, they offer optimized application opportunities especially in the electronics, consumer appliance, and entertainment markets. Significant merit is obtained in NiCad battery charging, photograph amplifier, motor speed control, lamp dimmer and other circuits.

Three dual diode types are offered as universal replacements for AFC circuits in most TV receivers. The G-E units have proven reliability, with more units in service than any other make. See publication 180.20 for more details.



General Electric offers a full line of miniature cartridge (tubular) rectifier diodes. These rectifier diodes incorporate thin cells which greatly increase function capacity in a given unit size. Up to 31,000 PRV is available in a 7" long cartridge. Metal cap and epoxy sealed end types are available. See SPD Publications 180.50 and 180.51 for complete specifications.

The standard stud intermediate line includes some of the most reliable products in its power range . . . 100 ma to 1 amp, 15 to over 4,000 volts. The cost per watt is particularly attractive.

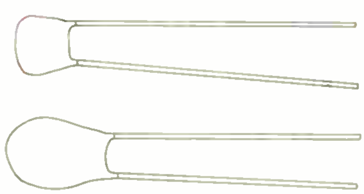


Thyrector diodes have unique capabilities as voltage surge protectors for guarding single crystal rectifier diodes and transistors against damaging voltage transients. The 1 inch square cell series (A) contains twenty sizes (25-500 volt rms). See SPD publications 180.30, 180.35, and 200.5 for complete information. Miniature Thyrector diodes (B) are available in either 15/32" or 5/32" round cells, from 30-600 volts rms. See publications 180.31, 180.36, and 200.5. Large area Thyrector diodes are available using 2" x 2" discs mounted on studs. The maximum peak current for a single pulse is 70 amperes. See Publications 180.32 and 180.37 for complete specifications. (Larger sizes available on special order.)

Selenium Arc Suppressors for direct current circuits are produced by a special variation of General Electric's Vac-U-Sel® process, thus giving them very suitable characteristics for the reduction of transient voltage magnitudes in DC circuits. Available in 5/32" and 15/32" round cell sizes. Maximum dc supply voltage per series blocking cell is 30 volts. See SPD publication 180.40 for complete spec information.

Large plate stacks use cells up to 6" x 10" in size, and are rated to 45 Vrms per cell. The high density capabilities of Vac-U-Sel® rectifier stacks very often enable them to be substituted for cells of much more active area with no sacrifice of life expectancy.

Now available is a new line of low current cartridge (tubular) miniature rectifier diodes. These rectifier diodes have been developed specifically as replacements in some applications for tube rectifiers in television sets and also for use in power supplies for radiation detectors, ignition analyzers, and commercial radar sets. Current ratings go up to 2.5 mA and stacks are available with PRV ratings as high as 20,000 volts.



Transients exist in all low-voltage distribution systems, and originate both inside and outside the system. Without protection, damage is likely to occur to all connected loads; especially semi-conductors, lamps, clock motors, and other electronic devices.

Two (2), miniature, epoxy-encapsulated Thyrector Diodes have been designed specifically for application in household appliances, TV, and radio protection. They provide protection from line-conducted transient voltages having magnitudes as high as 2000 and 3000 volts, respectively. Complete ratings and specifications available in Publication Numbers 180.33 and 180.34. Outline Drawing No. 272.

SOLID STATE CIRCUIT ASSEMBLIES

S100 LINE

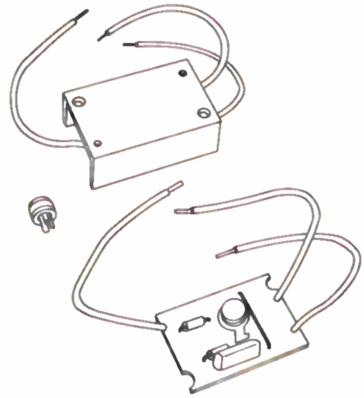
S100 Family: "Off-the-shelf" availability for 6 amp, 10 amp, and 15 amp triac packages. Input is the nominal 115 or 230V (RMS) line.
All of these assemblies feature an electrically isolated heatsink allowing the user to mount it directly to the metal frame of his equipment.
As the titles imply, these circuit variations allow the purchaser a wide variety of uses, including simple voltage control, shade-pole or permanent split capacitor type motor speed control, resistance heating control and many others.

Models		Comments
S100A1	(6A-120V)	Limited range voltage control—no RFI suppression. Suggested for fan motor or universal motor speed control applications.
S100A2	(6A-230V)	
S100A3	(10A-120V)	
S100A4	(10A-230V)	
S100A5	(15A-120V)	
S100A6	(15A-230V)	

Models		Comments
S100B1	(6A-120V)	Extended range voltage control—no RFI suppression. Suggested for resistive heating or lamp dimming control where RFI generation is not a serious problem. Also, useable as motor speed controller.
S100B2	(6A-230V)	
S100B3	(10A-120V)	
S100B4	(10A-230V)	
S100B5	(15A-120V)	
S100B6	(15A-230V)	

Models		Comments
S100C1	(6A-120V)	Extended range voltage control with RFI suppression. Classic incandescent lamp dimmer circuit. Also, useable for motor speed control.
S100C2	(6A-230V)	
S100C3	(10A-120V)	
S100C4	(10A-230V)	
S100C5	(15A-120V)	
S100C6	(15A-230V)	

Models		Comments
S100D1	(6A-120V)	Limited range voltage control with RFI suppression. Plus static switching function. Allows motor to run at full speed or switch to pre-set low speed based on single contact closure. Potential air cooled condenser fan use.
S100D2	(6A-230V)	
S100D3	(10A-120V)	
S100D4	(10A-230V)	
S100D5	(15A-120V)	
S100D6	(15A-230V)	



Models		Comments
S100E1	(6A-120V)	Limited range voltage control with RFI suppression. Also, equipped with second Diac-RL combination to allow minimum speed setting when controlling heater motors by thermistor feed-back.
S100E2	(6A-230V)	
S100E3	(10A-120V)	
S100E4	(10A-230V)	
S100E5	(15A-120V)	
S100E6	(15A-230V)	

Models		Comments
S100F1	(6A-120V)	Limited range voltage control with RFI suppression. Best choice for fan motor speed control.
S100F2	(6A-230V)	
S100F3	(10A-120V)	
S100F4	(10A-230V)	
S100F5	(15A-120V)	
S100F6	(15A-230V)	

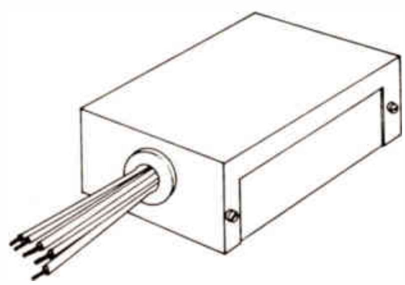
Models		Comments
S100G1	(6A-120V)	Static switching module. Replaces single pole relay. Requires external pair of light duty contracts (100 ma max) to control rated current. Very popular in applications involving high cyclic rate of operations. Use with reed switches.
S100G2	(6A-230V)	
S100G3	(10A-120V)	
S100G4	(10A-230V)	
S100G5	(15A-120V)	
S100G6	(15A-230V)	

For further information on S100 line refer to spec. sheets 155.20 thru 155.26. For prices see Confidential Price List.

S200 LINE—AC POWER CONTROLLERS

General—the S200 line consists of two current ratings (10 & 15 amp) and three voltage ratings (120, 240 & 277 volts RMS). All units have a "Family" appearance (similar to S100) and are all zero voltage switching power controllers. Utilizing PA424 integrated circuit to detect the zero voltage crossings of the supply voltage, these units are capable of controlling temperature in resistive heating applications within 1 to 2°F with practically no RFI being generated. They are particularly useful in process heating applications where RFI could cause erratic operation of other solid state controls. They will find ready use anywhere a resistive heating load is involved which is desired to be controlled by thermistor feedback.

Model	
S200A1	10 amps, 120 volts (RMS)
S200A2	10 amps, 240 volts (RMS)
S200A21	10 amps, 277 volts (RMS)
S200A3	15 amps, 120 volts (RMS)
S200A4	15 amps, 240 volts (RMS)
S200A41	15 amps, 277 volts (RMS)



Comments

Controls resistive loads up to 3600 watts
"Zero-Voltage Switching" lowers RFI
Solid-state long life and high reliability
Operates with a variety of variable resistance sensors
High input impedance allows sensors from 5K to 100K ohms
Control point drift with ambient temperature less than 0.02% of sensor resistance per degree centigrade
See spec. sheets 155.40 for further details.

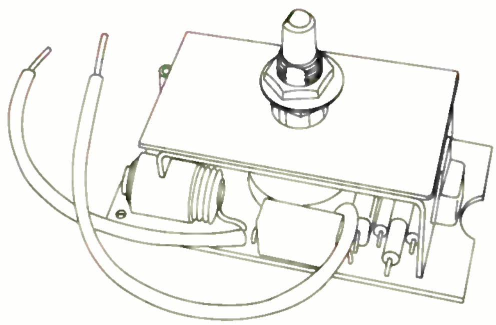
SOLID STATE CIRCUIT ASSEMBLIES (Continued)

S400 LINE

General—Our newest standard line, the S400 is very similar application-wise to the S100 line. It is, however, a **complete** control in that it incorporates its own main control potentiometer and a line switch as well. It will be available in four models, all rated at 5 amps max. at 120V RMS. All units will be mounted on a common printed circuit board and will be equipped with a self-contained heatsink. All units include trim pot to allow minimum output voltage setting. Individual features will be as follows:

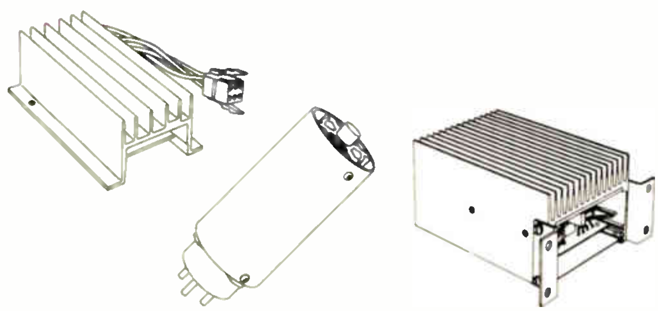
Models		Comments
S400A1	5A-120V	Limited range voltage control. Particularly designed as fan motor speed control. No RFI suppression included. Lowest cost end of line.
S400A1S	5A-120V	Same as S400A1 except with RFI suppression added. Medium prices section of line.
S400A1SC	5A-120V	Same as S400A1S except with line voltage compensation added. Automatically compensates for fluctuations in line voltage (for ± 10% variation in input we can hold ± 3V variation in output). Top of product line.
S400A1SCH	5A-120V	Same as S400A1SC except with high-voltage output limiting trim-potentiometer. Top of product line.

For further information, consult spec. sheet 155.60.

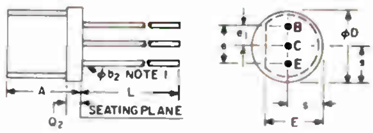


CUSTOMIZED ASSEMBLIES

Complete semiconductor circuit assemblies using discrete components are available in a variety of mechanical configurations, including printed circuit boards, potted modules, standard tube shells and many special packages to meet individual customer needs.
SCR and TRIAC motor speed controls. Solid state replacements for thyratron tubes. Static switching. High voltage rectifier stacks. Molded multiple diode modules for computer logic circuits. Molded SCR and transistor modules for computer and other uses. Temperature controllers. Automatic exposure lamp controls for copying machines, etc. Light activated controls. Static switching functions.



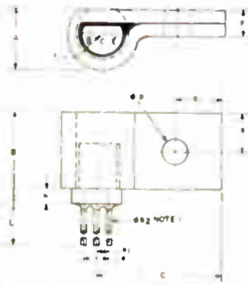
1



SYMBOL	INCHES		MILLIMETERS	
	MIN	MAX.	MIN	MAX
A	.170	.265	4.32	6.73
ϕb2	.016	.019	.406	.483
ϕD	.165	.205	4.19	5.21
E	.110	.155	2.79	3.94
e	.095	.105	2.41	2.67
e1	.045	.055	1.14	1.40
L	.500		12.70	
Q2		.075		1.90
s	.080	.115	2.03	2.92

NOTE 1: LEAD DIAMETER IS CONTROLLED IN THE ZONE BETWEEN .070 AND .250 FROM THE SEATING PLANE. BETWEEN .250 AND END OF LEAD A MAX OF .021 IS HELD.

1.2



SYMBOL	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A		.263		6.68
B		.435		11.04
ϕb2	.016	.019	.407	.482
C		.52[illegible]		13.20
e	.095	.105	2.42	2.66
e1	.045	.055	1.15	1.39
F		.140		3.55
h		.103		2.6
L	.500		12.70	
ϕB		.43		5.63
[illegible]	.156 REF		3.96 REF	
e2	.087 REF		2.2 REF	
[illegible]		.156		3.86

NOTE 1: LEAD DIAMETER IS CONTROLLED IN THE ZONE BETWEEN .070 AND .250 FROM THE SEATING PLANE. BETWEEN .250 AND END OF LEAD A MAX OF .020 IS HELD.

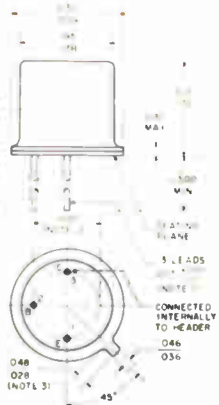
16

DIMENSIONS WITHIN JEDEC OUTLINE TO-18

NOTE 1 [illegible]

NOTE 2 [illegible]

NOTE 3 [illegible]

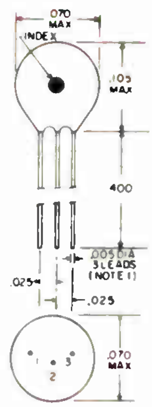


ALL DIMEN IN INCHES AND ARE REFERENCE UNLESS TOLERANCED

18.3

NOTES

1. LEAD DIAMETER IS NOT CONTROLLED WITHIN .020 OF THE BODY



ALL DIMENSIONS ARE IN INCHES AND ARE REFERENCED UNLESS TOLERANCED

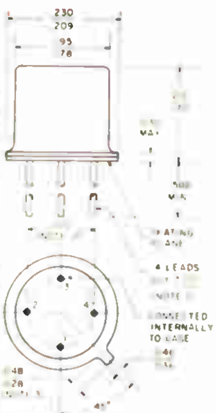
28

DIMENSIONS WITHIN JEDEC OUTLINE TO-18 EXCEPT FOR LEAD CONFIGURATION

NOTE 1 [illegible]

NOTE 2 [illegible]

NOTE 3 [illegible]



ALL DIMEN IN INCHES AND ARE REFERENCE UNLESS TOLERANCED

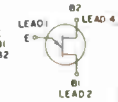
29

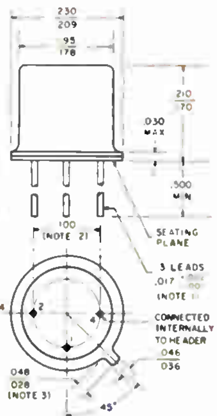
DIMENSIONS WITHIN JEDEC OUTLINE TO-18 EXCEPT FOR LEAD CONFIGURATION

NOTE 1 Lead diameter is controlled in the zone between .050 and .250 from the seating plane. Between .250 and end of lead a max of .021 is held.

NOTE 2 Leads having maximum diameter .019 measured in gaging plane .054 ... .001 ... .001 below the seating plane of the device shall be within .007 of true position relative to a maximum width tab.

NOTE 3 Measured from max diameter of the actual device.





ALL DIMEN IN INCHES AND ARE REFERENCE UNLESS TOLERANCED

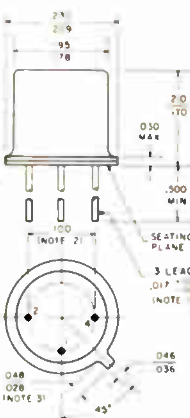
30

DIMENSIONS WITHIN JEDEC OUTLINE TO-18 EXCEPT FOR LEAD CONFIGURATION

NOTE 1 [illegible]

NOTE 2 [illegible]

NOTE 3 [illegible]



ALL DIMEN IN INCHES AND ARE REFERENCE UNLESS TOLERANCED

31

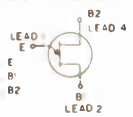
DIMENSIONS WITHIN JEDEC OUTLINE TO-5 EXCEPT FOR LEAD CONFIGURATION

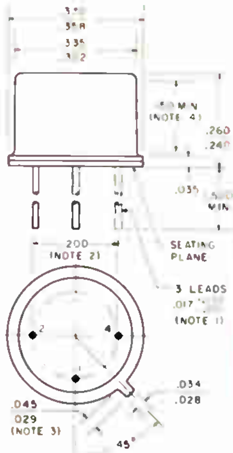
NOTE 1 [illegible]

NOTE 2 [illegible]

NOTE 3 [illegible]

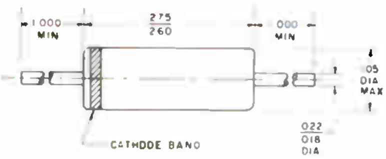
NOTE 4 [illegible]





ALL DIMEN IN INCHES AND ARE REFERENCE UNLESS TOLERANCED

37



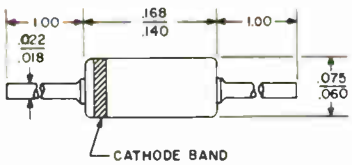
NOTES

1. ALL DIMENSIONS ARE IN INCHES AND ARE REFERENCE UNLESS TOLERANCED
2. LEAD DIAMETER NOT CONTROLLED WITHIN .050" OF THE BODY

OUTLINE DRAWINGS (Continued)

38

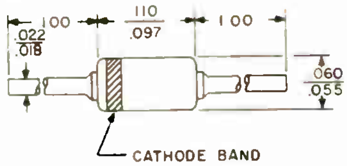
DO-35



NOTES:
1. ALL DIMENSIONS ARE IN INCHES AND ARE REFERENCE UNLESS TOLERANCED.
2. LEAD DIAMETER NOT CONTROLLED WITHIN .050" OF THE BODY.

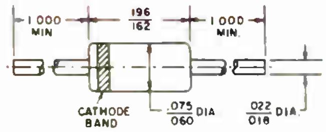
39

DO-34



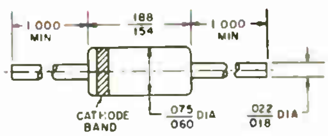
NOTES
1. ALL DIMENTIONS ARE IN INCHES AND ARE REFERENCE UNLESS TOLERANCED
2 LEAD DIAMETER NOT CONTROLLED WITH-IN .050" OF THE BODY.

40



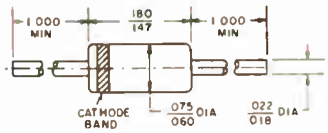
NOTES
1 ALL DIMENSIONS ARE IN INCHES AND ARE REFERENCE UNLESS TOLERANCED
2 LEAD DIAMETER NOT CONTROLLED WITHIN .050" OF THE BODY
3 BODY CONTOUR IS OPTIONAL WITHIN THE DIMENSIONS GIVEN. SLUGS, IF ANY, ARE INCLUDED WITHIN THIS CYLINDER AND ARE NOT SUBJECT TO THE MINIMUM BODY DIAMETER
4 NOMINAL LEAD LENGTH IS 1.250

41



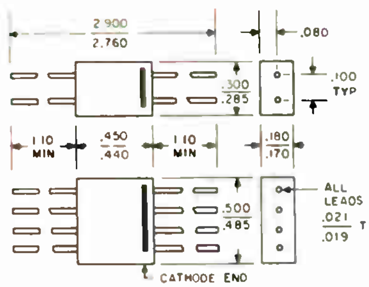
NOTES
1 ALL DIMENSIONS ARE IN INCHES AND ARE REFERENCE UNLESS TOLERANCED
2 LEAD DIAMETER NOT CONTROLLED WITHIN .050" OF THE BODY
3 BODY CONTOUR IS OPTIONAL WITHIN THE DIMENSIONS GIVEN. SLUGS, IF ANY, ARE INCLUDED WITHIN THIS CYLINDER AND ARE NOT SUBJECT TO THE MINIMUM BODY DIAMETER
4 NOMINAL LEAD LENGTH IS 1.250

42



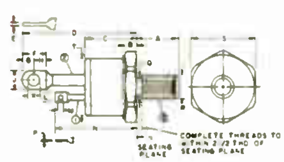
NOTES
1 ALL DIMENSIONS ARE IN INCHES AND ARE REFERENCE UNLESS TOLERANCED
2 LEAD DIAMETER NOT CONTROLLED WITHIN .050" OF THE BODY
3 BODY CONTOUR IS OPTIONAL WITHIN THE DIMENSIONS GIVEN. SLUGS, IF ANY, ARE INCLUDED WITHIN THIS CYLINDER AND ARE NOT SUBJECT TO THE MINIMUM BODY DIAMETER
4 NOMINAL LEAD LENGTH IS 1.250

43



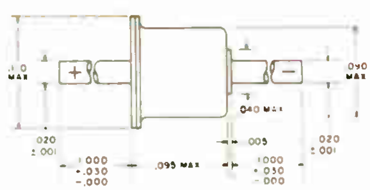
ALL DIMEN IN INCHES AND ARE REFERENCE UNLESS TOLERANCED

45



SYM	INCHES		METRIC MM	
	MIN	MAX	MIN	MAX
A	422	45[illegible]	10 72	11 4[illegible]
B	120	[illegible]	[illegible]	3 42
C	534	[illegible]	[illegible]	4 34
D	190	[illegible]	[illegible]	[illegible] 74
E	033	047	[illegible]	1 18
F	280	REF	[illegible]	REF
G	130	REF	3 [illegible]	REF
H	120	—	3 05	—
J	200	260	5 09	6 55
K	129	142	3 28	3 60
L	090	115	2 29	2 91
M	055	066	1 40	1 67
N	.831	901	21 11	22 88
P	012	—	31	—
Q	220	—	5 59	—
S	676	684	17 18	17 36
T	—	597	—	15.15

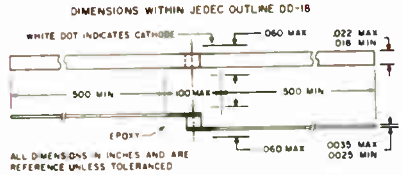
47



ALL DIMEN IN INCHES AND ARE REFERENCE UNLESS TOLERANCED

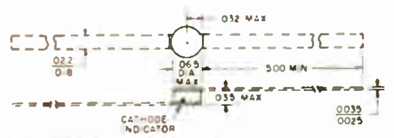
48

DIMENSIONS WITHIN JEDEC OUTLINE DO-18



ALL DIMENSIONS IN INCHES AND ARE REFERENCE UNLESS TOLERANCED

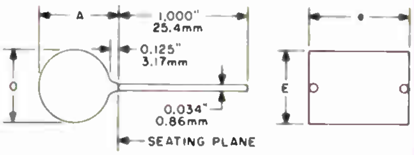
49



1 ALL DIMENSIONS ARE IN INCHES AND REFERENCE UNLESS TOLERANCED
2 UNIT WILL BE SUPPLIED WITH LEADS WHEN SPECIFIED. WHEN LEADS ARE SUPPLIED, THE DIMENSIONS ARE WITHIN JEDEC DO-20 OUTLINE

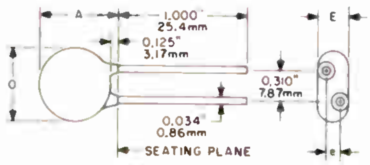
OUTLINE DRAWINGS (Continued)

50



Model	A MAX In	A MAX MM	D MAX In	D MAX MM	E MAX In	E MAX MM	e1 MAX In	e1 MAX MM
V420LB20	745	[illegible]	620	15.74	[illegible]	10.03	345	8.76
V420LB40	745	18.92	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	9.39
V460LB20	745	18.92	[illegible]	15.74	[illegible]	[illegible]	345	8.76
V460LB40	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
V480LB20	[illegible]	[illegible]	620	[illegible]	[illegible]	[illegible]	345	[illegible]
V480LB40	745	18.92	[illegible]	15.74	[illegible]	[illegible]	345	[illegible]
V480LB80	[illegible]	25.52	[illegible]	22.35	395	[illegible]	370	[illegible]
V510LB20	745	18.92	620	15.74	395	10.03	345	8.76
V510LB40	745	18.92	620	15.74	395	10.03	345	8.76
V510LB80	1.005	25.52	[illegible]	22.35	395	10.03	[illegible]	[illegible]
V1000LB80	745	18.92	620	15.74	700	17.78	[illegible]	[illegible]
V1000LB160	[illegible]	25.52	[illegible]	22.35	750	19.05	[illegible]	[illegible]

51

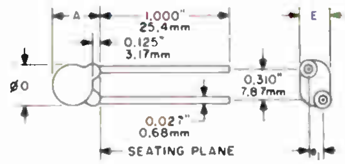


Model	A In	A MM	D In	D MM	E In	E MM	e1 In	e1 MM
V130LA10	745	[illegible]	[illegible]	[illegible]	[illegible]	5.84	110	2.79
V130LA20	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	5.84	170	4.31
V150LA10	745	18.92	620	15.74	230	5.84	110	2.79
V150LA20	1.005	25.52	880	22.35	230	5.84	170	4.31
V250LA15	745	18.92	620	15.74	[illegible]	7.36	170	4.31
V250LA20	745	18.92	620	15.74	[illegible]	7.36	170	[illegible]
V250LA40	1.005	25.52	880	22.35	[illegible]	7.36	180	4.57

NOTE

1) [illegible]

52



Model	A MAX In	A MAX MM	D MAX In.	D MAX MM	E MAX In	E MAX MM	e1 MAX In	e1 MAX MM
V130LA1	460	11.68	335	8.50	190	4.82	100	2.54
V130LA2	460	11.68	335	8.50	190	4.82	100	2.54
V150LA1	460	11.68	335	8.50	190	4.82	100	2.54
V150LA2	460	11.68	335	8.50	190	4.82	100	2.54
V250LA2	460	11.68	335	8.50	250	6.35	155	3.94
V250LA4	460	11.68	335	8.50	250	6.35	155	3.94

NOTE

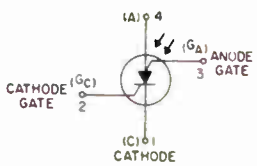
1) Lead spacing dimensions as measured within 0.050 inches (1.27 mm) of seating plane

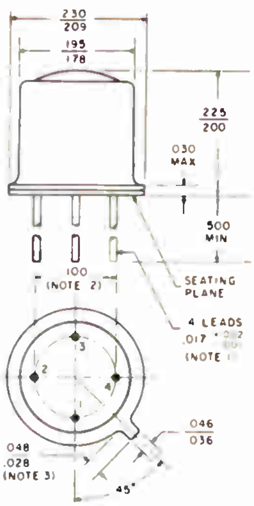
53

NOTE 1 Lead diameter is controlled in the zone between .050 and .250 from the seating plane. Between .250 and end of lead a max. of .021 is held.

NOTE 2 Leads having maximum diameter (.019) measured in gaging plane .054 + .001 − .000 below the seating plane of the device shall be within .007 of true position relative to a maximum width tab.

NOTE 3 Measured from max. diameter of the actual device.





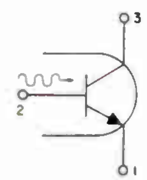
ALL DIMEN. IN INCHES AND ARE REFERENCE UNLESS TOLERANCED

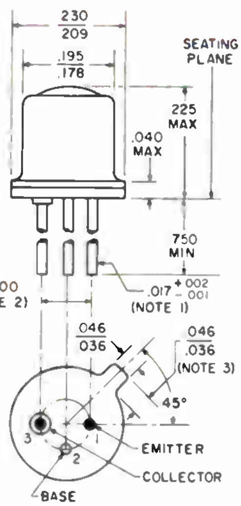
54,54 A

NOTE 1: Lead diameter is controlled in the zone between .050 and .250 from the seating plane. Between .250 and end of lead a max. of .021 is held.

NOTE 2: Leads having maximum diameter (.019) measured in gaging plane .054 + .001 − .000 below the seating plane of the device shall be within .007 of true position relative to a maximum width tab.

NOTE 3: Measured from max. diameter of the actual device.

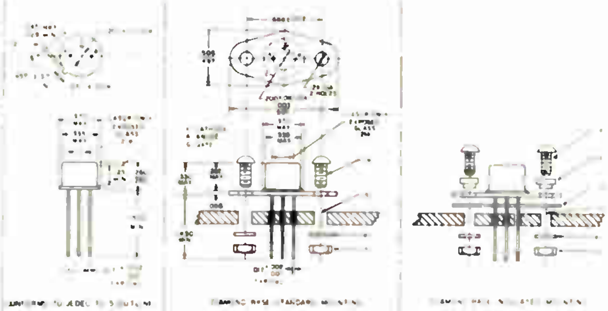




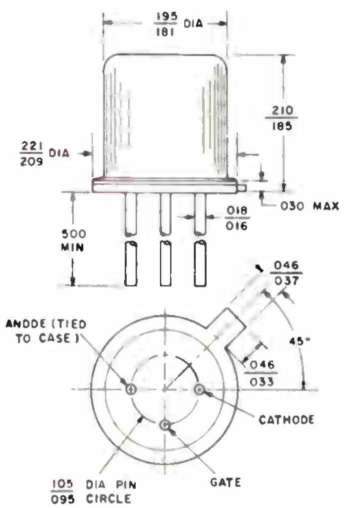
ALL DIMEN. IN INCHES AND ARE REFERENCE UNLESS TOLERANCED.

101

102

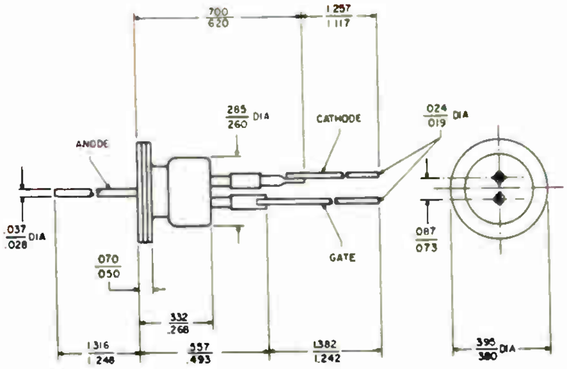


102.1

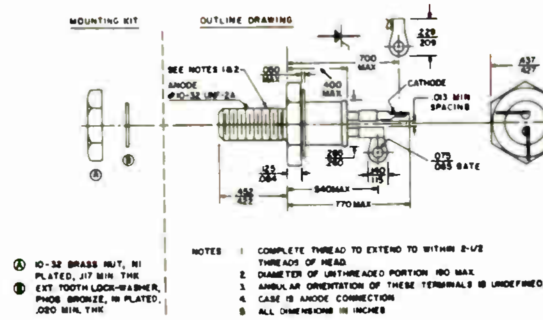


OUTLINE DRAWINGS (Continued)

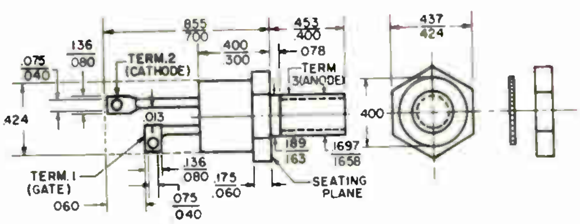
103



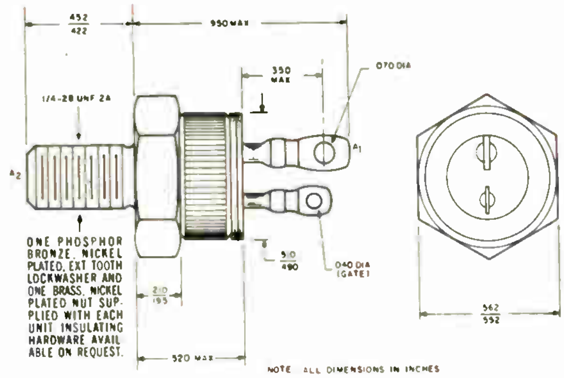
104



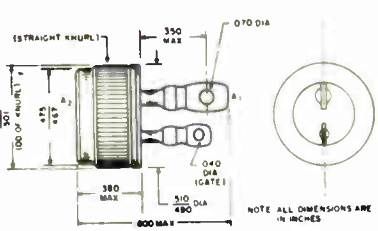
104.1



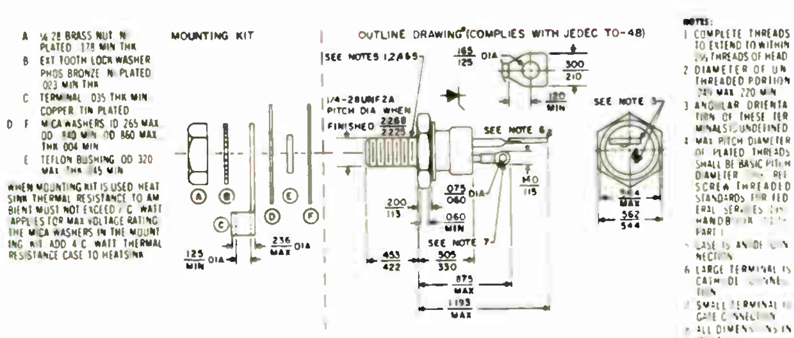
105



106



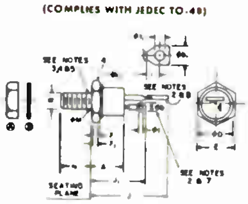
107



OUTLINE DRAWINGS (Continued)

107.1

NOTES:

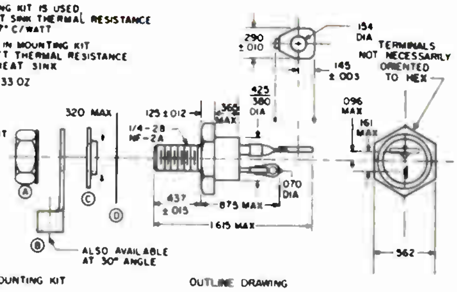


SYMBOL	INCHES MIN	INCHES MAX	MILLIMETERS MIN	MILLIMETERS MAX	NOTES
A	.330	.505	8.38	12.82	
φD	[illegible]	.140	2.02	3.56	2
φD1	[illegible]	[illegible]	5.33	7.62	2
φD2		[illegible]		12.82	
E	.544	.560	13.82	[illegible]	
F	.113	[illegible]	[illegible]	5.08	[illegible]
F1	.060				
J		[illegible]		[illegible]	
J1		.875		22.23	
L	[illegible]		[illegible]		
φM					[illegible]
N	.422	[illegible]	[illegible]	[illegible]	
φT	.060	[illegible]	[illegible]	[illegible]	
φW	[illegible]	[illegible]	[illegible]	[illegible]	
[illegible]					[illegible]

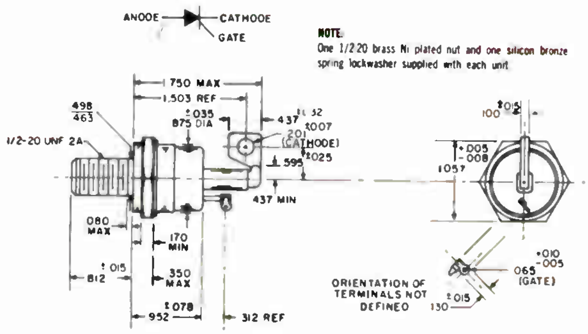
107.2

NOTES: (1) STUD IS ANODE CONNECTION
(2) WHEN MOUNTING KIT IS USED, MAXIMUM HEAT SINK THERMAL RESISTANCE TO AMBIENT • 7° C/WATT
(3) MICA WASHER IN MOUNTING KIT ADDS 4°C/WATT THERMAL RESISTANCE JUNCTION TO HEAT SINK
(4) NET WEIGHT 33 OZ

Ⓐ 1/4-28 BRASS KEP NUT CADMIUM PLATED
Ⓑ TERMINAL .040 THK COPPER, TIN PLATED
Ⓒ TEFLON WASHER .025 WALL THK .032 SHOULDER THK
Ⓓ MICA WASHER .005 THK



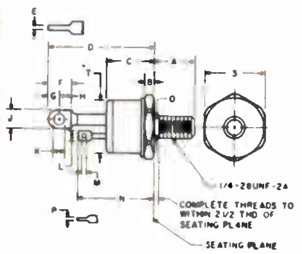
108



NOTE:
One 1/2-20 brass Ni plated nut and one silicon bronze spring lockwasher supplied with each unit

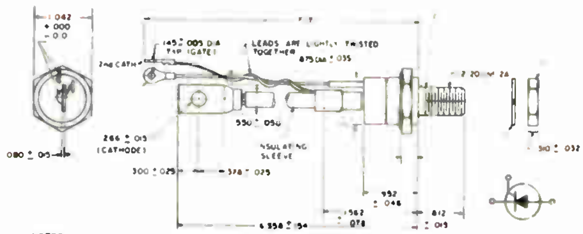
108.1

OUTLINE DRAWING



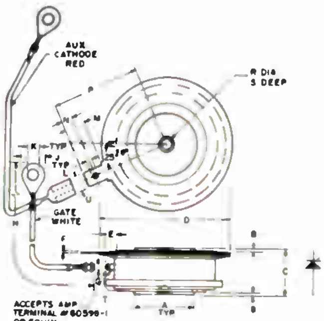
SYM.	INCHES MIN	INCHES MAX	METRIC MIN	METRIC MAX
A	.422	.452	10.72	11.47
B	.120	.135	3.05	3.42
C	.534	.565	13.57	14.34
D	1.190	1.250	30.23	21.74
E	.029	.062	.74	1.58
F	.218	—	5.53	—
G	.118	—	2.99	—
H	.096	—	2.42	—
J	.200	.260	5.08	6.60
K	.129	.142	3.28	3.60
L	.090	.118	2.29	2.81
M	.056	.066	1.40	1.67
N	.831	.901	21.11	22.88
P	.012	—	.31	—
Q	.220	—	5.59	—
S	.678	.684	17.10	17.38
T	—	.597	—	15.15

109



NOTES
1 COMPLETE THREADS TO EXTEND TO WITHIN 2 1/2 THREADS OF HEAD
2 ANGULAR ORGANIZATION OF THESE TERMINALS IS UNDEFINED
3 LEAD COVERED WITH SILICON RUBBER INSULATION (CLASS H) 600 VOLT ASTM STANDARD WALL
4 APPROX. WEIGHT 4 OZS
5 CONFORMS TO JEDEC TO-49 OUTLINE

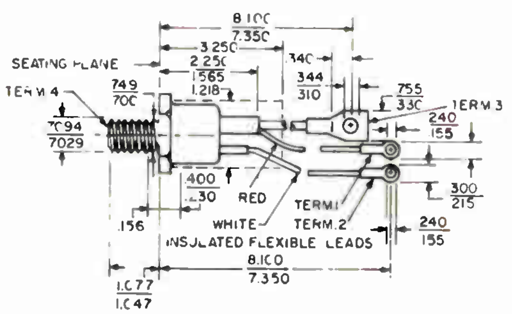
109.1



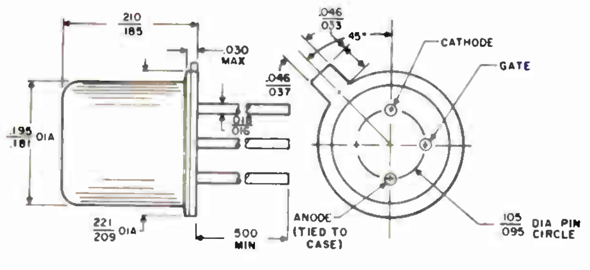
ACCEPTS AMP TERMINAL #60598-1 OR EQUIV
H - STRAIGHT LEAD LENGTH, TYP 2 LEADS
T - SURFACE CREEPAGE

SYM	DECIMAL INCHES MIN	DECIMAL INCHES MAX	METRIC MM MIN	METRIC MM MAX
A	744	.732	18.897	19.101
B	030	060	.762	1.524
C	515	563	13 081	14.381
D	1 600	1 656	40 64	42 08
E	110	—	2 794	—
F	013	017	.330	432
G	057	.059	1.447	1.449
H	7 600	8 000	183 03	203.18
J	—	300	—	7620
K	.137	153	3 479	3 886
L	063	070	1 651	1 778
M	243	260	6 223	6 604
N	120	140	3 048	3 556
P	1 090	1 128	27 69	28 55
R	135	.145	3 429	3 683
S	067	083	1 701	2 108
T	340	—	8 636	—
	188	.189	4 724	4.801

110, 110.1

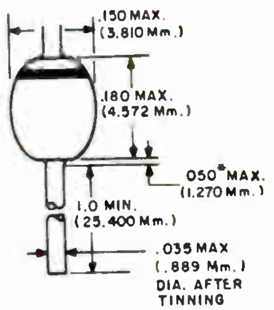


112



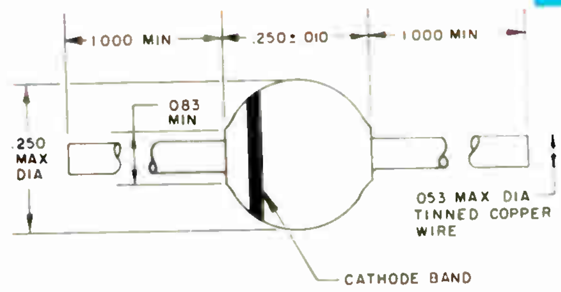
OUTLINE DRAWINGS (Continued)

119



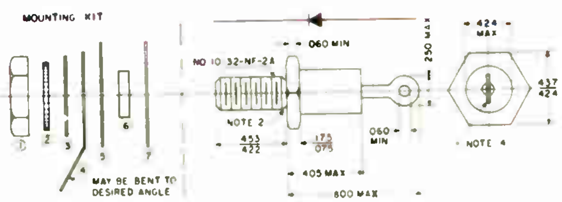
ALL DIMENTIONS ARE IN INCHES AND (METRIC)
*WELD AND SOLDER FLASH NOT CONTROLLED IN THIS AREA

119.2



NOTES:
1. ALL DIMENSIONS ARE IN INCHES AND ARE REFERENCE UNLESS TOLERANCED
2. LEAD DIAMETER IS NOT CONTROLLED WITHIN .060 OF BODY

120

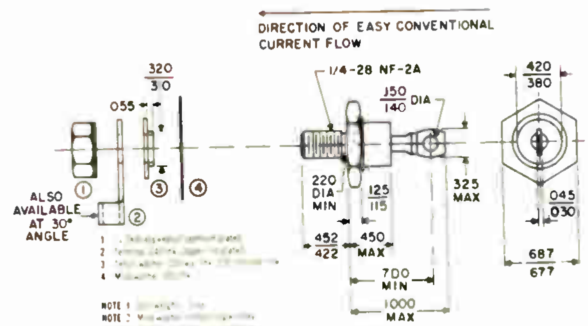


1 10 32 BRASS NI PL HEX NUT
2 LOCK WASHER (EXT) STEEL NI PL
3 FLAT WASHER .? O D .004 THK
4 TERMINAL .010 THK COPPER TIN PL
5 MICA WASHER .005 THK
6 TEFLON WASHER .032 WALL THK
7 MICA WASHER .005 THK

NOTES:
1 UNIT MUST NOT BE DAMAGED BY TORQUE OF 15 IN LB APPLIED TO 10 32 NF 2B NUT ASSEMBLED ON THREAD
2 DIA OF UNTHREADED PORTION .189 MAX AND .169 MIN
3 COMPLETE THREADS TO EXTEND TO WITHIN 2½ THREADS OF HEAD
4 ANGULAR ORIENTATION ON THIS TERMINAL IS UNDEFINED
5 MAXIMUM PITCH DIAMETER OF PLATED THREADS SHALL BE BASIC PITCH DIAMETER .1697 REFERENCE SCREW THREAD STANDARD FOR FEDERAL SERVICES 1957 HANDBOOK H28 1957 PI

COMPLIES WITH EIA REGISTERED OUTLINE DO 4
APPROX WEIGHT = .15 OZ

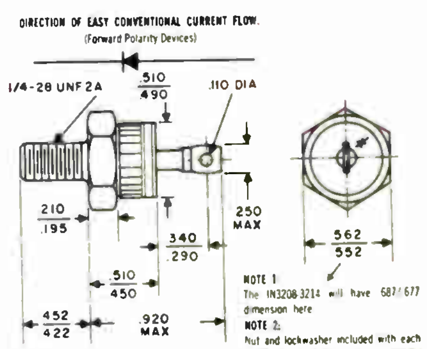
123



1
2
3
4

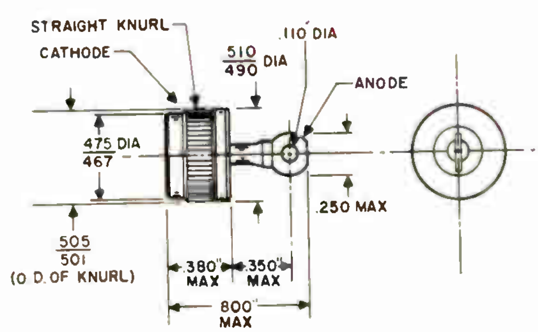
NOTE 1
NOTE 2

125

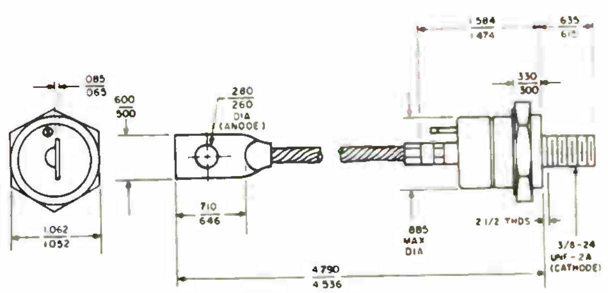


NOTE 1
The 1N3208-3214 will have .687/.677 dimension here
NOTE 2:
Nut and lockwasher included with each rectifier. Insulating hardware available on request

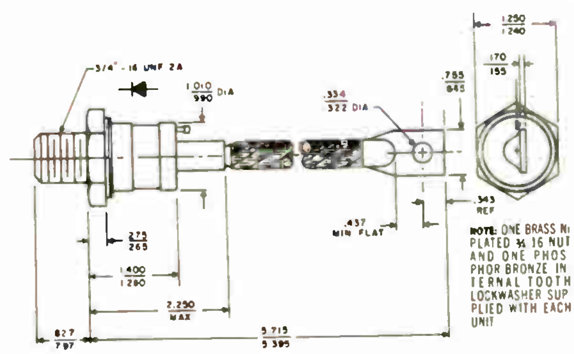
126



127



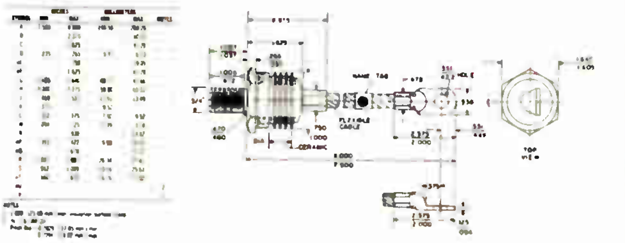
128



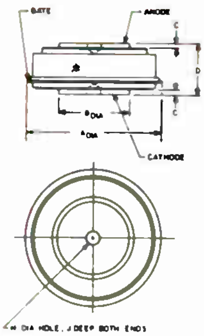
NOTE: ONE BRASS Ni PLATED ¾ 16 NUT AND ONE PHOSPHOR BRONZE INTERNAL TOOTH LOCKWASHER SUPPLIED WITH EACH UNIT

OUTLINE DRAWINGS (Continued)

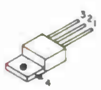
129



154

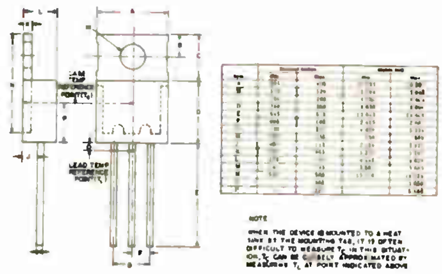


173.1

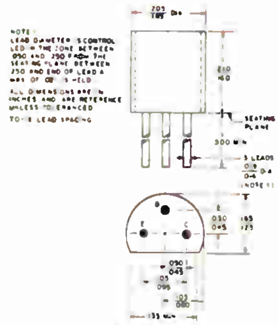


TERMINAL ARRANGEMENT

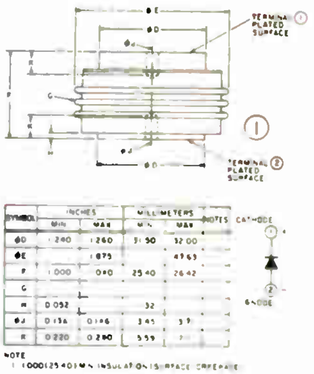
1. CATHODE
2. ANODE
3. GATE
4. MOUNTING TAB (ELECTRICALLY COMMON TO ANODE)



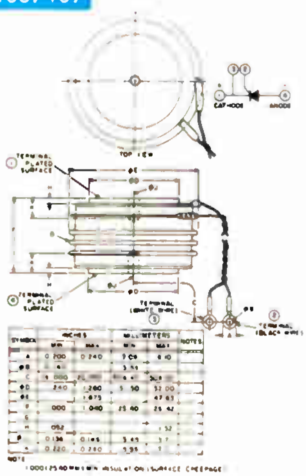
175



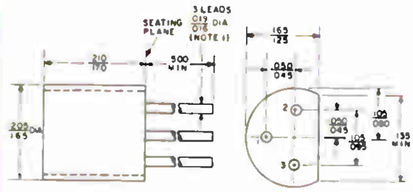
182



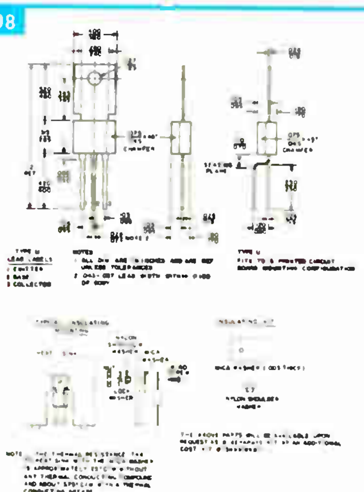
185, 186, 187



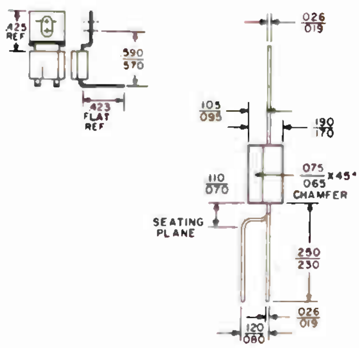
195.1



198



199



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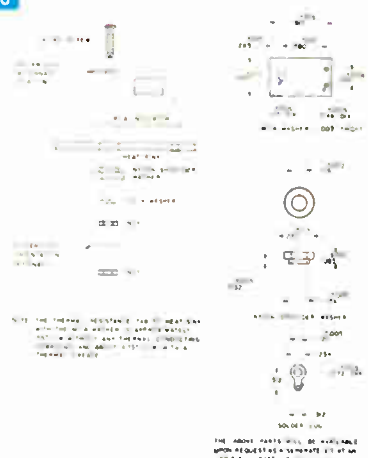
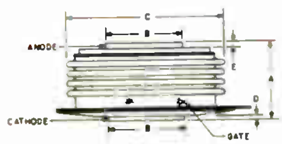


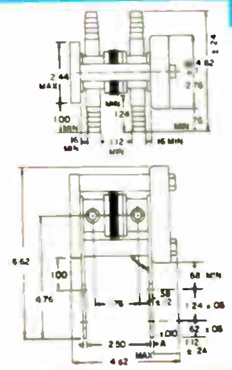
OUTLINE DRAWINGS (Continued)

201

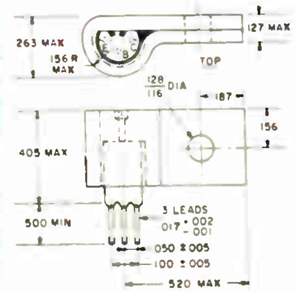


	DECIMAL (INCHES)		METRIC (MM)	
	MIN	MAX	MIN	MAX
A	1 026	1 065	26 04	27 05
B	1 043	1 057	26 49	26 85
C	—	2 100	—	63 44
D	020	105	508	2.67
E	.030	096	762	2 44

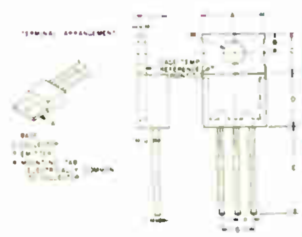
217



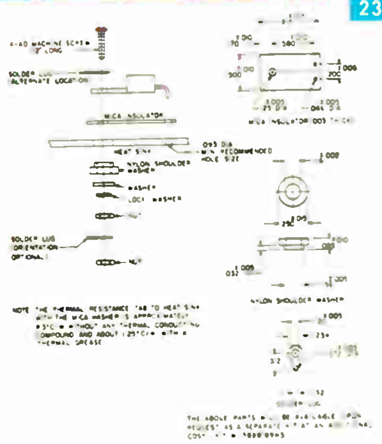
228



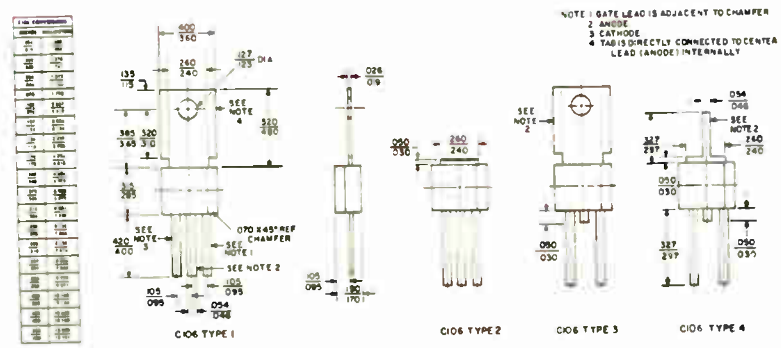
229



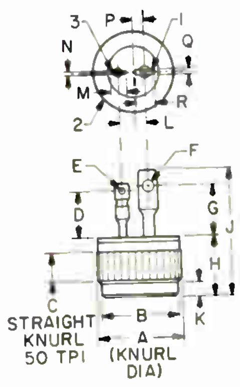
230



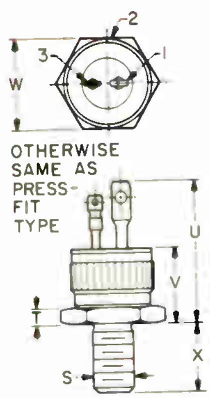
232



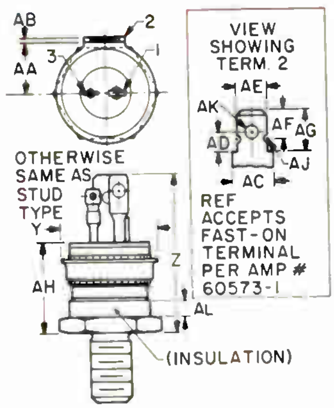
241



242



243



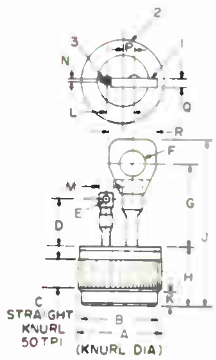
SYM	DECIMAL (INCHES)		METRIC (MM)	
	MIN	MAX	MIN	MAX
A	501	505	12 73	12 83
B	.467	475	11 86	12 07
C	.177 REF		4 50 REF	
D	.260	301	6 60	7 65
E	035	045	89	1 14
F	065	075	1 65	1 41
G		.350		8 89
H	340	376	8 64	9 55
J		.782		19 86
K	083	097	2 11	2 46
L	.130	.180	3.30	4.57
M	.085	115	2 16	2.92

SYM	DECIMAL (INCHES)		METRIC (MM)	
	MIN	MAX	MIN	MAX
N	016	023	41	58
P	.065 REF.		1.65 REF.	
Q	028	035	71	89
R	110	135	2 79	3 43
S	1/4-28 UNF2A		1/4-28 UNF2A	
T	086	098	2 18	2 49
U		865		21 79
V		475		12 07
W	552	562	14 02	14 27
X	432	442	10 97	11 23
Y	580	610	14 73	15 49

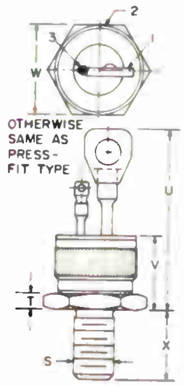
SYM	DECIMAL (INCHES)		METRIC (MM)	
	MIN	MAX	MIN	MAX
Z		975		24 77
AA	290	330	7 37	8 38
AB	017	024	43	61
AC	235	265	5 97	6 73
AD	115	121	2 29	3 07
AE	186	189	4 72	4 80
AF	170 REF		4 32 REF	
AG	.245	255	6 22	6 48
AH		585		14 86
AJ	025	R-REF	64	R-REF
AK	065	.070	1 65	1 78
AL	.100	110	2 54	2.79

OUTLINE DRAWINGS (Continued)

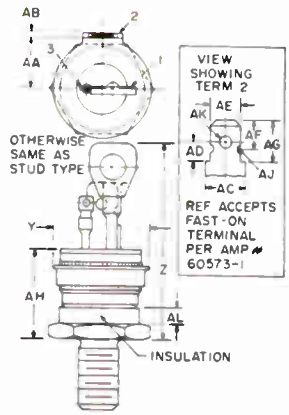
256



257



258

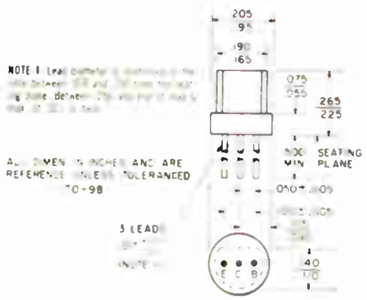


SYM	DECIMAL (INCHES)		METRIC (MM)	
	MIN	MAX	MIN	MAX
A	501	505	12 73	12 83
B	467	475	11 86	12 07
C	177 REF		4 50 REF	
D	260	301	6 60	7 65
E	035	045	89	1 14
F	145	160	3 683	4 064
G	480 – REF		12 19 – REF	
H	340	376	8 64	9.55
J		1 064		27025
K	083	097	2 11	2 46
L	130	180	3 30	4 57
M	085	115	2 16	2 92

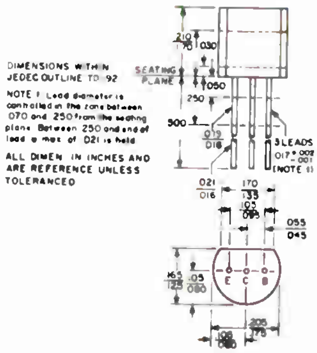
SYM	DECIMAL (INCHES)		METRIC (MM)	
	MIN	MAX	MIN	MAX
N	016	023	41	58
P	065 REF		1 65 REF	
Q	044	062	1 117	1 575
R	284	302	7 213	7 671
S	1/4-28 UNF2A		1/4-28 UNF2A	
T	086	098	2 18	2 49
U		1.150		29.210
V		475		12 07
W	552	562	14 02	14 27
X	432	442	10.97	11 23
Y	580	610	14 73	15 49

SYM	DECIMAL (INCHES)		METRIC (MM)	
	MIN	MAX	MIN	MAX
Z		1 260		32 00
AA	290	330	7 37	8 38
AB	017	024	43	61
AC	235	265	5 97	6 73
AD	.115	121	2.29	3 07
AE	186	189	4 72	4 80
AF	170 REF		4 32 REF	
AG	245	255	6 22	6 48
AH		585		14 86
AJ	025 R-REF		64 R-REF	
AK	065	070	1 65	1 78
AL	.100	.110	2 54	2.79

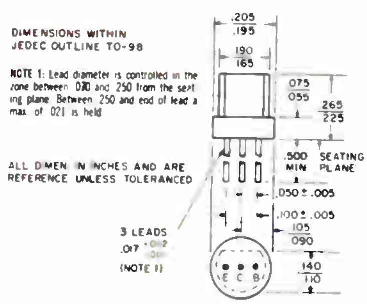
262



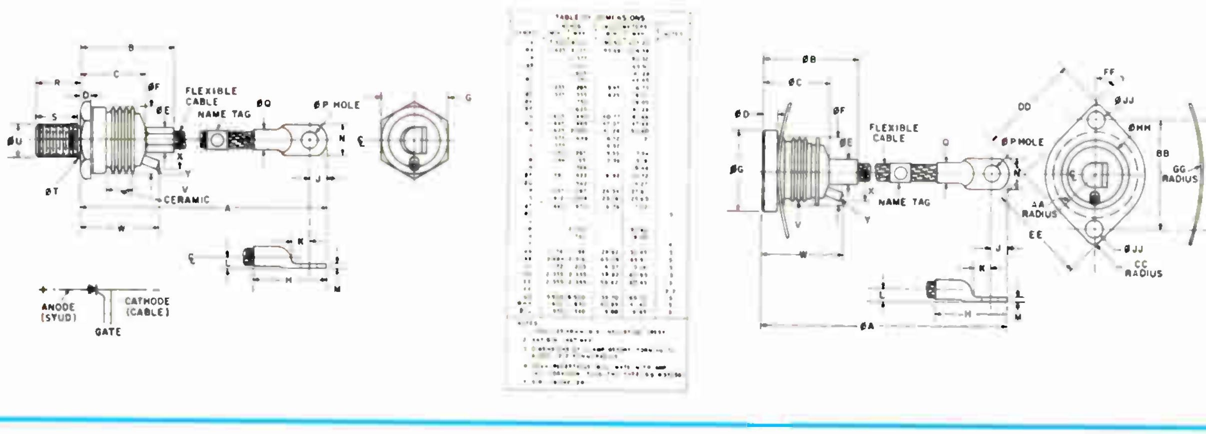
263



264

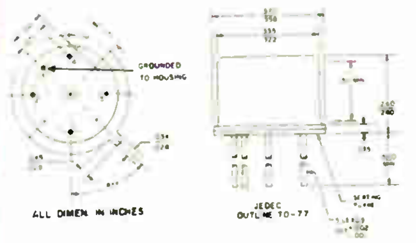


267

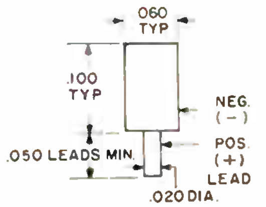


OUTLINE DRAWINGS (Continued)

268



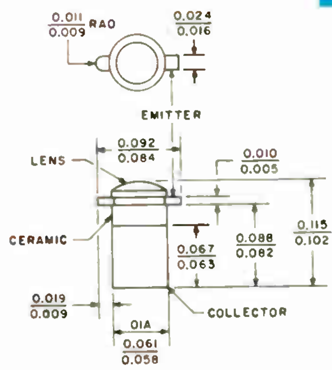
269



MECHANICAL SPECIFICATIONS

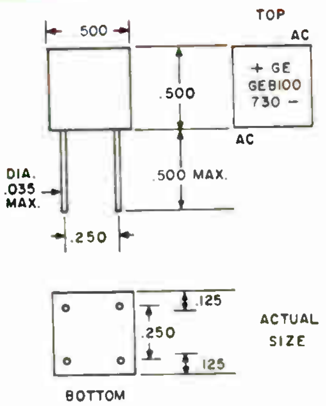
Max. Overall Length – .100 in. (excluding leads)
Max. Diam. – .060 in.
Lead: .019 – .021 in diam. .050 in. length minimum

270

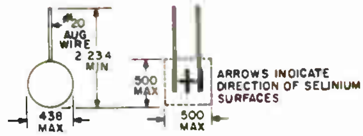


ALL DIMENSIONS ARE IN INCHES

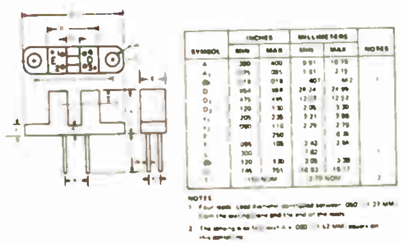
271



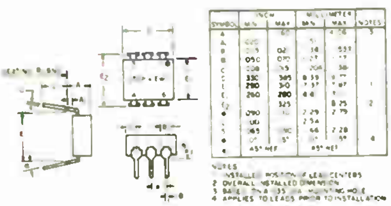
272



273



274



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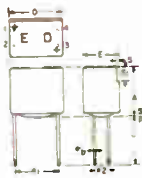

SYMBOL	INCHES MIN	INCHES MAX	MILLIMETERS MIN	MILLIMETERS MAX	NOTES
A		.350		8.89	
φb	.016	.019	.407	.482	
D		.375		9.52	
e1	.285	.315	7.24	8.00	
e2	.090	.110	2.29	2.79	
E		.250		6.35	
L	.300		7.62		
S	.010	.020	.26	.50	
S1	.085	.105	2.16	2.66	

NOTES
1. FOUR LEADS. LEAD DIAMETER CONTROLLED BETWEEN .050" (1.27 MM) FROM THE SEATING PLANE AND THE END OF THE LEADS.

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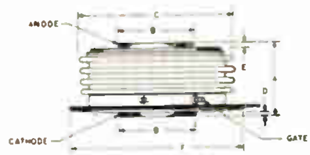

	DECIMAL (INCHES)		METRIC (MM)	
	MIN	MAX	MIN	MAX
A	1.025	1.065	26.04	27.05
B	1.330	1.350	33.78	34.29
C	–	2.100	–	53.44
D	.020	.105	.508	2.67
E	.030	.096	.762	2.44
F	–	2.280	–	57.90

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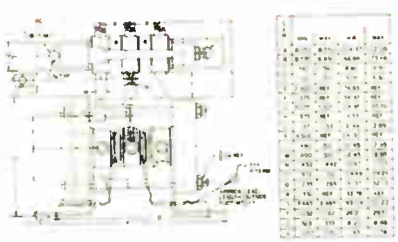

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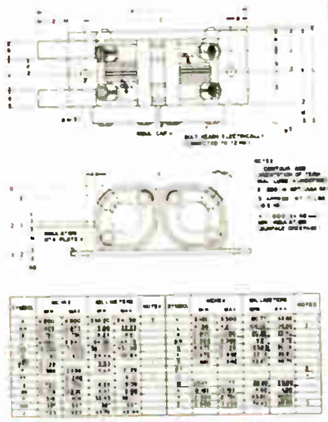

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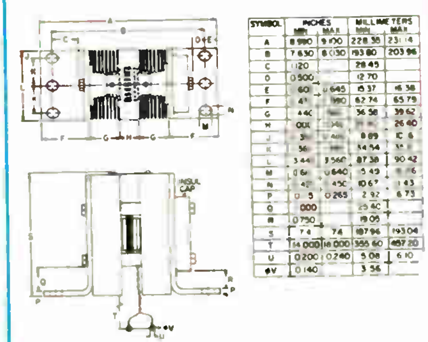

OUTLINE DRAWINGS (Continued)

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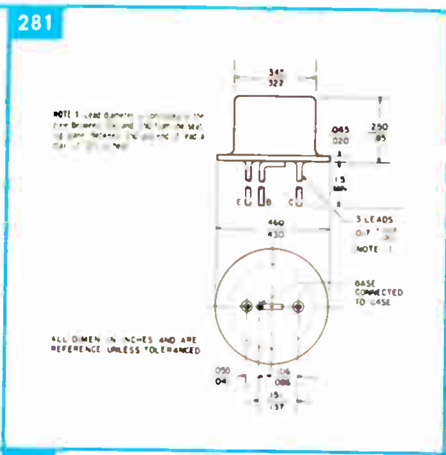

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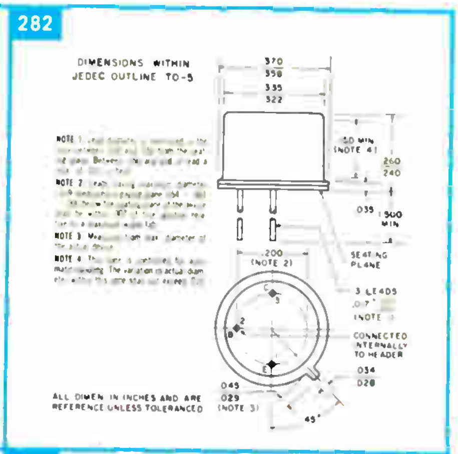

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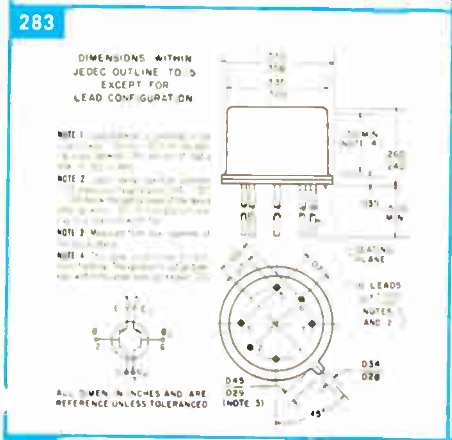

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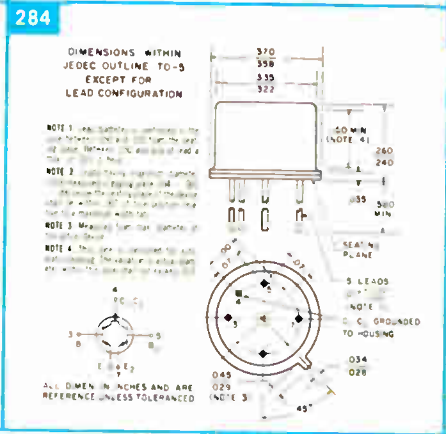

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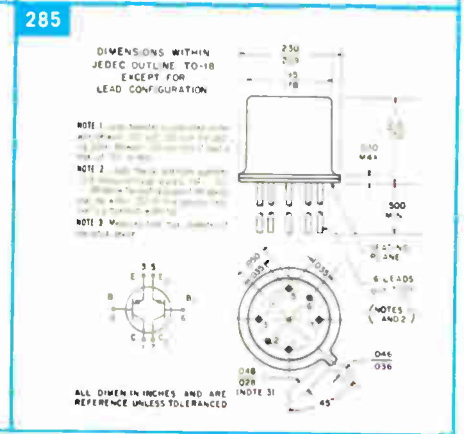

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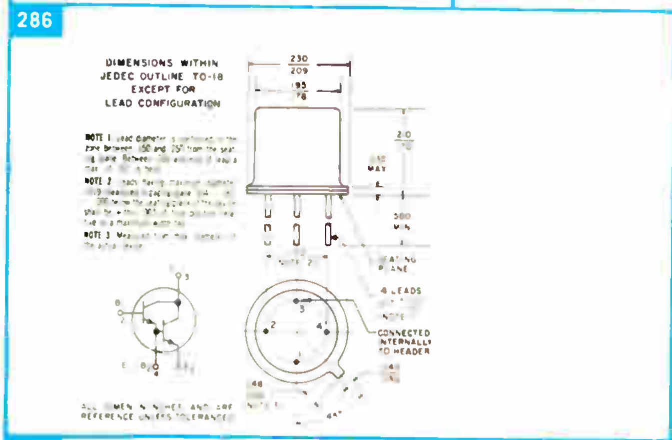

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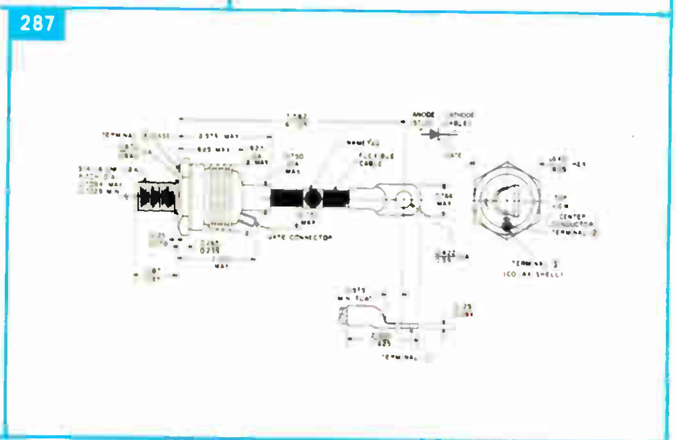

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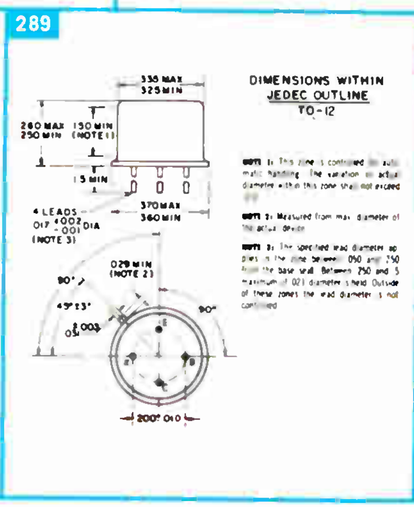

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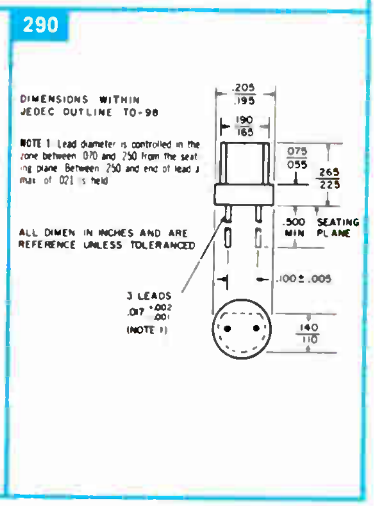

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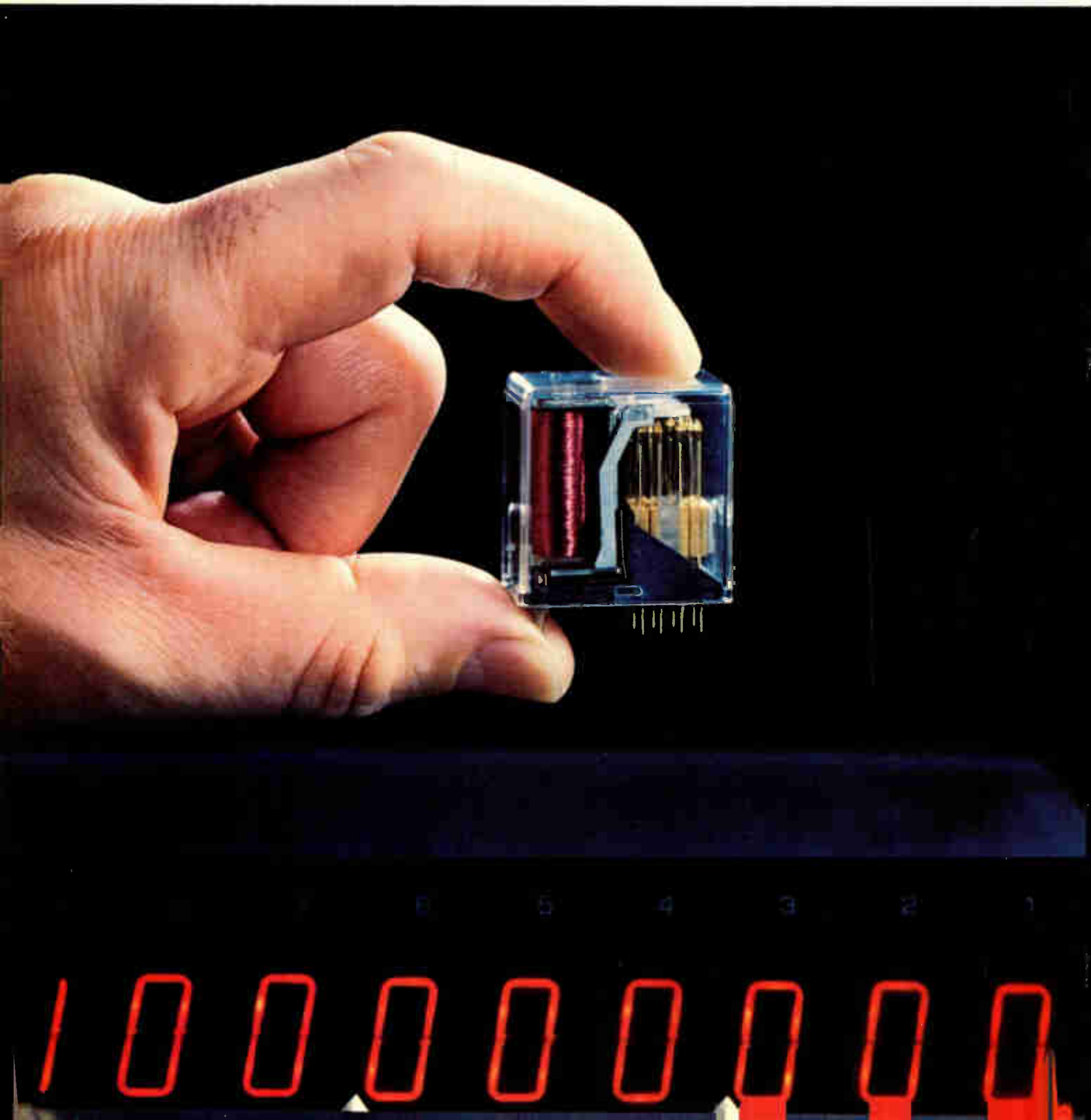

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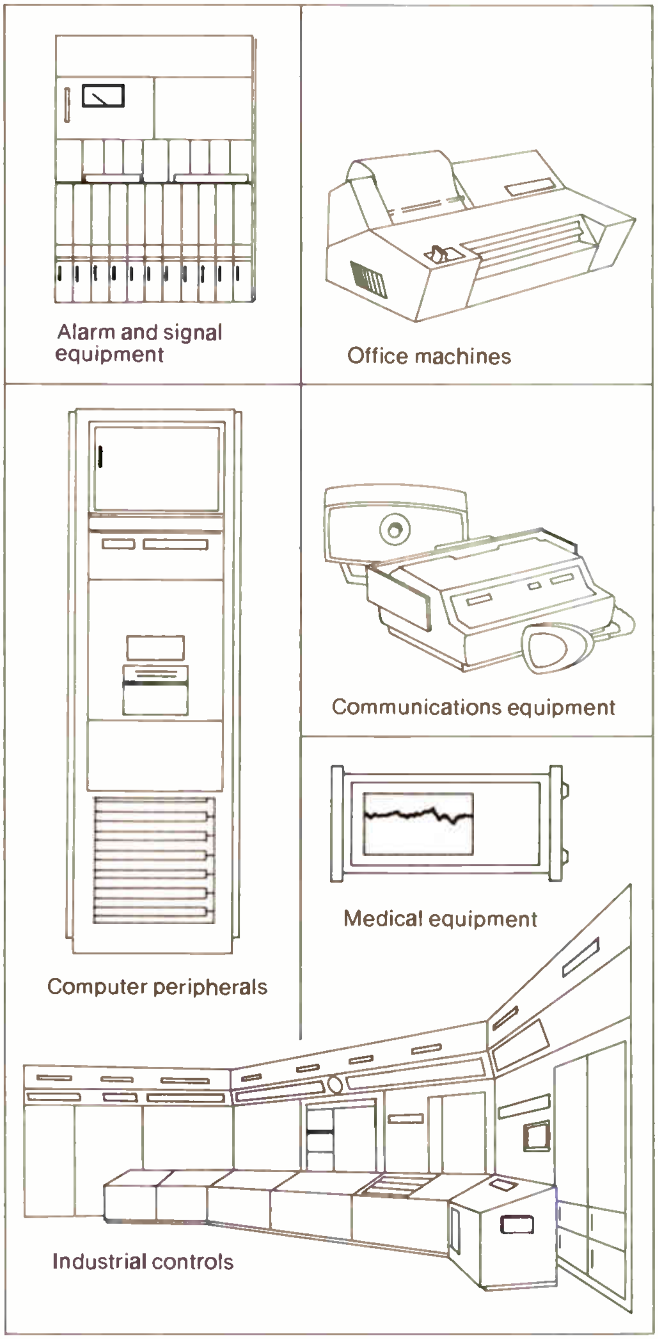

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Aerospace and Electronic Systems (Wincon): IEEE, Sheraton, U. of Pa., Philadelphia, Feb. 13–15.

IEEE International Convention (Intercon): IEEE, Coliseum and New York Hilton, March 26–29.

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Southwestern IEEE Conference and Exhibition (Swieeeco): IEEE, Houston, Texas, April 4–6.

International Symposium on Circuit Theory: IEEE, Four Seasons Sheraton, Toronto, Canada, April 9–11.

International Magnetics Conference (Intermag): IEEE, Washington Hilton Hotel, Washington, D.C., April 24–27.

Carnahan Conference on Electronic Crime Countermeasures: IEEE, U. of Kentucky, Carnahan House, Lexington, Ky., April 25–27.

Electron Device Techniques Conference: IEEE, United Engineering Center, New York, May 1–2.

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Naecon: IEEE, Sheraton, Dayton, Ohio, May 14–16.

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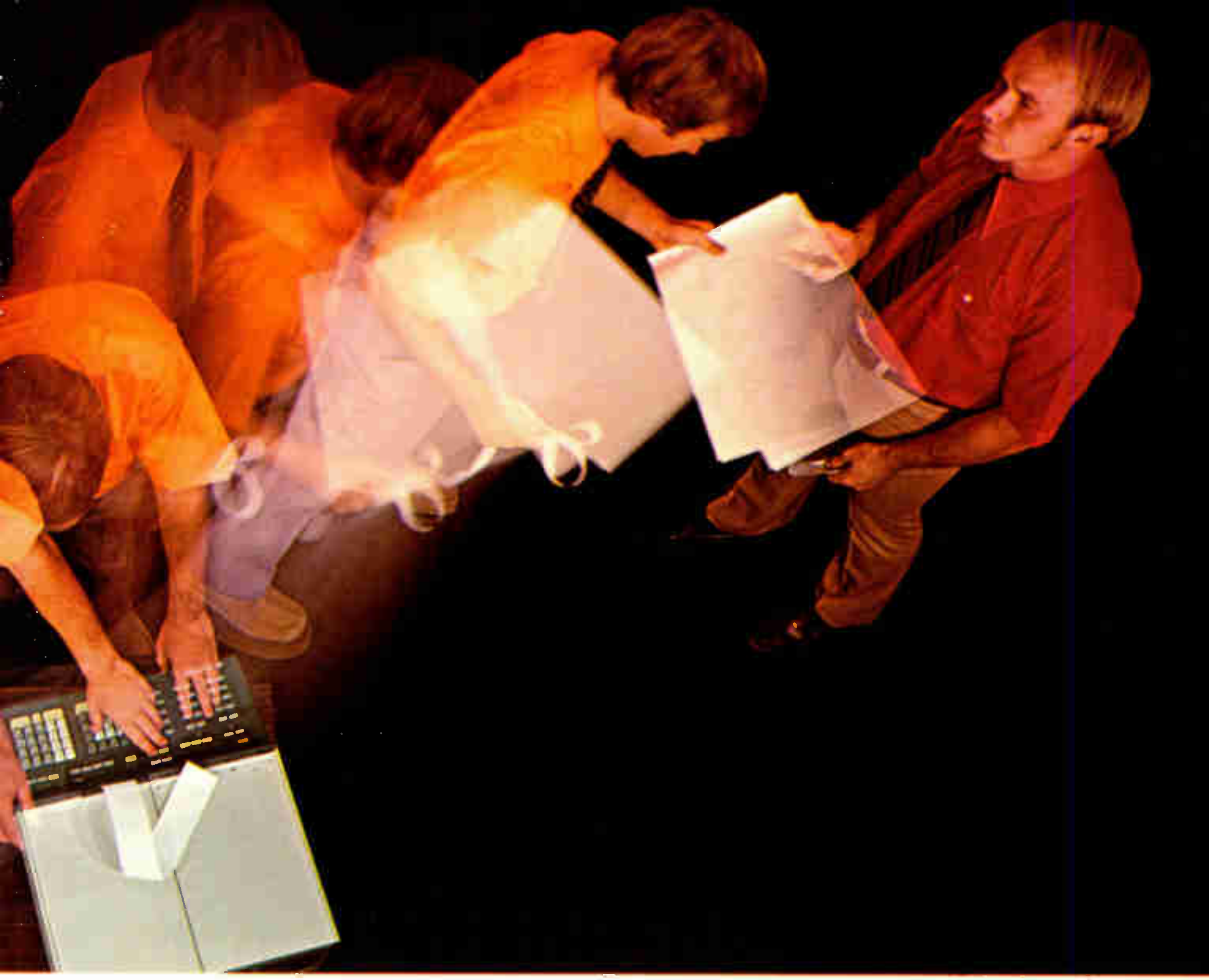

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QUADRATIC
EQUATION
OF THE FORM
  2
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ENTER A=
         1.000*
ENTER B=
         1.000*
ENTER C=
         1.000*


COMPLEX ROOTS
REAL PART=
        -0.500
IMAGINARY PART=
         0.866
```

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 1.000*

 1.000*

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-0.500
-0.866

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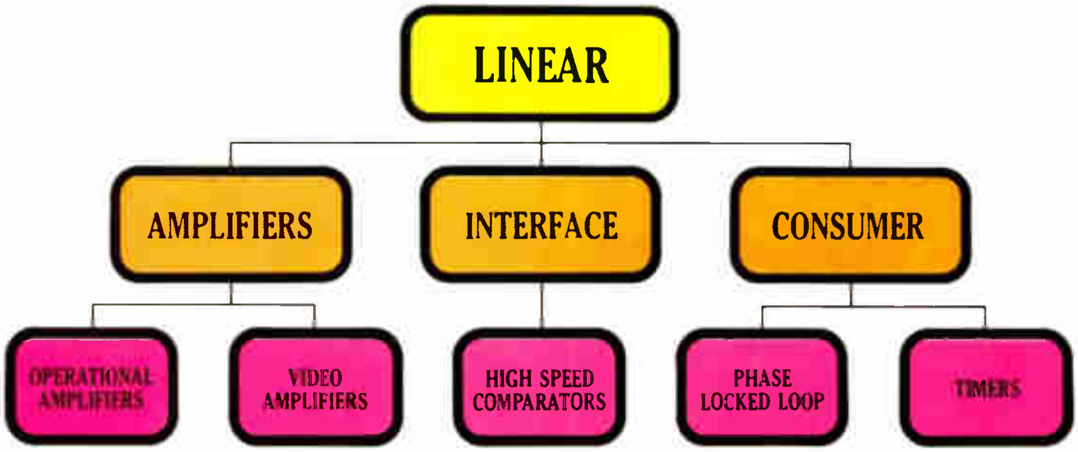

SIGNETICS LINEAR. First with phase locked loop! First with the universal IC timer! First with the Schottky-clamped comparator! Plus a solid line of standard-busters in between.

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Old shoe linear gets the boot at Signetics. We never leave well enough alone. And from this commitment has come industry-shaking innovations. Spectacular enough to set new technological standards. Practical enough to expand your options without penalizing system design, compatibility or efficiency. But with so much versatility built in, the flexibility of each component reduces circuit count.

Phase Locked Loop. The world's first PLL devices eliminated tuned circuits altogether when Signetics put complete systems on a chip. Operating from dc to 30 MHz, our PLL invention has proved extremely versatile—useful for AM and FM demodulation, frequency multiplication and division, or frequency sensing (tone decoding). With no precision components required. Signetics ships the broadest PLL product line available anywhere: circuits 560, 561, 562, 565, 566, 567 now on the shelves.

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Magnetic bubbles losing out to CCD technology

Are magnetic bubbles dead? The answer may well be yes, as far as commercial-memory makers are concerned, says C. Lester Hogan, president of Fairchild Camera & Instrument Corp. He should know because Fairchild has been following bubble development ever since the technology was introduced at Bell Labs in 1969. **In fact, even Bell apparently has cut back bubble-device development in the last year in favor of work on charge-coupled devices.**

Hogan says, "The great promise of bubble technology never materialized, and it has quickly been overshadowed by charge-coupled devices." Hogan, who feels that bubbles never made it as serious competitors of disk technology because of the difficulties inherent in the magnetic materials, predicts that CCD memories will eventually replace disk drives. "With CCDs, we can do everything magnetic bubbles can do, only we can do it smaller, cheaper, faster, and better."

Jerrold readies two-way TV trials

Look for Jerrold Electronics Corp., Philadelphia, to set up an experimental bidirectional cable-television system this spring. **This move swings Jerrold's enormous weight into developing new two-way services for CATV.** With more than 50% of the cable hardware market, the General Instrument subsidiary may set a new pace for earlier starters in two-way TV now running experiments in California, Texas, and Florida. The Jerrold trials will be cosponsored by a cable-TV operator.

Avco 10-kW laser going to work at Caterpillar Tractor

What may be the most powerful industrial laser yet has gone into operation at the Caterpillar Tractor Co. Manufacturing and Materials Development Center, East Peoria, Ill. A carbon-dioxide, continuous-wave device, the new laser delivers more than 10 kilowatts. It was developed at the Avco Everett Research Laboratory Inc., Everett, Mass.

Caterpillar plans to study its use in metalworking and fabrication—heat-treatment, machining, cutting, and welding. With a view toward future markets, Avco designed the unit to conform to industrial-safety standards and to operate in industrial environments that are hot, acid, and dirty. It also is adaptable to computer control on automated production lines.

Retailers promise P-O-S item code

The National Retail Merchants Association has gone out on a limb to promise completion by the end of this year of a standard code for identifying retail merchandise. **If successful, the code will end the confusion among point-of-sale terminal manufacturers over how to equip their machines to read coded sales tags.** The NRMA is expected to recommend optical coding because optical codes are less expensive to print than are other kinds. Also, the supermarket industry in March will establish an optical code for groceries and other merchandise. Since many items sold in supermarkets today are also handled by department and discount stores, there's pressure to have compatible coding.

$20,000 tester for pc boards

Technology Marketing Inc., custom designer of memories and computer equipment for other firms, will soon introduce a relatively low-cost $20,000 system for testing printed-circuit boards. The Costa Mesa, Calif., company developed the general-purpose desktop tester after experience in providing specialized production-test equipment for its designs; the company says it delivered about 50 of these dedicated testers last year.

The new system can be programed from its front panel, or it can be programed automatically by a known good board. Test programs are stored in core and on plug-in IBM magnetic cards capable of storing 80,000 bits. The test system is controlled by an internal microprogramed minicomputer, and it includes self-test and diagnostic capabilities, according to the company. Both analog and digital boards can be tested by changing the test fixtures.

LC displays gain ground

Liquid-crystal displays are finding their way into more products. **Perhaps most unusual is a throwaway clinical thermometer using temperature-sensitive cholesteric liquid crystal that's printed on a thin, flat plastic "stick."** Liquid Crystal Inc. of New York, recently formed from the liquid-crystal operation of Ashley-Butler Inc. of Somerville, N.J., and Thermograph Products Inc., Pittsburgh, says it has delivered samples to a "major pharmaceutical distributor." Temperature on the oral thermometer is delineated by a bar-graph-like line of cholestric "pips," each sensitive to a given temperature to within ±0.1°F. The more sensitive pips, at the high end of the scale, change from an opaque green to transparent as the thermometer is held in the mouth; numbers printed on the stick indicate at what temperature the color change has occurred.

Neutrons 'see' aluminum in closed package

General Electric's H.E. Sharp has developed a neutron radiography technique that permits inspection of completed IC packages that have aluminum wire bonds. **Such packages can't be X-rayed because aluminum is virtually transparent to the rays.** The GE technique requires the use of gadolinium-alloyed aluminum wire because gadolinium makes aluminum opaque to neutrons.

H-P adds calculator

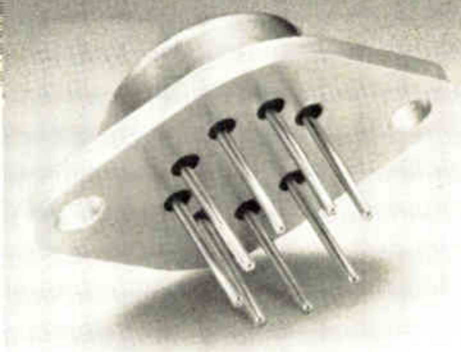
The huge success of the HP-35 pocket calculator for engineering and scientific uses **has prompted Hewlett-Packard to introduce another model**, this one for business and financial users, including bankers, brokers, insurance personnel, and accountants.

Fairchild eyes production order for GM ignition

Even though Fairchild Semiconductor has until next May to prove its ability to make a hybrid semiconductor ignition system for General Motors' Delco division, **it's clear that the Mountain View, Calif., firm is banking heavily on converting its present development contract** [*Electronics*, Jan. 4, p. 34] **into a production order this year.** From a pilot line, Fairchild has delivered some 1,000 of the systems, using a combination of monolithic ICs and discretes, to Delco. Flip-chip techniques are used to bond the active devices to ceramic substrates.

C. Lester Hogan, president of Fairchild Camera & Instrument Corp., ever bullish, says he knows of no other firm Delco is working with to develop such an ignition system, adding that he "can't build capacity fast enough to build what I think General Motors will order."

THE BEST WAY TO SWITCH HIGH POWER LOADS FOR PRECISELY TIMED INTERVALS.



C-LINE ONESHOT POWER PULSERS

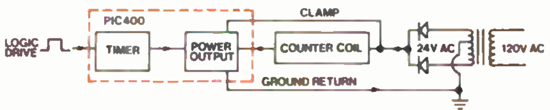
The Unitrode Power Pulser is a hybrid circuit available in two series optimized for switching loads up to 500 watts (60V) for 0.5 to 50ms. Output pulse width tolerance is within 1% of the internally preset time with a temperature coefficient of –0.04%/°C from 0°C to 125°C. It is a complete, ready-to-use thick film circuit in a compact TO-3 package.

VOLTAGE SWITCH – PIC400

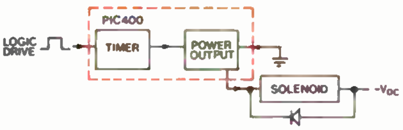
Upon actuation by an input pulse from an IC logic gate, the output of the PIC400 will switch the supply voltage across the load independent of the shape or duration of the input. No external components are necessary. The load may be placed in either the collector or emitter of the darlington output and may be driven from either a positive or negative supply. A wide variety of options are available, including 1800W switching capability (15A, 120V), extended pulse width range (from a fraction of a millisecond to several seconds), and controlled rise and fall rates. The two applications listed below illustrate the versatility of the PIC400.

TYPICAL PIC400 SERIES APPLICATIONS

1. Driving electro-mechanical counter from 24V AC.



2. Solenoid actuation from negative power supply.

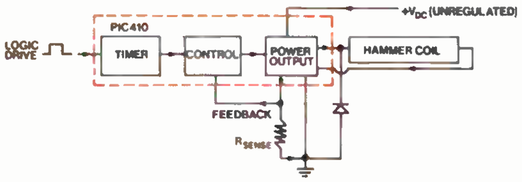


REGULATED CURRENT SWITCH – PIC410

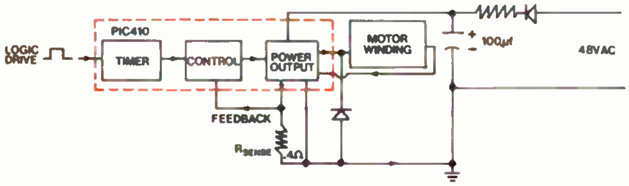
The PIC410 is a more sophisticated version of the PIC400. The output pulse is current regulated to within 1% of an externally preset value by means of a switching regulator in the output circuitry. This insures substantially lower internal power losses and higher efficiency than could be obtained with a series regulator. A rapid turn-off circuit insures the fastest possible current decay upon termination of the output pulse. The range of options available for the PIC410 are the same as for the PIC400. Two typical applications follow.

TYPICAL PIC410 SERIES APPLICATIONS

1. Constant current switching of high speed print-hammer from unregulated supply.



2. Driving high-speed stepper motor (with 5A constant current pulse) from 48V AC.



For more specific information call Vinnie Savoie – collect – at (617) 926-0404, or return the coupon to Unitrode Corporation, 580 Pleasant St., Watertown, Mass. 02172.

Unitrode Corporation
Dept. 1Y, 580 Pleasant St., Watertown, Mass. 02172

PLEASE SEND INFORMATION ON:

☐ PIC400 ☐ PIC410
☐ Application Note ☐ Power Darlingtons

My application is: ______________________

____

Name: ______________________

Title: ______________________

Address: ______________________

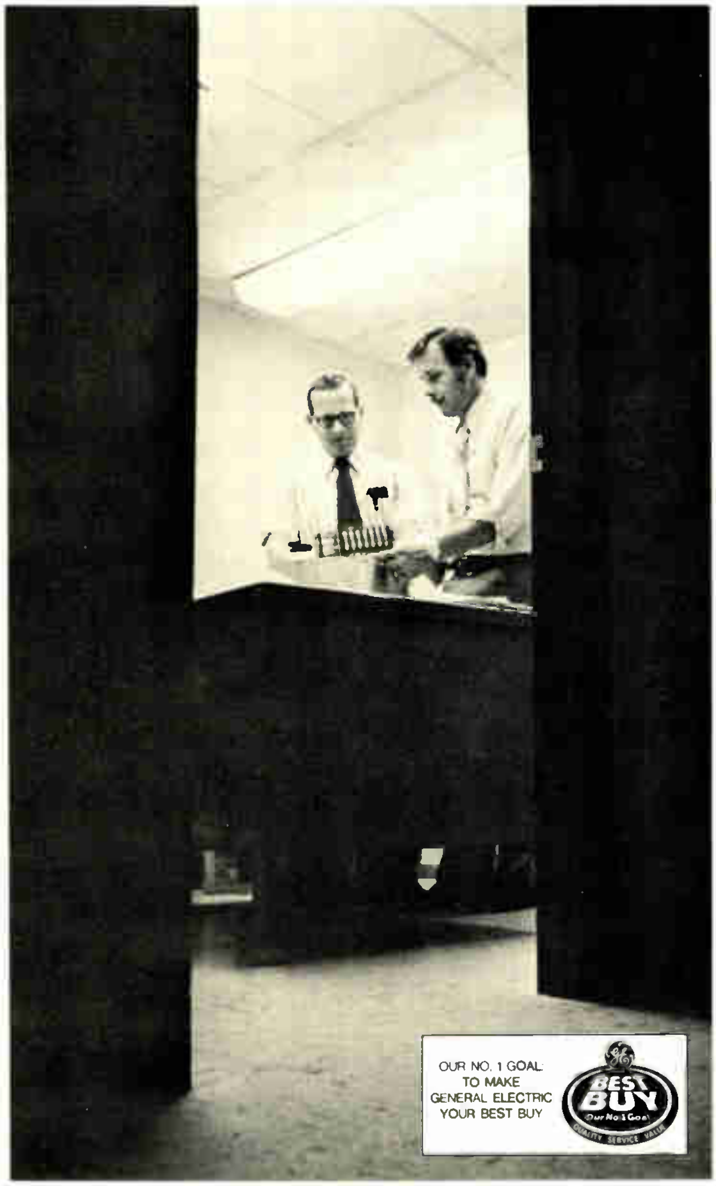
City: ____________ State: ________ Zip: ______

Telephone: ______________________

See EEM Section 4800 And EBG Semiconductors Section for more complete product listing

UNITRODE quality takes the worry out of paying less.

Two GE men gave up a night's sleep. But they rebuilt our switch in time to meet a crash change in customer specs.



The change came at the last minute. A Cleveland OEM found he couldn't use the complex GE control switch he'd just received. A new one would take 10-12 weeks to get. But all he had was one week.

He called Jim Wink, GE's Cleveland District Sales Manager, and explained the problem. Jim and his Senior Sales Assistant, Ken Korbel, picked up the part at the customer's plant. That same afternoon. And then they called one of our design engineers.

The next morning Jim and Ken were back with the switch. They'd taken it back to the office and spent the night resequencing and regrinding the cams. It met the new specs exactly. And the customer got his rush order out in time. We can give you other examples where we wouldn't leave our customers alone. And we intend to. When a company has people like Jim Wink and Ken Korbel, you deserve to know about it. 690-11

GE won't leave you alone.

GENERAL ELECTRIC

Hostile Congress threatens life of Grumman F-14

Fighter is battleground for larger struggle over control of funds; avionics major factor in cost hike

The threat of cancellation looms larger for Grumman Aerospace Corp.'s troubled F-14A air-superiority fighter. If the Navy or the Defense Department doesn't swing the ax, then funds can be withheld from the Nixon Administration by a hostile 93rd Congress, under the firm control of Democrats.

This is the estimate of an increasing number of Democrats, particularly on the Senate side, who are seeking issues to reassert congressional power over the purse in 1973 after a series of setbacks in confrontations with the White House.

"Grumman will become a household word," says one Senate staffer, "just like Lockheed did last year" when the financially pressed California aerospace giant got a one-vote majority approving a precedent-setting Federal guarantee of a private line of credit for its commercial-aircraft ventures.

At stake in the Grumman dispute is the Bethpage, N.Y., corporation's refusal to perform on the Naval Air Systems Command's 48-plane option under lot V of a 313-plane fixed-price contract. Grumman contends that the contract, which it regards as the last of the discredited "total-package procurement" awards conceived under former Defense Secretary Robert S. McNamara, is invalid and unenforceable, since it would force the company to "close its doors."

Barrier. Although the Navy wants the planes badly, it is restricted in renegotiating the contract by the precise language of the fiscal 1973 appropriation, which orders the service to procure "not less than 48 aircraft" under lot V at a price "not to exceed $570.1 million." The Navy exercised its option on Dec. 11, 1972, but Grumman has refused to perform, citing its earlier contention that it would lose $2.2 million per plane.

The Navy is anxious to get the dispute settled without turning to a prolonged court struggle. "Every day nothing happens, it costs another $30,000. That's a million a month," says one Government source privately. Yet the Navy can expect nothing but opposition in Congress. Even Senate Republican Barry Goldwater of Arizona, usually a staunch supporter of military programs, has rebelled.

Under the Navy's minimum purchase of 313 planes, including 12 R&D models, the existing program will cost $5.267 million—including $1.463 million for R&D and $3.804 million for procurement. That puts the average unit price at $16.8 million per plane, the nation's most costly. And that doesn't include the loss of $2.2 million per plane Grumman wants to recoup on the cost of such Government-furnished equipment as the Hughes Aircraft Phoenix missile, estimated to cost about $3.6 million per plane for an all-up system of six rounds. The total, based on Senate testimony before the Cannon subcommittee last April, puts the operational cost per plane well above the $20 million forecast last year.

Overruns. Avionics subcontractors to the F-14A are credited by its Capitol Hill opponents as significant contributors to the cost escalation. Although Grumman says it has obtained price extensions from sup-

TYPICAL AVIONICS COST CHANGES FOR 331 ITEMS
(in millions of dollars)

Supplier	Items	Base	Changes	Relief	Total
IBM	multidisplay indicator group	$13.8	–	$15.2	$29.0
Teledyne	central system digital computer	17.4	0.5	23.8	41.7
Garrett AiResearch	central air data computer	5.0	1.4	7.3	13.7*
EDO Corp.	jettison release mechanism	2.5	0.7	2.4	5.6
Novatronics	interference blanker	1.4	–	1.0	2.4
Honeywell	automatic flight control system	8.6	2.9	4.3	15.8
Hartman	digital data indicator	1.4	–	0.3	1.7
Curtiss Wright	flap/stat drive	6.4	4.8	7.4	18.6
Raytheon	Sparrow launcher	5.4	2.4	7.0	14.8

*Garrett later testified its CADC contracts totaled $18.97 million, up $10.5 million, through Lot IV.

pliers on lot V options that expired unexercised in early January, there are signs that subs are pushing for significant repricing proposals while the Navy and Grumman try to strike a bargain they believe will be politically acceptable. Most suppliers are keeping silent, except for extending their options temporarily on lot V.

Nevertheless, Grumman's own estimate before the Cannon subcommittee provides a clue to the changes that led the Senate Armed Services Committee to conclude that "Grumman seriously underestimated its subcontractor costs, which represent about 50 cents of every F-14 dollar to Grumman. Actual contract awards to the subcontractors were nearly $300 million over Grumman estimates." [See table on p. 105]

Grumman's figures on "restructured sellers and potential repricing requirements" for 17 of its key subcontractors, including a dozen electronics suppliers, last April showed a $185 million increase to $577.6 million from a $392.6 million base. This included an escalation of $76.7 million from change proposals, plus $108.4 million in subcontractor "relief." "Those figures are surely higher now," says one knowledgeable Senate staff man, "but they are still useful guidelines until we hear from the navy." □

Solid state

IBM's Esaki uses superlattice to build new class of devices

Experimental semiconductors being made at IBM in a project headed by Leo Esaki, developer of the tunnel diode, could lead to what Esaki calls "a new class of high-speed devices for which there will be no frequency limit."

What Esaki is doing in his major project as an IBM Fellow at the Thomas J. Watson Research Center in Yorkstown Heights, N.Y., is building a "superlattice" of alternating layers of semiconductors and their alloys. "In the past," he says, "we depended on the nature of materials as God gave them to us. Now we want to develop new materials." The objective is to produce a periodic variation in semiconductors.

It has been 15 years since Esaki's discovery that if a p-n junction were reduced in width to less than 150 angstroms, conduction electrons would produce tunneling, characterized by the now familiar negative resistance curve of the tunnel, or Esaki, diode.

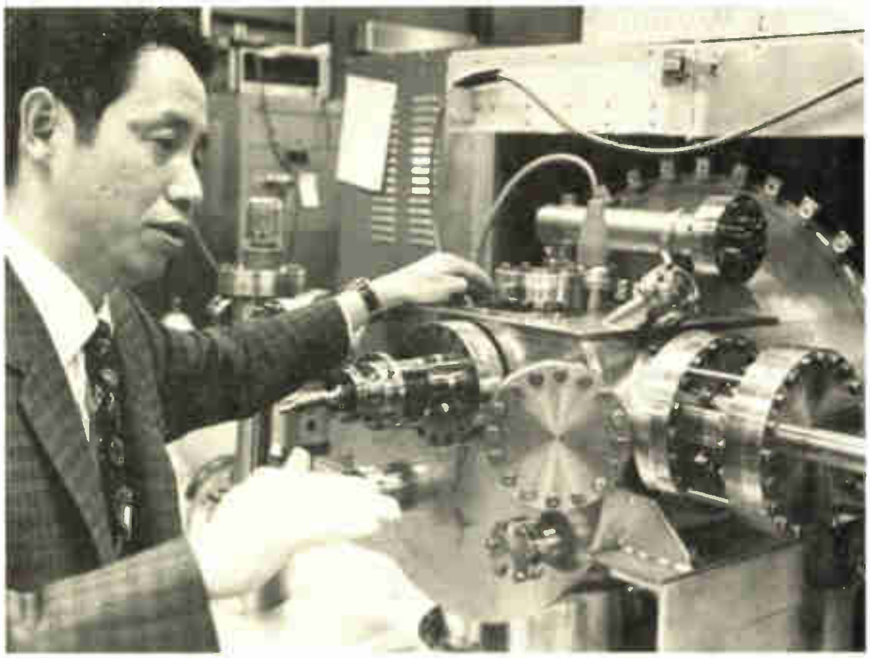
Esaki now proposes the period of his superlattice to be less than 100 Å; this is shorter than the mean free path of electrons in semiconductor materials. Such a structure, says Esaki, should permit the interaction of electron waves with the superlattice potential.

In the devices now being made, Esaki says, "we're beginning to see a negative resistance." Planar-type devices have been made from a superlattice structure of alternating layers of gallium arsenide 50 Å thick and gallium-aluminum arsenide 20 Å thick. The active area of the device was of the order of 10^{-6} square centimeters, and a weak negative resistance was found to exist beyond 2 volts.

What remains to be done? "We have many stupid electrons, and we have to get rid of them by improving the quality of crystals," says Esaki. "Stupid electrons" is his whimsical term for electrons having mean free paths too short to permit interaction with the period potential of the superlattice.

Esaki is using what is probably the most sophisticated crystal-growing apparatus ever developed. It is an ultra-high-vacuum (10^{-10} Torr) epitaxy system. There are six sources for multiple evaporation, a mass analyzer for spectroscopic monitoring, and a scanning, high-energy, electron-diffraction system for ensuring the smoothness of each layer.

The entire evaporation system is controlled essentially by two computer programs. The first calibrates and enters parameters for the system. The system receives information from the mass analyzer, and from this data, it determines the timing of each set of components. The second program controls the



No frequency limit. That's what IBM's Leo Easaki is seeking with his superlattice devices.

operation of the equipment. The main computer, an IBM 1130, interfaces with the apparatus via an IBM System 7.

This work is partly funded by the U.S. Army Research Office, Durham, N.C. □

Satellites

ESRO to pick U.S. Aerosat partner

The European Space Research Organization (ESRO) is about to select a U.S. carrier to share operation of the Aeronautical Services Satellite (Aerosat) under broad principles being drafted with the U.S. Such selection makes it appear likely that hardware contracts to equipment suppliers could be let as early as this fall if the outcome of ongoing discussions to speed the long-delayed program get Government approval.

Under these principles, ESRO has asked the U.S. international carriers of record—Communications Satellite Corp., ITT World Communications, RCA Globcom, and Western Union International—for proposals. ESRO is expected to select one within the next few months to be its U.S. partner. The launch timetable would require that equipment suppliers be selected by fall. Reemphasized as an experimental program to be launched in late 1976, Aerosat has been reduced to a three-satellite, $90 million system from a six-satellite, $140 million system.

It is generally agreed that ESRO and a U.S. company to be selected will operate equal shares of the satellites. The U.S. company would work out with ESRO how it would contract with U.S. equipment suppliers for the U.S. share. The Federal Aviation Administration would lease aeronautical services from the U.S. company, while ESRO would run the European side for its member nations.

If solidified, the Aerosat accord appears to be a victory for ESRO, which, fed up with U.S. delays told the U.S. to join it, or it would do the job alone, says one source. The ESRO-U.S. company principle placates the White House Office of Telecommunications Policy, which object to U.S. Government ownership, but sidesteps the issue of 50-50 production sharing.

Besides technical and policy questions, before a final memorandum of understanding can be signed any agreement would have to go through a series of ratifications, including contracts among parties, U.S. intragovernmental okay, and White House and congressional approval. The decision to leave the details for an operational Aerosat system to be worked out through the International Civil Aviation Organization is expected to ease approval.

Among the questions involved with the experimental Aerosat are: possible participation of Canada as owner or partner and whether it can be both owner and user; how ESRO and a U.S. company will select suppliers; whether or not the U.S. carrier also can be a supplier, although this seems unlikely; and what voice the FAA will have in determining policy; a question also is how a U.S.

NASA to experiment with making semiconductor materials in space

As any manufacturer can attest, making semiconducting and crystalline materials involves intricate problems of economics, yields, qualities, and quantities. However, the National Aeronautics and Space Administration thinks that space manufacturing can alleviate some of those problems. Thus, the agency plans to spend $3 million in fiscal 1973 on R&D and will include several space manufacturing experiments on the upcoming Skylab orbital workshop.

While large-scale processing of delicate electronic materials in space is at least a decade away, NASA thinks that the spadework must be undertaken now to reap its potential when the space shuttle becomes operational. "In the extended free-fall in space, you can control processing better than on earth," says James H. Bredt, manager of NASA's Materials Science and Manufacturing in Space (MS/MS) programs, who lists potential benefits as:

- Levitation of "molten materials and [the ability to] grow them without touching anything," thus improving purity and composition.
- Production of "mixtures that are unstable on earth."
- Elimination of nearly all disturbing acceleration and vibrations, important in processing gases and fluids. "In crystal growth, you can control the melt and growth."

"A lot of things that are black arts now can be turned into real sciences," Bredt says. "Materials could be produced to their limits," the solid-state physicist forecasts. "There is no semiconductor product now that works as well as it theoretically should." Pushed to its potential, "LSI could lead to the smallest and fastest computer products."

One Skylab experiment will attempt to grow perfect and chemically homogeneous gallium-arsenide crystals epitaxially on single-crystal substrates. This will be done by transporting the solution through a temperature gradient maintained in a column of liquid gallium metal. Other Skylab experiments include cadmium selenide, cadmium telluride, and indium antimonide.

"It's too early to decide what materials could be mass-produced in space," Bredt says, "and in a way you don't have to decide yet," though he nominates such as silicon, germanium, and niobate. Bredt acknowledges that at $10 million per space shuttle flight, "baseline operating costs will be high," which "restricts you to production programs."

Louis R. McCreight, manager of General Electric Co.'s space processing program, Valley Forge, Pa., also asserts that space processing is feasible, depending on the materials and techniques. He foresees an unattended automated factory in a shuttle laboratory.

company deals directly with a foreign government entity on an international issue. □

Optoelectronics

Memory tube uses metal grid on Si

A new solid-state target structure for storage tubes promises improved writing and erase speeds, as well as the ruggedness and easier fabrication already available in other types of solid targets. Developed at the Hughes Aircraft Co. Industrial Products division in Oceanside, Calif., the structure has a metallic grid deposited on a silicon or glass substrate.

Although Hughes has been using the tube in equipment and systems for about a year, the company hasn't been discussing construction details.

Older storage tubes had a fragile, mesh-type storage target in front of a separate signal output plate. In writing, a conventional electron gun like that in cathode-ray tubes deposits charges that depend on the intensity of the electron beam at various points on the target. Then, in reading, an unmodulated beam scans the target; electron transmission, and hence output, through the mesh depends on the charge at any location.

A recent improvement is a solid-target tube, first marketed by Princeton Electronic Products and now also used by other firms. Its target structure uses reflection modulation, rather than transmission. The charge-storage locations are silicon-dioxide islands fabricated on the surface of a conducting silicon substrate, which acts as a signal plate, as well as support for the grid. Electrons repelled by the charged islands cannot reach the substrate and are collected by a separate collector.

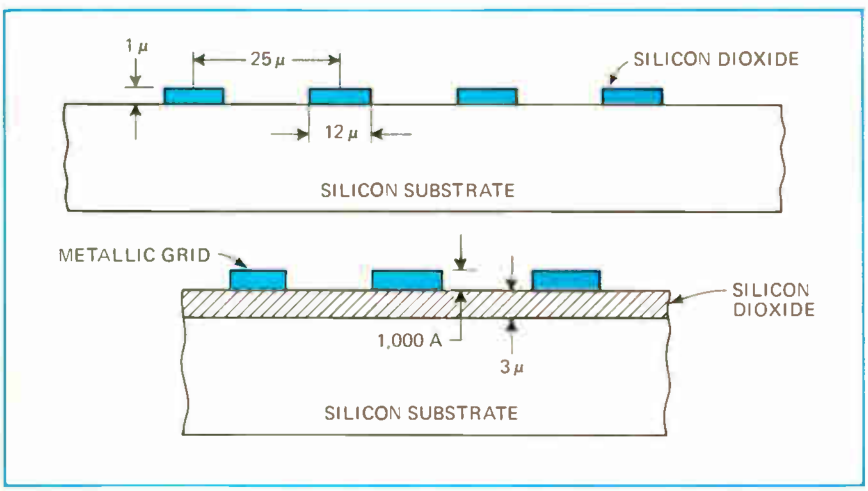
Glass base. Hughes' improvement is also a solid-state structure much like Princeton's, but with a glass substrate, rather than silicon, and a metallic mesh-like grid on its surface. This, then, is the reverse of the Princeton structure in that the charge is stored on the insulating substrate with the signal plate actually a grid on its surface. Ken Hesse, manager of advanced display components at Hughes, claims that this structure, developed by E. E. Herman, provides 400 times less capacitance between the storage locations and the plate than that of the earlier solid structure, with consequent improvement in speed.

Hesse himself has provided a further development, a silicon-dioxide insulating layer on a silicon substrate, rather than the glass. Even though this is only three times faster than the Princeton structure, he says, 1.5-inch silicon substrates of suitable quality and high resistivity are much easier to obtain and less expensive than glass.

He says that the tube is capable of writing a diameter in less than a couple of microseconds, with target erasure in one frame. Hesse says that the lower writing current required for the tubes for a given speed also permits finer resolution. In fabrication, photolithographic and production steps are much like those in making ICs.

Hughes so far is using its tubes in equipment, but Hesse says the company would sell the tubes separately. They are used in such applications as slow-scan (soft-copy) facsimile, thermography storage in medicine, image processing, and photodigitizing. □

Metal islands. Hughes has taken the Princeton Electronic Products solid-target tube (top) a step further by using a glass substrate. Next, says Hughes, is the structure shown at bottom.



Avionics

LSI leads to smaller Gamma 1

While two generations of aircraft inertial navigation systems have achieved high standards of accuracy and reliability over the past several years, their size often makes them hard to squeeze into crowded equipment bays. But by turning to large-scale integration and hybrid circuitry, the Singer Co.'s Kearfott division is building a new third-generation system. Gamma 1, which has "half the size, half the weight and half the alignment time" of comparable units, claims Arnold A. Weiss, program manager for commercial inertial systems.

"Going to LSI and hybrid circuitry allows us to get the costs down and reduce size and weight significantly," Weiss says. "It's the latest electronics technology; it's as pure and simple as that." The result is an inertial navigation unit that weighs about 25 pounds, measures 7.5 by 7.6 by 12.5 inches, aligns in eight minutes, and, though listed in the usual $100,000 ball park [*Electronics*, Jan. 4, p.53] will sell for "at

Automated Systems Software

The TEKTEST™ III Software operating system developed for the Tektronix S-3260 Automated Test System is designed to enable **maximum device throughput** while permitting engineering studies when required. TEKTEST III is a new test language written by Tektronix Software Engineers. The language was designed to be **easily understood by systems engineers** yet **powerful** enough to control the full hardware testing capabilities of the S-3260.

The TEKTEST III Executive disc operating system permits interactive test program preparation. Other features permit *on line editing, on line debugging* and *functional test pattern editing.*

All commands are as descriptive as practical and are entered in English language format. For more information on TEKTEST III and the S-3260 contact your Tektronix Field Engineer and ask for a copy of *S3260 Automated Test System Control Through TEKTEST III Software* and the *S-3260 Brochure.*

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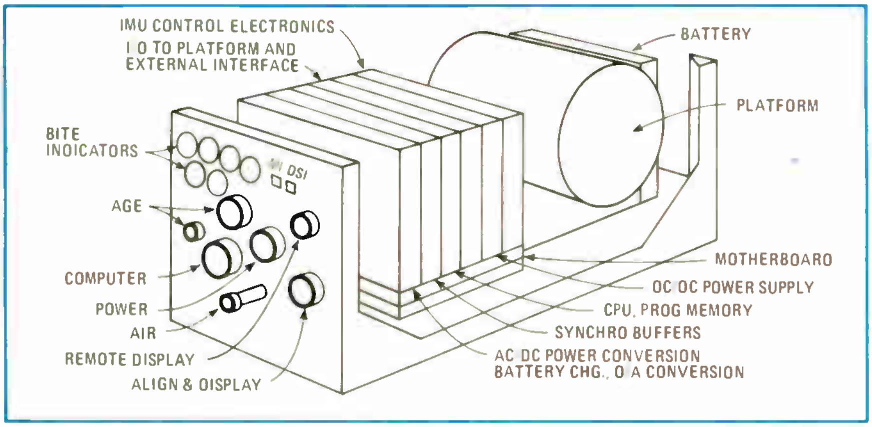


Ready to fly. Kearfott's third-generation inertial navigation system, Gamma 1, is 7⅝ inches high, 7½ in. wide, and 12½ in. in depth. It costs $15,000 less than competitive versions.

least $15,000 less than the competition."

Consequently, Singer expects to sell about 300 units in the next five years to airlines and executive-aircraft owners, although Weiss says "I'm more enthusiastic now about the latter market."

As for a military market, "I honestly don't know, but, at a minimum, it could be another 300 units," Weiss says.

The modular unit, designated the SKN-2610, also includes a control display unit, incorporating C-MOS circuitry to reduce the heat dissipated in the cockpit, and mode-select and battery units. And it has sufficient computer and hardware capacity to be augmented by other sensors, such as Omega, Loran, or doppler. FAA certification is expected before the end of the year.

An important advantage is that, because the unit is a half-size box—it fits into a three-quarters ATR short package instead of the conventional ATR long—it can be mounted either way in a standard equipment rack, he adds. Weiss points out that the inertial measurement unit in the navigation system builds on Kearfott's KT-70 design, of which some 2,000 have been delivered to military and commercial customers. However, the IMU in the SKN-2610 relies on a "cantilevered" gimbal structure instead of the conventional ring gimbal. This reduces by a third the size of the gimbal structure and improves the access to the unit for maintenance. The Gamma 1 (for Gyroflex Advanced Miniature Modular Autonavigator) was derived from military contracts.

A key part of the new unit is the "whole computer, including

News briefs

Fairchild, Polaroid in $19 million deal

Fairchild Camera & Instrument Corp. received a contract from Polaroid Corp. calling for up to $19 million in electronic circuitry for Polaroid's new instant-picture camera, the SX-70. Fairchild President C. Lester Hogan says Polaroid is likely to be his biggest customer this year [*Electronics*, Jan. 4, p. 34].

Under the contract, Fairchild will be a major supplier of the three solid-state modules that control the exposure, flash-firing, and motor functions of the camera. Production quantities of the modules now are being shipped to Polaroid, Fairchild said. The ICs were developed in a three-year program by the two companies.

Western Union gets first domsat OK

Western Union, which was the first to ask FCC approval and the first to contract for satellites [*Electronics*, Aug. 28, 1972, p. 32], became the first company receiving commission approval to begin building a domestic satellite system. The company was incorrectly called Western Union International in a previous story [*Electronics*, Jan. 4, p. 33]. The FCC approved satellite construction for the estimated $70 million communications network to begin operating by mid-1974, but withheld approval of earth-station construction, pending further consideration. WU not only is first out of the starting gate, it is the only one ready, as the commission says no other application is ready to be acted upon. Several potential applicants are expected to drop out as the domsat stakes race continues.

RCA names Vonderschmitt

RCA's Solid State division, Somerville, N.J., has a new head: Bernard Vonderschmitt, a 27-year veteran of RCA, who moves up from divisional vice-president, solid state integrated circuits.

He succeeds William C. Hittinger, named last month to be executive vice-president of the corporation's consumer and solid state division [*Electronics*, Dec. 18, 1972, p. 38].

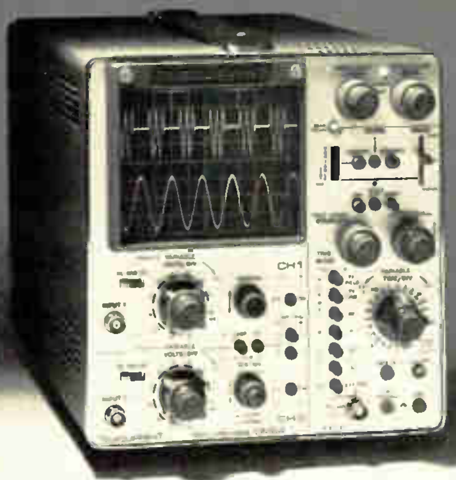
GI looks east

New York-based General Instrument Corp. has picked Richard F. Adler to head its new sales and marketing operation in the Far East, General Instrument-Japan. Replacing Adler as vice president and general manager of the Semiconductor Components division, Hicksville, N.Y., is Douglas O'Connor, who joined the company a few months ago from Fairchild Semiconductor. The division turns out rectifiers, MOS field-effect transistors and multiplexers.

Baggage X-ray

Airlines have generally been experimenting with portable low-level X-ray systems, [*Electronics*, Sept. 25, 1972, p. 32] for examining the carry-on baggage of their passengers. But now Delta Airlines is testing at New York's Kennedy International Airport a relatively high-level Dynafluor II system, which uses X rays and fluoroscopy, built by Philips Electronics division of PEPI, Inc., Mt. Vernon, N.Y.

MORE VALUE IN TELEQUIPMENT DUAL-TRACE OSCILLOSCOPES



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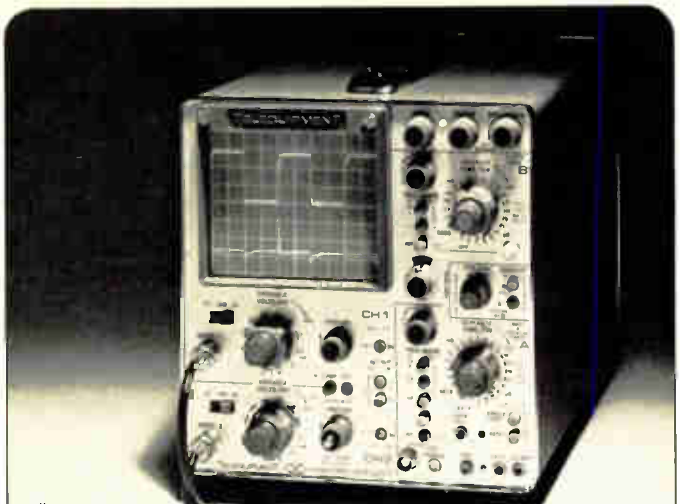

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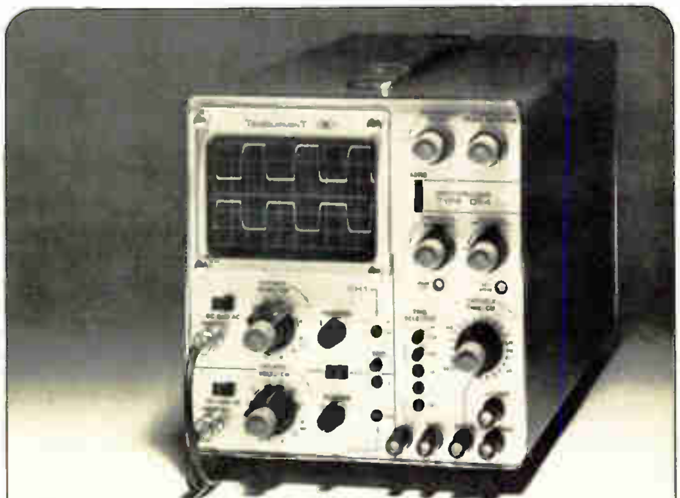

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For a demonstration circle 110 on reader service card memory, on one card," Weiss says. Mounted on a 6-in.^{2} card, the parallel processor features 43 read-only-memory chips for its 7,168-word program and data memory, 10 LSI chips of five types (mostly from Fairchild Semiconductor) and four hybrid circuits. In addition to the program memory, the system has an LSI random-access scratch-pad memory of 512 words, a nonvolatile one of 64 words, and a microprogram of 128 words of LSI ROM. Execution times are 9.8 microseconds for addition, 68.4 μs for multiplication and 73.2 μs for division.

Other improvements have been made in the inertial platform, including restructured gimbals, improved Singer Gyroflex gyros, and better accelerometers.

Singer Kearfott also has another part of the inertial-navigator market. It makes the gimbals and inertial platform for Collins Radio Co's second-generation 61-B system. □

Military electronics

C-5A testers get new automatic gear

Impressed with what it calls the "excellent success" of automatic test systems for base-level maintenance of the C-5A's flight-control system, the Air Force has ordered eight more at a total cost of $1.6 million. The test systems for the giant transport are the H-316 minicomputer-directed 2600 series from Honeywell Inc.'s Government and Aeronautical Products division in Minneapolis, Minn., and will replace older tape-controlled systems supplied by the Bendix Corp.

The new stations, which the Air Force designates the MR-1505, will enable maintenance people at each of the C-5As' four bases in the U.S. to pinpoint faulty modules and printed-circuit-card assemblies from among the 120 in the five line-replaceable units that make up the flight control's two stability-augmentation systems, two autopilot computers, and one auto-throttle computer. Faulty cards will be sent, as at present, to the MR-1505 installation at Tinker Air Force Base, Okla., for depot-level repair in which faulty components are detected and replaced. Malfunctioning line-replaceable units are, of course, pinpointed on the flight line by the C-5A's combination of built-in test computer, onboard fault-locating computer, and warning flags.

During the first 3,000 hours of operation since it was installed at Tinker last May, the Honeywell test equipment has had only five hours of downtime, reports Larry Smith, manager for the C-5A's automatic flight control system at Aeronautical Systems division, Wright-Patterson Air Force Base, Ohio.

Exceptionally good performance recommendations were also forthcoming to the Air Force from commercial users of the Honeywell test equipment. These include American Airlines, United Air Lines, and McDonnell Douglas, all of which have been using the 2600-series gear for trouble-shooting aboard the DC-10 wide-bellied aircraft.

Spurred by change. The impetus to buy the Honeywell equipment came from engineering changes that had to be made in the C-5A's flight-control system as a result of all-weather landing tests made late in 1971, Smith explains. The cost of writing the new programs on the Bendix equipment, particularly after Honeywell engineers doing the flight-control redesign produced test specifications in their own programming language, plus the cost of modifying the interfaces between the test gear and the line-replaceable units, led the Air Force to opt for the Honeywell test system, he continues.

A big plus was Honeywell's demonstration that the MRO-187 interface presently used with the old test station could be tied into the MR-1505. Thus, the same test gear could be used for both the old and new versions of the flight-control system, which is being modified gradually, Smith says.

Another factor was the need to share the Bendix gear between two aircraft. This was a goal of the origi-

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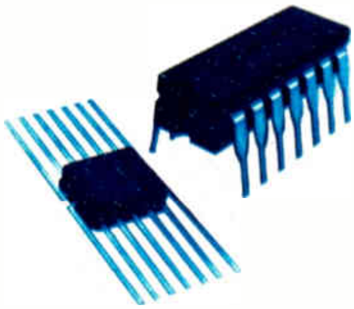

tem, it will order 21 more at an estimated total cost of $78 million for the en-route air-traffic-control center, says Spencer S. Hunn, director of FAA's Systems Research and Development service.

"We would like to make a production award as early as possible," Hunn adds. The prototype is to be delivered during the winter of 1975 for six months of testing. Production plans would call for delivery of five systems a year, beginning in 1976, with final installation by 1980. The system is designed for a life cycle of 20 to 25 years, he says.

FAA needs the EVS because the agency faces high costs from leasing much of the present nonautomatic system from the telephone company. And expansion to meet added requirements would be even more expensive, Hunn says. Because the agency estimates that EVS will save $350 million in phone bills over 15 years and pay for itself in six or seven, "it made sense to own the stuff outright," he explains.

"In essence, it's a special-purpose electronic telephone-switching system," explains Albert E. Tegeler, chief of the FAA's Control System section. A complex of three processors the size of its Univac 1615 minicomputers automatically will give controllers instantaneous communications by rerouting calls over a variety of available circuits to avoid busy or down circuits. Electronic circuits and relays will replace mechanical relays.

In automating controller communications, EVS will handle voice flow between the controller on one end and pilots, administrators, and other controllers, who may be either within the same center or at other centers. To be replaced with new equipment are radio, intercom, interphone, and switchboard networks, as well as trunk service to the military automatic voice network (Autovon), the Federal Telecommunications Service, and commercial telephone networks.

Tegeler adds that EVS will give the FAA real-time quality-control over its lines. EVS equipment also will take up one-fourth the room of present gear.

Now that the EVS automatic link within each air-traffic-control center is planned, the FAA is thinking about a network for the 1980s to connect all EVS installations similarly to the military's Autovon system. Still in the formulation stage, the switched aviation communications (Savcom) network automatically would manage the whole EVS system and switch calls between centers. The agency has not decided whether an existing ATC would house Savcom processing gear or if it should go in a new center. □

Software

Commercial version of Multics offered

Honeywell Information Systems has announced a commercial version of Multics, a time-sharing computer system that it calls the "most advanced and sophisticated computer system in the world today." The product of more than seven years of development jointly with Massachusetts Institute of Technology, Multics is based on an enhanced version of the H-6080—the largest of Honeywell's 6000 computer series.

Multics differs from other available time-sharing systems in that it not only uses virtual memory and paged bulk storage, but its bulk storage is segmented, which Honeywell claims to provide equally efficient operation for both large and small users. The system also includes a microprogramed controller that replaces the control-system software that was used in development at MIT. The result is a faster Multics system capable of servicing as many as 100 users simultaneously.

A Honeywell spokesman says that Multics adapts to the user's needs and abilities, rather than forcing the user into a given time-sharing operational format. At MIT, for example, even the time-sharing systems of other colleges, such as Dartmouth, are held in memory for emulation. Also, the Multics system is said to t

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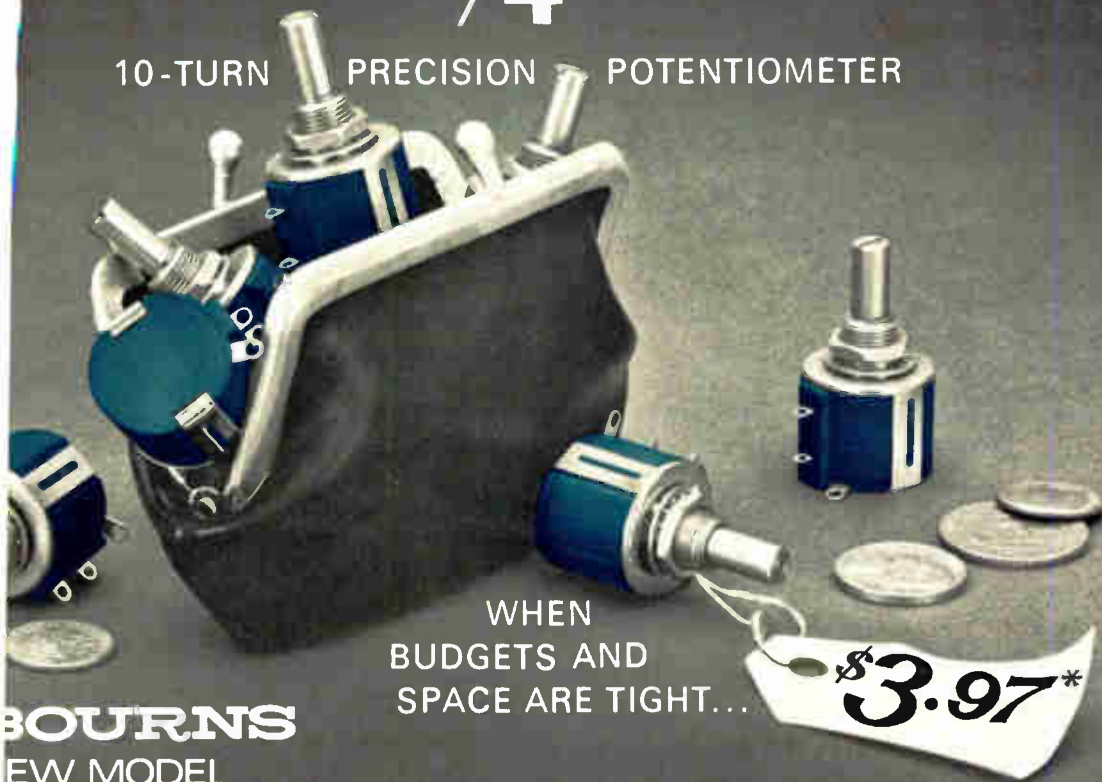

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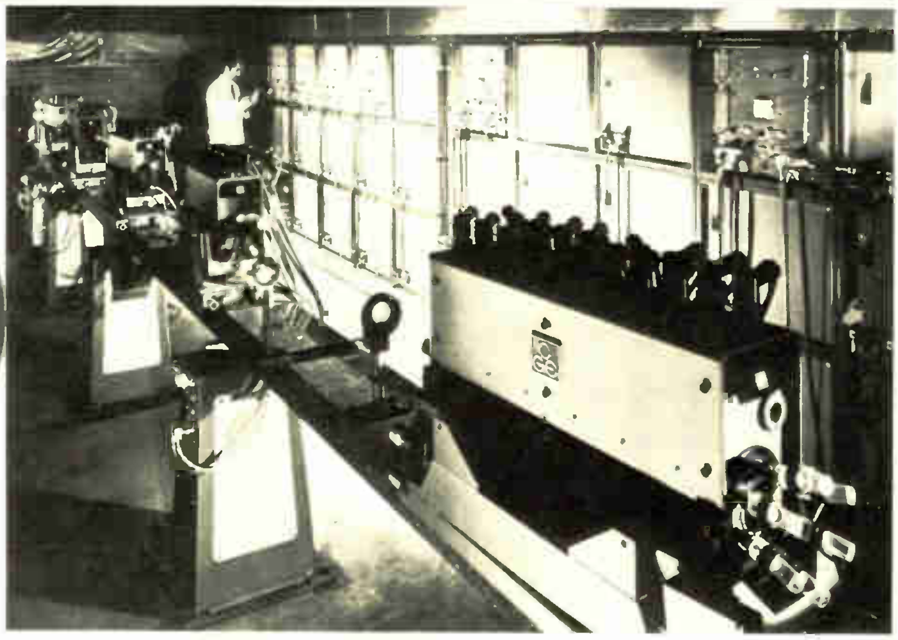

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could perform some of the same functions. Only about $17 million had been spent so far on the HEAO program.

A little luckier was Fairchild Industries Inc. of Germantown, Md. Even though it was told that its Applied Technology Satellite (ATS) G had been canceled, most of the more than $60 million for the ATS F and G satellites has been spent on F, which is still set for launch in 1974.

The ATS program has straightened out and has been rescheduled after running into problems [*Electronics*, Feb. 14, 1972, p. 49], but NASA decided under budget pressure that, with the domestic-communications-satellite market open [*Electronics*, Jan. 4, p. 33], communications satellites now can be developed by the members of private industry.

No impact. Fairchild, as a matter of fact, says that the cancellation of G "looks like it will have no significant impact on the company, at least for the first half of this year." Fairchild is a contender for the domestic-satellite market.

Civilian development of a short-takeoff and landing (STOL) transport also received a blow. NASA chopped a contract with Lockheed-Georgia to study and possibly build a quiet-engine, propulsive-lift experimental STOL plane. The White House budget office also hasn't yet released $2 million in fiscal 1973 funds earmarked for STOL quiet-engine development.

Also, with the closing of the Plum Brook, Ohio, nuclear research station, the agency sharply curtailed its space nuclear power efforts and dropped its nuclear propulsion research. □

Instrumentation

Slew knobs replace light pens

Researchers at a California nuclear science laboratory have hit on an alternative to the familiar cathode-

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And PM3110 signals are displayed on a full 8x10cm graticule, not the usual 6x10, this permits the entire CRT surface to be used for accurate measurement.

RELIABILITY. The PM3110 can withstand input overloads up to 1,000 volts for as long as 30 seconds; inputs as high as 500 volts can be handled with perfect safety, a great advantage in TV service applications.

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Circle 121 on reader service card

ray-tube display and light pen. They use slew knobs—two knots mounted on two shaft encoders that generate pulse trains. The computer interprets these pulse trains in much the same way that it interprets light-pen signals and takes appropriate action—modifying the display, making computations, or what have you.

The idea isn't new. The nuclear scientists at Lockheed's Palo Alto Research Laboratory are using the older technique instead of the newer light pen. Slew knobs are not limited to particular kinds of applications in the way that light pens and other familiar man-machine interaction devices are. On the other hand, they do have disadvantages for some applications.

Basically, there are two ways to use a light pen. One is to point at a part of a display to trigger some designated action by the computer. The other is to move a marker on the screen so that it draws a line or curve, or connects two otherwise unrelated sections of the display. Slew knobs are good for the first application, but not so good for the second—as anyone can testify who has tried to use Etch-a-Sketch, the child's toy that traces patterns in metallic powder adhering to the back of a transparent screen.

The big advantage of the slew knobs is their generality; because they are independently mounted, their signals are not limited to X-Y coordinates or any other predetermined meaning, but they can be programed to do anything.

Functionally, slew knobs are similar to the mouse, the joystick, and the trackball, other common display input devices. All three are two-shaft encoders; however, the shaft encoders of all these are mounted at right angles, and they produce signals that are interpreted as X-Y coordinates of points on the display. While the slew-knob signals can also control X-Y coordinates, they are not limited to this interpretation because they are physically independent. Their independence is what makes the curve-drawing application difficult—although this can be simplified by software that interprets signals. □

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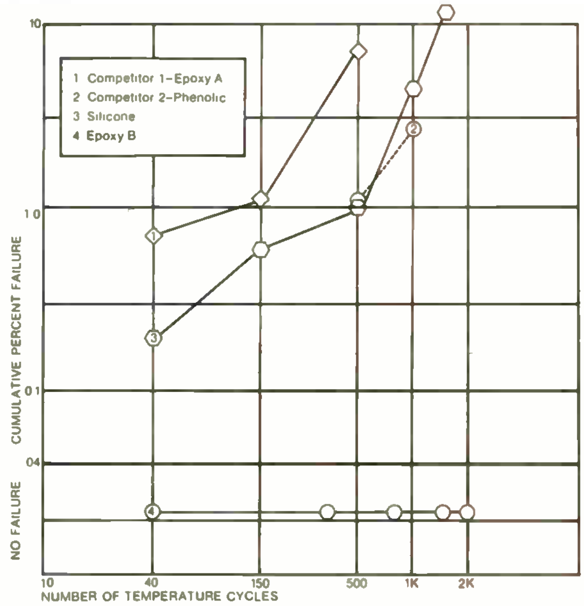

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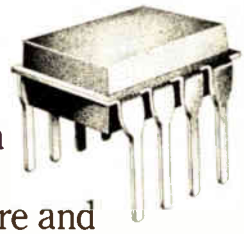

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FCC's Hinchman forecasts four or more domsats

America's domestic satellite communications requirements will come to four and possibly more systems, predicts Walter R. Hinchman, the Federal Communications Commission's new policy and planning chief. Hinchman should know, since he was the White House domestic satellite specialist in the Office of Telecommunications Policy before moving over to the FCC post carved out for him.

Hinchman's four-plus number of candidates **contrasts with earlier FCC staff projections of a three-system complex.** Among them he includes: a **joint AT&T-Comsat venture** (along with the hint that AT&T will later go it alone); **Hughes-GT&E** pending a successful blend of service offerings; the **already approved Western Union venture** to be called Westar [*Electronics*, Jan. 4, p. 33], plus one or more systems for specialized services evolving from combinations of remaining competitors.

Semiconductor statistics suspended by EIA

Monthly publication of U. S. semiconductor production statistics will be dropped by the Electronic Industries Association, says president V. J. Adduci, confirming earlier staff reports [*Electronics*, Jan. 4, p. 36]. Members remaining in the Solid State Products division (SSPD) will get a 40% dues rebate for the last three quarters of 1973 under a revised budget adopted at a mid-January emergency meeting of the SSPD executive committee chaired by Delco Electronics' Frank Jaumot (see p. 10). The action followed the resignation from EIA of Fairchild Semiconductor and Texas Instruments, near the end of 1972.

Adduci says **the SSPD will substitute "monthly management summaries" of total solid-state sales and bookings.** Confirmation of the recommendations is expected at EIA's March meeting in Washington.

Univac, IBM, TI tie up touring Soviet ATC team . . .

The lion's share of U. S. industry tour time by a **Soviet delegation interested in a possible buy of U. S. air-traffic-control equipment** [*Electronics*, Jan. 4, p. 50] has been locked up by Sperry Rand Corp.'s Univac division, IBM, and Texas Instruments—the three manufacturers instrumental in setting up the mission from Moscow sponsored by the American Institute of Aeronautics and Astronautics (AIAA). The Russians will spend close to four days at Sperry Rand plants and installations, a day each at IBM and TI, and part of another day at Cutler Hammer's AIL division during **the two-week visit that ends later this month.** The Soviets are also visiting FAA and NASA installations and, while they met other vendors at the AIAA annual meeting, industry sources say it is easier to sell on home ground. FAA officials insist that **the Russians will visit other companies "on their next trip."**

. . . but U.S. naïveté hobbles first talks

Even though there are **White House indications that Pentagon export embargoes will present no problem** in the event of a U. S. sale of computerized air-traffic-control equipment to the Soviet Union, **industry's inability to coordinate its proposal efforts hobbled the first round of U. S.-Russian talks** in Washington. American manufacturers, lacking significant precedent for large deals with the Soviets, were left confused when the response to U. S. inquiries about how to structure a proposal was that it was up to the Americans to make that judgment.

The slashing of Federal support for domestic R&D

Meat axes are much in evidence in the capital as President Nixon's budget managers rush to fulfill their chief's desire to put a lid on Federal spending, beginning with the fiscal 1974 budget that will go to Congress at the end of January. The result is that many Federal research programs in electronics and other technologies are being lopped off so fast that much of the nation's research community is angry and frustrated. These critics also question the whole system of R&D priorities set up by the White House, which seems to be highlighting short-term applications programs with trade potential to the exclusion of nearly everything else in the domestic sector.

Who are the critics? There are many. Among the most prominent are Edward David, who recently resigned as science adviser to the President to join battery maker and Navy torpedo contractor, Gould Inc., and most of the Presidential Science Advisory Committee (PSAC), all of whose resignations have been accepted by the White House, pending a complete reorganization of its Office of Science and Technology [*Electronics*, Nov. 6, 1972, p. 51]. But David and the PSAC members must be considered passive critics, having stopped short of publicly challenging the budget policies.

An unhappy Branscomb

Among the distinguished outspoken critics is former National Bureau of Standards boss Lewis M. Branscomb, now with IBM. Emphasizing that his personal concerns were those of "a scientist and private citizen," Branscomb used the forum of the Scientific Research Society of America meeting in Washington a month ago to deliver some sharp criticisms of the Nixon program for stimulating commercial R&D. He specifically targeted the direction of Experimental Technology Incentives Program (ETIP), which is being promoted and directed by William Magruder, presidential adviser and former SST project director [*Electronics*, Jan. 31, 1972, p. 42].

Branscomb finds himself uncomfortable with ETIP "as many conceive it." He does not believe "that the way to approach the identification and removal of barriers to innovation is through contractual relationships with single companies for the conduct of commercial research and development. It is hard to imagine that decisive results will flow from Government-funded development unless the Government is the real, rather than the surrogate, customer for the resulting product. We have no way to find that narrow band of return-on-investment that is insufficient to justify investment of private capital, yet somehow sufficient to justify the Government's participation."

Nevertheless, the Bureau of Standards has been restricted to initiating but a single new program, ETIP, out of its largest budget in history, notes Branscomb with some bitterness. "After the excellent policy basis set in the President's R&D message to Congress last March, the new appropriated funds for many well-thought-out programs that address barriers to private R&D without interfering with the free play of competitive forces have apparently been impounded." With his old agency left only with ETIP as an initiative, Branscomb calls it "very disappointing to see a pattern of successful work in support of economic development and public protection, welcomed by the industrial R&D community, turned off and replaced by a speculative program whose basis for usefulness is still to be established."

Who's all right?

Criticisms such as Branscomb's on the direction of Federal support for nonmilitary R&D are only beginning to appear within the electronics industries. At that, they are still largely confined to affected researchers heard griping at industry symposia. Corporate managements for the most part tend to focus on the benefits of the Nixon hold-down on Federal spending and its ostensible goal of halting tax increases. Their attitude, described by one research manager as one of "I'm all right, Jack," appears not to have sensed what the overriding emphasis on applications development programs portends for the long-term future of U.S. technology. Nevertheless, that issue and its implications for industry are sure to surface in the new Congress, one that is increasingly angry at having its legislative programs frustrated by the President's arbitrary impounding of appropriated funds.

Among other places on Capitol Hill where answers will be sought to the question of who's all right—and who is not—in the Nixon program for advancing civilian applications of technology: the new Office of Technology Assessment, whose congressional committee is being chaired by Sen. Edward M. Kennedy of Massachusetts, that commonwealth now jokingly referred to in some Nixon quarters since the election as "the lone star state." It shapes up as one of a number of bitter battles between the White House and the Congress in 1973.

—Ray Connolly

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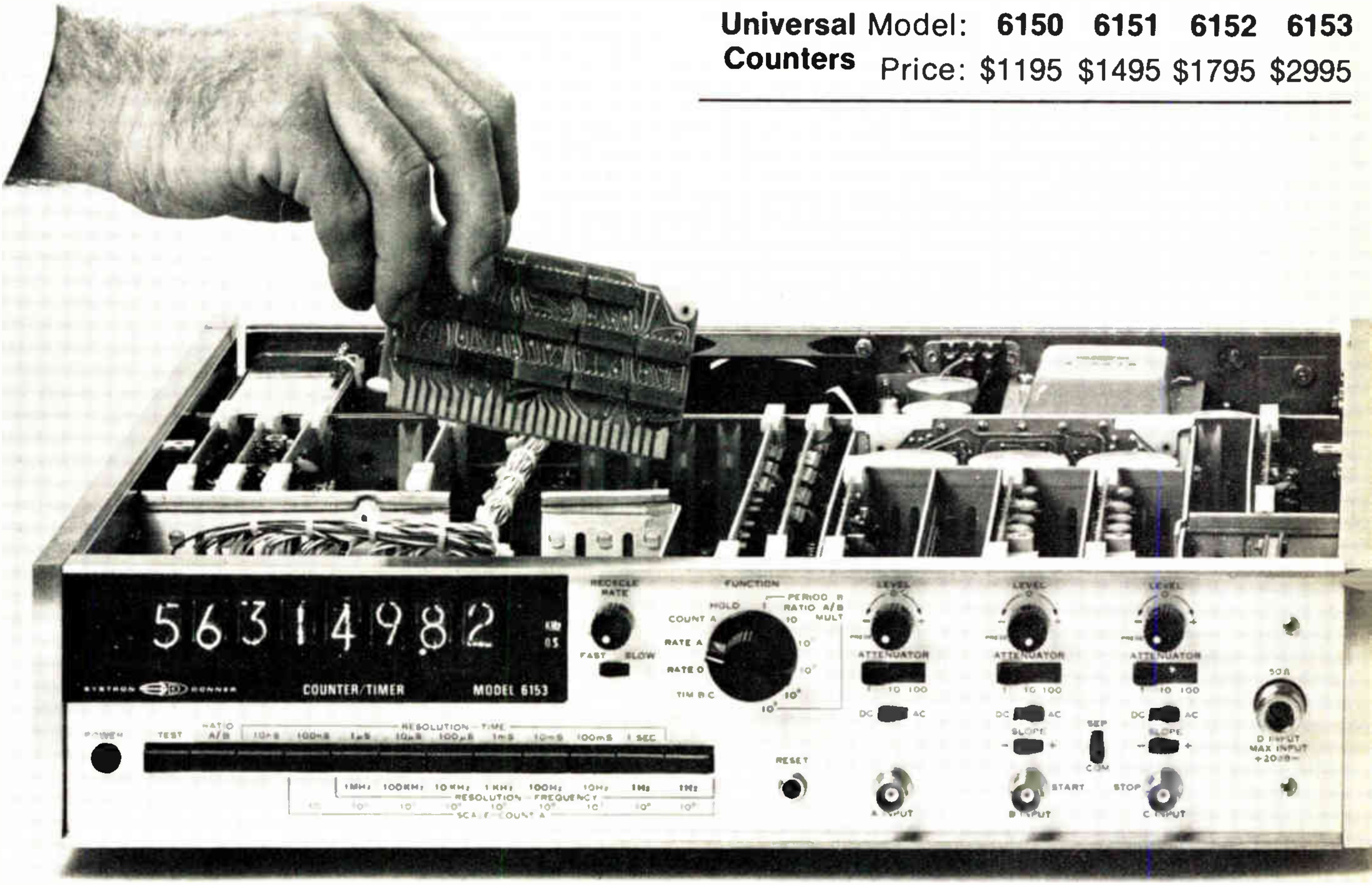

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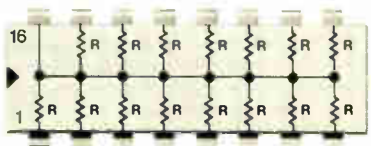

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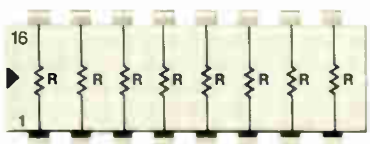

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68	150	470	1.5K	3.3K	6.8K	22.0K
100	220	680	2.0K†	4.7K	10.0K	

*Standard in 898-3 only.
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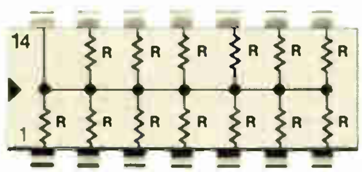

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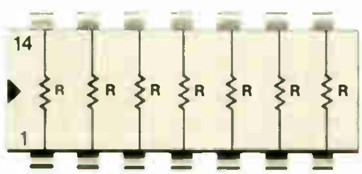

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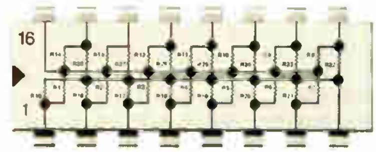
STANDARD RESISTANCE VALUES
(± 2% or ± 2Ω)

22	62	180	510	1.5K	4.3K	11K
24	68	200	560	1.6K	4.7K	12K
27	75	220	620	1.8K	5.1K	13K
30	82	240	680	2.0K	5.6K	15K
33	91	270	750	2.2K	6.0K	16K
36	100	300	820	2.4K	6.2K	18K
39	110	330	910	2.7K	6.8K	20K
43	120	360	1.0K	3.0K	7.5K	22K
47	130	390	1.1K	3.3K	8.2K	
51	150	430	1.2K	3.6K	9.1K	
56	160	470	1.3K	3.9K	10K	



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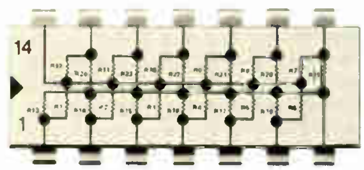
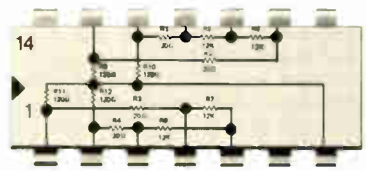


899-5-R220/330
Pulse squaring TTL terminator.
Price (1,000-4,999) $1.35



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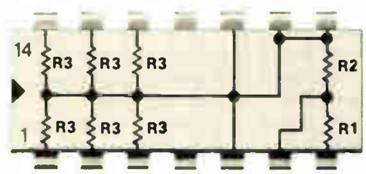

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DIP network provides six line terminators and the threshold setting divider for the Intel 3208A sense amplifier.
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Circuit conserves energy in photo flash units

Photographers will soon be getting more flashes per charge—and per minute—from the new generation of automatic electronic flash units now hitting the market.

Like the units now on the market, they control their own light output, freeing the photographer from having to readjust his lens aperture each time he changes his distance from the subject. However, when their full illuminating capabilities are excessive, the new units do not waste energy like the earlier units. Instead, the photographer gets more flashes from his batteries and quicker recycling after each flash.

The race to develop a unit of this type on both sides of the world was a dead heat. Japan's Nikon and Braun in West Germany both unveiled their new automatic flash units recently in Germany.

Longer life. Nikon's unit has a switch that gives automatic operation, with a choice of three different lens apertures, or full output for manual operation. During manual operation about 40 flashes are obtained with ordinary penlight cells, and recycling time is about 8.5 seconds. But for automatic operation at a distance of 3 feet, the same dry cells will give about 400 flashes, and recycling time is reduced to less than 1 second.

Other Japanese companies now have units, too. Matsushita Electric Industrial Co. has put a similar flash unit on the market. And Toshiba has announced a similar unit to go on sale in February.

The basic electronic flash is simple. It consists of a direct-current-to-direct-current converter, a capacitor to store energy, a gas-filled flash tube, and a trigger circuit to synchronize the flash with the camera shutter. The first generation automatic flash units use the same basic circuit with additional components that terminate the flash when subject illumination is adequate, when the photo is taken at less than the maximum distance.

Quench. A sensor, normally a silicon photodiode or phototransistor, picks up light reflected from the subject. Its output, amplified and integrated, actuates a switching circuit when its output reaches a predetermined value. That circuit triggers a so-called quench tube—a small low-impedance gas tube that short circuits the flash tube—thus terminating the flash and discharging the energy still stored in the capacitor. The quench tube is a simple arrestor-type gas discharge tube with external trigger electrode—capacitive current flowing from the trigger electrode to cathode is sufficient to fire the tube.

Nikon engineers sought to replace this circuit with a series switching circuit that would stop the flash without dumping the charge remaining in the capacitor. But they could not do so because no suitable switching device existed. This year, however, Mitsubishi Electric Corp., which is in the same industrial group as Nikon, was able to produce a suitably small silicon-controlled rectifier that can handle 300 volts and surge currents in excess of 300 amperes, and still be turned off within 5 microseconds. □

Italy

Drumming up sales with rhythm IC

The percussive world of the dance-band drummer might seem to have little in common with the arcane world of MOS. But SGS-Ates—Italy's leading semiconductor manufacturer, located on the outskirts of Milan—thinks otherwise.

It is offering a single-chip "rhythm" generator that supplies much of the skill once required of a drummer. This IC is the key component of the electronic rhythm accompaniment for electronic organs.

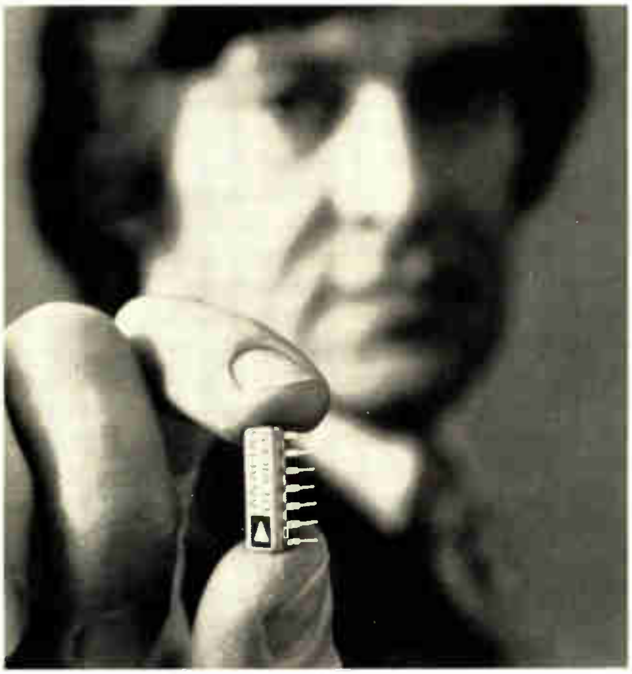
One outstanding feature of the IC is that, via a relatively inexpensive change of masks during manufacture, clients can select up to 12 different rhythms. Thus, by courtesy of SGS-Ates MOS Planox technology, dance band organists can back their sounds with anything from waltz to rock rhythms, or if they want, even an Irish jig or a tarantella.

The basic idea, SGS-Ates says, already existed as a result of regular contact with Italian and European organ manufacturers. But that idea was put into practice in late 1971 when a leading european organ manufacturer wanted a custom-designed single chip. The client not only wanted to be in the technological forefront but also wanted to cut down on the cost and space taken up by the conventional components, which were either combinations of ICs or, more frequently, transistorized circuits.

Intervention. The SGS-Ates 24-pin package offers savings in assembly time, space, and materials that can reach as high as 30%. It measures a meager 2.97 by 1.52 centimeters, compared with up to 10 by 10 cm for the transistorized circuits. Although having adapted the original chip for the standard market, SGS-Ates considers it a semi-custom item, because users will be able to customize part of the chip—the final circuit masking—themselves.

The immediate market that SGS-Ates has in mind is the Italian organ and accordion market, which the company reports is the largest in Europe, with at least half of Europe's manufacturers of such equipment and more than half the European industry's sales. □

If you thought our first I.C. multiplier solved a lot of your problems, take a look at this one.



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Soviet belief in own computers spells poor sales for West

Though a leading Soviet automation expert, V. Galeev, who is in charge of the city of Moscow's computer center, in *Pravda* this week described widespread waste, duplication of effort, and lack of government leadership in developing software, the Soviets' confidence in their hardware is stronger than ever. A spot check with informed Western business and computer experts in Moscow reveals that currently there is a **decidedly gloomy outlook for computer and peripheral equipment sales to the Soviet Union.** "There are clear-cut signs that the Soviets, rightly or wrongly, are convinced that they can resolve most of their major computer problems with their own equipment or equipment from Eastern Europe," says one of Moscow's most seasoned computer marketing experts.

Negotiations are still under way for sales of computer systems to Aeroflot, Intourist, and the Kama River truck plant, the sources say. Moreover, all are expected to be signed by the end of the current year. Firms bidding include IBM, ICL, Sperry-Univac, and Leasco. But again, some sources here think that **Soviet planners may well opt for Soviet/Comecon-built equipment,** and even Kama—whose eventual computer system is estimated at $15 million—**may buy Western equipment only to supplement its needs.**

Plessey X-band devices show low noise

Builders of instrument-landing and electronic-countermeasures systems are experimenting with samples of low-noise, high-gain gallium-arsenide field-effect devices built into microstrip amplifiers. Production samples of the devices, developed by transistor researchers at the Plessey Co. Caswell Laboratories, yield maximum stable gain of 10 decibels at 9.5 gigahertz. Noise measurements are not yet complete, but it's estimated at 6.5 dB in X band, extrapolated from a directly measured 4 dB at 5 GHz. Unity gain cutoff is around 40 GHz.

High gain with low noise is obtained by using a three-layer GaAs structure in which the high-resistivity substrate has a similar epitaxial layer grown on it before the active layer, 0.3 micrometer thick, is grown on top of that. The intermediate layer produces a sharper change in carrier concentration at the active interface, which boosts the gain, and it has fewer structural defects than the bulk substrate, which cuts noise. For high definition, the photoresist in the gate region is exposed to an electron beam, but ultraviolet light is retained for source and drain.

Technical abstracts available from German EE society

For engineers, technicians, and scientists who want access to material published in electronics or electrical journals, the German association of electrical engineers has started up a computerized information service called the Electrotechnical Literature Service. **Available to any subscriber in any country, it furnishes abstracts of technical articles published in about 500 magazines from around the globe.** Articles in English are summarized in English, all others in German. Fee for the service is between $14 and $75 a year, depending on the number of abstracts and frequency at which they are mailed. These charges work out to an average of 2 cents per abstract.

Motorola seeks president for French plant

Motorola is looking for a new French president for its semiconductor plant in Toulouse to replace Tienne Cassignol, the former professor who has been in charge since the plant started operating in 1969. **Cassignol resigned this month to become president of Jaeger S.A.**, a French producer of avionics equipment and automobile instruments, many of them electronic. Motorola European vice-president Robert Heikes says the Jaeger offer gives Cassignol an opportunity to expand his managerial responsibilities in a way that would have been impossible in the near future at Motorola. "He would have been a candidate for my job, but I'm not planning to leave tomorrow," Heikes says.

Directly switched laser achieves 1-GHz bit rate

Tests at Standard Telecommunication Laboratories Ltd. by the team working on laser-powered glass-fiber digital data transmission have shown that STL's mesa-type gallium-aluminum-arsenide double hetero-structure **laser can be switched directly to produce a pulse-code-modulated data stream at a bit rate of 1 gigahertz.** This is quite fast enough to be acceptable in operational systems and much faster than previously reported for direct switching. To attain such a bit rate, it's been generally assumed that complicated modulation, possibly optical, would be necessary. STL's mesa is typically 30 micrometers across and dc-biased to 130 milliamperes, which is around the lasing threshold. Added to the steady bias are 20-mA modulating pulses.

Japan starts fax service to Korea

Japan's overseas telecommunications carrier, Kokusai Denshin Denwa, has started public facsimile service to Korea from Tokyo. The service, says the company, can send **at reasonable rates Chinese, Japanese, and Korean characters and graphic information.**Customers sending lengthy manuscripts will benefit from rates that are less than half those of the present word rate. Two page sizes, full and half, are available. A full page, equivalent to about 400 words, costs only $16.80, compared with $53.33 for standard message transmission.

Ericsson sells electronic phone exchanges to Mexico

Sweden's L M Ericsson has landed its first export order for an electronically controlled rural telephone exchange system—a $3 million order from the Mexican telecommunications administration. **The order covers some 100 small exchanges, which include both integrated circuits and discrete components in the control units.** The Ericsson system was developed in cooperation with the company's Norwegian subsidiary, A/S Elektrisk Bureau, which is making similar exchanges for Norway.

Addenda

Sweden's Bofors has sold its electronic equipment subsidiary, AB Meteor, to the electrical-equipment maker ASEA. Meteor, founded as a subsidiary of a security-guard service, was acquired by Bofors in 1969. It has developed several computer-linked control systems, and its major product is a banknote-dispensing system. . . . **Japan's Murata Manufacturing Co. is setting up a U.S. manufacturing plant** in Cartersville, Ga., to make ceramic capacitors, piezoelectric devices, and varistors. . . . Another Japanese company, Oki Electric Industry Co. is setting up a joint venture, Oki Data Corp., in Cherry Hill, N. J., **to import Oki's computer-peripheral and terminal equipment.**

IC makers speed JAN qualification

The prospect of a rising military market for parts that meet joint Army-Navy specifications induces manufacturers to get on the qualified-vendor list

by Larry Armstrong, Midwest bureau manager

After a surge of activity late last year, many integrated-circuit suppliers have qualified as Joint Army-Navy vendors. Although they have beefed for years about the inconveniences of conforming to JAN specs [*Electronics*, Oct. 25, 1971, p.97], IC houses have been lured into the fold by the promise of sizeable shipments in the first quarter of 1973 and by the prospect of simplifying in-house high-reliability specs.

"The market," says Frank Jelanko, military merchandising manager at Signetics Corp., Sunnyvale, Calif., "will probably be large enough that you'll be hurt if you're not qualified." He expects that about 10%—$3 to $5 million—of the high-reliability ICs sold in 1973 will be JAN parts.

"We picture the JAN parts as taking over a large part of the market now covered by customers' high-reliability specifications," says Charles Ketchum, product marketing group manager for TTL at Motorola Semiconductor Products division, Phoenix, Ariz. "Like others in the industry, we also have had our own high-rel program, but we see the JAN parts replacing them in a few years."

No consensus. Long-range estimates of the market range all over the ball park. Bob McKenna, manager of military strategy at Texas Instruments, Houston, predicts, "Within the next two to three years, the JAN IC market will be up to $30 million annually, assuming substantial growth in the total military IC market." Tom Magill, marketing manager for JAN ICs at ITT Semiconductor division, West Palm Beach, Fla., the first manufacturer to qualify an IC to meet the JAN spec, predicts that the JAN market will be in excess of $100 million by 1975.

But while many firms have won either interim or final qualification from the Defense Electronics Supply Center to produce and sell JAN-symbolized ICs, most characterize shipments to date as "minimal"—they expect substantial orders to begin this quarter. Texas Instruments, however, apparently is the exception. TI reports that it has been shipping 50,000 JAN devices a month since October, although many of the devices have gone to distributors.

Many manufacturers seem reluctant to build inventories knowing that another vendor's final qualification will oust their interim quali-

Now available. TI's McKenna: "The growth of JAN ICs will be impacted almost totally by availability."

The who, what, and how of JAN specs

The JAN IC program is an effort to create an industry standard for high-reliability integrated circuits for military uses. The program is supervised by the Defense Electronics Supply Center (DESC). MIL-STD-883 tells how to test ICs, MIL-M-38510 details how 883 must be applied in specifiying procurement of ICs, and JAN specification "slash sheets" give the detailed electrical and mechanical specifications that families of ICs must meet.

Qualification requires two steps. Part II is interim—a manufacturer is listed after he has been surveyed by DESC, after he's submitted design and test documentation for each part he intends to produce, and after he has submitted electrical test data taken on a minimum sample of parts per slash sheet. Following submission of additional qualification test data, he is listed as part I supplier. Part II is a temporary qualification—good for a year; but as soon as any vendor achieves part I, others making that device have 30 days to achieve final qualification, or they lose their part II listing.

JAN numbers specify not only device type, but also the lead materials and finish, package, and 883-device-testing class. At last count, 31 specification slash sheets covering 120 device types had been issued under the JAN IC program. Bipolars make up the bulk of the ICs covered by the slash sheets, but other technologies are included as well. Among them: a dozen linear devices, a programable read-only memory, and two complementary-MOS devices. In addition, a number of other C-MOS slash sheets covering some 27 device types are close to final issue. Industry also expects to see slash sheets fairly soon for more memories, the 5400 Schottky TTL family, and diode-transistor and emitter-coupled logic.

fied parts. Not completely so, says McKenna: "Material being produced for JAN business on the books, or devices on the customers' and distributors' shelves is still considered JAN material." Devices in a manufacturer's stock are disqualified until he achieves final qualification.

Price has undoubtedly cut down on shipments. "Right now, it looks like it will cost as high as three to five times as much to build to JAN instead of similar, high-rel military device lines," McKenna says, and he echoes the sentiment of the industry. This increased cost reflects the military requirement to build only domestically, tightened electrical parameters, 100% dc-parameter testing at high, low, and room temperatures, 100% electrical switching tests, periodic testing, and reporting requirements, as well as such nonrecurring factors as equipment costs and qualification.

Price differential. Jelanko, of Signetics, agrees that the JAN-qualified ICs are three to five times more costly than commercial-grade ICs. He attributes this to the costs of domestic assembly. And he says that if at a later date the military allows offshore assembly, the costs will drop, and the JAN market could become 25% of the total IC market—but no more than that, he adds.

Advanced Micro Devices, Sunnyvale, Calif., in the process of qualifying its plant now, expects "huge administrative hurdles"—documentation and inspection—ahead, says G. Bowers, director of product assurance. He doesn't expect technical problems in testing devices.

Charles Von Urff, military-aerospace marketing manager at National Semiconductor Corp., Santa Clara, Calif., agrees that there are no technical problems in testing procedures, but adds that the testing equipment means a heavy additional investment.

But prices for JAN circuits are already dropping, points out Joseph Brauer, chief of the Solid State Applications section in the Reliability branch, Rome Air Development Center, Rome, N.Y. Companies are finding it easier to produce devices to a single specification than to the many different ones they had to worry about before, he says, repeating a frequent rationale given for the establishment of the standards. As for the price premiums being paid as a result of rigid spec and testing requirements, these vary considerably among devices, he

The view from RADC

"After all the sound and fury, people found they actually could get good yield on quality devices," says Joseph Brauer, chief of the Solid State Applications section in the Reliability branch, Rome Air Development Center, Rome, N.Y. "We've seen a dramatic reduction in prices since the first mil specs for ICs were out." Brauer, who was instrumental in drafting MIL-M-38510, has been critical in the past about the poor quality of ICs his branch has evaluated.

Brauer characterizes as "generally small" the ratio of JAN IC costs to other high-reliability program costs, but one ratio that is large, he adds, is the price difference between the lowest and highest bidder, particularly for a complex part. Bids may range over a five- or 10-to-one ratio, indicating to Brauer that some companies are not as serious about what they're doing as others.

Industry has signaled that it welcomes standardization, "as long as we don't get too nasty about it," he says. "We've had better communications in the spec-generation process than ever before." But some of the loudest complaints about individual specs may have been just "smoke screens" to cover up a company's deficiencies in the choice of process or schematic or both, he adds.

As an example of this new industry-Government cooperation, Brauer points to a new Texas Instruments brochure, "a simplified guide to JAN ICs and Mil-M-38510." It has some exceedingly complimentary words on how well the JAN IC program is going, Brauer says. "I couldn't have written it better myself."

says. Simple gates may sell for "very close to commercial prices," he says, while more complex devices are more expensive.

Spec simplification. Offsetting these higher device costs will be the reduced cost of procuring ICs, which industry sources expect may be cut by as much as one-third—by the elimination of customers' in-house spec-writing groups and qualification activities. "One of the equipment subs on the F-15, for example, has reported $150,000 savings for the initial development quantity of JAN ICs over the cost of buying to its own nonstandard specs," says Terry Utz, standards engineering manager and F-15 parts-control-board chairman at McDonnell Douglas Corp., St. Louis. "He's already placed the order and gotten delivery, so it's not something that's going to happen—it's something that has happened."

The big market impetus will be the Government's insistence that JAN ICs be used on major military programs, and industry says it's been supplying qualified circuits for the F-15, B-1, and even F-4 aircraft modification programs, as well as other programs still in their early stages. "The Harpoon missile wasn't able to use JAN ICs in development, but will use about 2,000 per bird in production," Utz says.

And manufacturers expect that many programs that do not require JAN specs will go that way because of the availability of multiple sources. "A JAN circuit is a JAN circuit, regardless of who is supplying it," says ITT's Magill. "The only factor will be price and delivery." Magill also points out that, since discrete JAN equivalents are used in some commercial programs, JAN ICs may follow suit. But he cautions that can only become a small factor in the market.

"We've detected a surprising market in small subcontractors building military field equipment," adds TIs McKenna. "These people are becoming extremely interested in the distributor availability of JAN, although it may be for systems not requiring JAN devices. It allows them to utilize the characterization and qualification work done by the manufacturer in obtaining the JAN qualification." □

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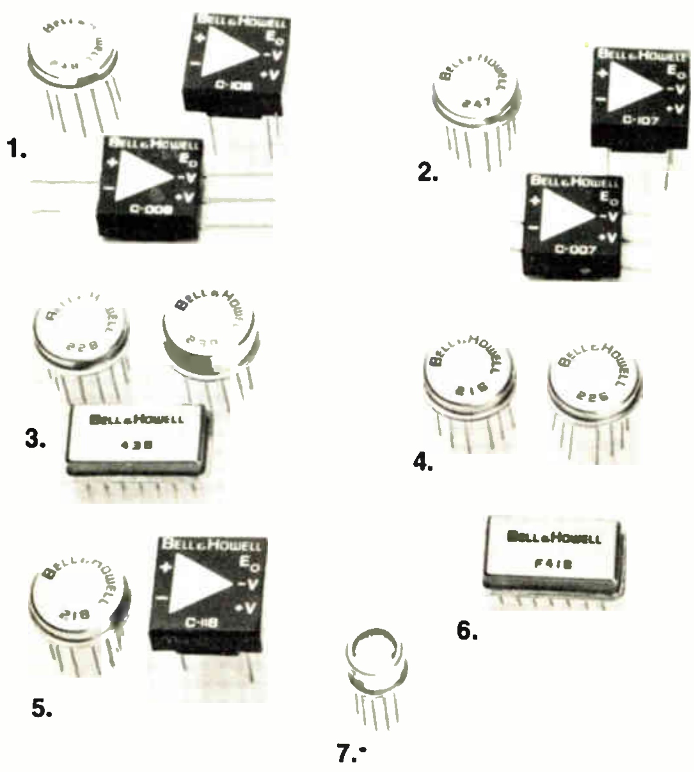

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BELL & HOWELL

Commercial electronics

Loran C signals commercial bid

Four receiver manufacturers, capitalizing on digital IC design, have cut prices to less than $5,000 for marine navigation receivers

by Lyman J. Hardeman, Communications & Microwave Editor

Loran C, once exclusively military, is becoming available to commercial shipping, fishing vessels, and even large private yachts. The key to the commercial market for navigation systems is price. The first generation of Loran C receivers cost well over $20,000 per unit. But recently receiver manufacturers have come up with new designs that make extensive use of digital integrated circuitry and innovative hardware, and receiver prices have dropped to between $3,000 and $5,000.

Development of low-cost Loran C receivers has been stimulated by U.S. Coast Guard funding of research and development. But now, careful market research, even more than technical design, will be a critical factor for companies seeking to win a chunk of the commercial Loran C business. It is not apparent now, for example, whether the commercial user is willing to pay more for automatic features or whether he may be willing to sacrifice a few operator conveniences for lower costs. It is certain, however, that use of Loran C equipment is gaining momentum and will play a much more dominant role among navigation systems of the 1970s.

For several years, inexpensive Loran C receivers that detect and process the pulse envelope of the transmitted Loran C waveform have been marketed. Loran C is a navigation system in which the difference in time of arrival of pulses transmitted from two or more fixed-station pairs is compared at a mobile receiver to determine the receiver's location. The system's operating frequency is 100 kHz, and its bandwidth is 20 kHz. The new receivers considered here achieve much greater accuracy (down to about a quarter of a nautical mile, or 5–10 times better than envelope detectors) by tracking the phase of the rf waveform inside the transmitted pulse envelope.

Who makes them. Two of the four companies that have developed such receivers are Teledyne Systems Co., Northridge, Calif., and Litcom division of Litton Industries, Melville, N.Y. Both developed their units under Coast Guard sponsorship. Epsco Inc. and International Navigation Inc., both located near Boston, have developed receiver models using in-house funds, and each of these two companies last month announced marketing arrangements with European-based distributors.

John Hopkins, commercial marketing manager at Teledyne, emphasizes that the earlier so-called Loran C-type receivers now selling at about $1,000 or so, employ envelope-detecting techniques similar to those of Loran A and therefore don't use the full capability of the Loran C signal. Hopkins believes that "many users mistakenly think that Loran C is less accurate than Loran A because of these receivers."

For the full-capability receivers, both rf front-end design and the extensive use of digital integrated circuits have been strong factors in reducing receiver hardware costs. All of the commerical receivers contain a hard-limiting amplifier in the rf

For commercial navigation. Loran C receiver from Litcom is expected to sell for less than $5,000. It includes a centralized processor and a narrow-band rf input filter.

section, a cost-saving design that is often considered less attractive for military receivers because of its susceptibility to jamming interference.

Standard TTL integrated circuits are being used extensively to implement the numerous Loran C digital functions. However, under separate development programs, the military is pushing to get most Loran C functions on several metal-oxide-semiconductor LSI chips. Once this is accomplished, fallout from these efforts may be applied to commercial receivers, and costs could drop even more.

Like Teledyne's receiver, Litcom LCR-301 is manufactured to Coast Guard standards. But unique to the unit, states Claude Pasquier, director of the company's Navigation Products department, are a centralized multipurpose processor and high-performance front-end filter. The single processor replaces numerous specialized circuits that were previously required to perform the multiple functions in the receiver. Considering the diversity of such functions, Pasquier believes that Litcom's multipurpose processor is a major factor in minimizing costs as well as in increasing the reliability and reducing the size and weight of the unit.

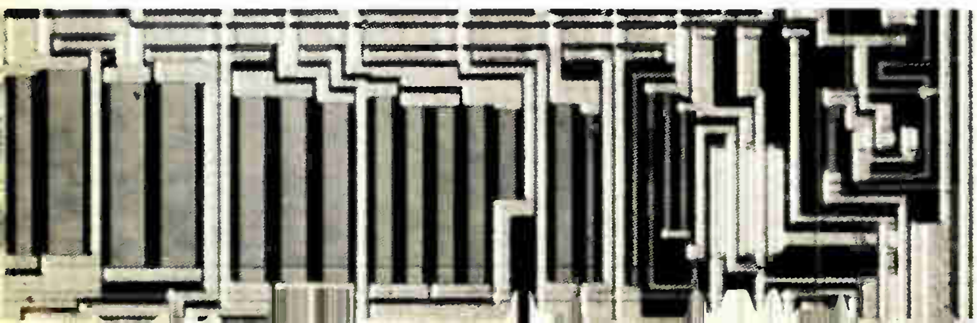
The front-end filter in the Litcom receiver produces a 20-kHz passband at the 100-kHz Loran C center frequency. This is done by designing the filter so that all frequencies outside the 20-kHz passband are attenuated by approximately 50 dB. In competing designs, narrow-band notch filters must be manually tuned to cancel the effect of interfering signals.

Prices. The Teledyne TDL-601 receiver is now in early stages of production, with deliveries to start next June. Price is not definite yet, but it will probably be about $5,000 retail. Teledyne will sell through dealers to ensure service, hence the price is higher than the $3,000 to $4,000 originally projected. The company has sold "well over 100 receivers" in this early stage, says Hopkins.

The Litton receiver is also in the preproduction stage. Volume production prices to users are expected to range from $4,000 to $5,000. The model 4010, built by Epsco is priced the lowest of all the Loran C receivers; it sells for $2,995. Bob Bartlett, engineering vice-president at Epsco, reports that nine preproduction models have been extensively tested, and delivery of production receivers will start this month.

Epsco cut some $500 of the cost of its unit by eliminating the processing circuitry needed to automatically lock on to two of the three Loran C stations, says Bartlett. This means that the user must manually input his approximate position. Epsco is betting that many of commercial customers will be willing to sacrifice this automatic feature in return for the lower price.

The fourth full-accuracy Loran C receiver is International Navigation Co.'s model 101, which like the Epsco unit, requires manual acquisition of secondary Loran C transmitters. The unit sells for about $3,500. □



Circle 141 on reader service card

Companies

Minicomputer firm thrives on OEMs

In a unique strategy, Computer Automation passes up popular end-user market and cuts costs to concentrate on mass sales to systems houses

by Paul Franson, Los Angeles bureau manager

When the recession of 1970–71 struck, a number of start-up minicomputer manufacturers died aborning. Still others that had committed themselves to the original-equipment-manufacturer market began abandoning it for end-user business—any business that would keep the orders coming. Possibly unique among U. S. minicomputer makers is Computer Automation Inc., Irvine, Calif., which got its start as an OEM supplier about five years ago, weathered the recession without wavering from its original market target, and is even more firmly committed exclusively to OEMs today.

Determined firm's course. "We will not be a systems company," says David Methvin, Computer Automation's 35-year-old founder and president. "We're in the OEM business to stay—by choice," he asserts. That determination is paying off. Sales for fiscal 1972 reached $4.87 million, with profits better than $649,000, and one investment analyst predicts that the company will top $9 million in fiscal 1973 sales.

Methvin won't make public his sales and earnings forecasts. He points to the record: 320 minicomputers shipped in the most recent quarter, in contrast to 550 all last year, recent orders of more than $3.3 million from five OEM customers, and $2,150,000 in sales for the first quarter of fiscal 1973.

Computer Automation is probably best known as the originator of the Naked Mini—a computer without power supply, chassis, or programer console, which is typically buried in the customer's system. But the firm also makes "dressed" minicomputers in its Alpha line. The first product, an eight-bit machine, made its bow in December, 1967; since then has come a series of eight- and 16-bit machines that evolved into the Naked Mini and Alpha lines. Computer Automation's 1,000th machine was delivered last July; number 2,000 is expected to be shipped from the company's new 73,000 square foot leased plant next month.

Price of the eight-bit stripped processor is as low as $1,450, and when the 16-bit version was announced in late 1971, its price ($2,500 for a minimum of 10) sent a shudder through the industry and triggered a round of price reductions much like those that have typified the semiconductor industry.

The analogy isn't far off; Methvin points out that the declining price curve is opening many markets, just as semiconductor price reductions have: "We used to quote on five, 10, maybe 100 computers, two years ago. Now, after the Naked Mini, we bid on 500, 1,000, even 10,000."

A broadening customer base. Computer Automation has more than 100 customers, but only a few are taking larger numbers of computers. Only a year ago, Methvin says the firm had a single major customer (he defines major customer as one responsible for over $1 million per year). But now he has five, and hopes eventually to have 30.

General Computer Systems Inc., a Dallas manufacturer of key-disk-tape systems is a major customer, as are Docutel Corp. of Irving, Texas, which makes automatic bank tellers; and Hycel Inc., of Houston, which makes automatic medical instruments.

In addition to these markets, Computer Automation is seeking markets in office equipment, point-of-sale systems, the telephone industry, and, to a lesser degree, the automotive industry.

The diversity of customers points up Methvin's strategy: "The whole world is a market for minicomputers, but I know that I can't get into end-user markets unless I concentrate on one or two. But we can get into all of the markets through the back door." The back

Trend-bucker. David Methvin, Computer Automation's president, finds profits in the OEM business.

door to the market is provided by the system supplier to whom Computer Automation sells. As an example, he mentions Docutel Corp.'s automated bank teller. "It's a very complex product and market. One company couldn't compete effectively in more than one market like that. But the back doors of all the systems suppliers look the same. They have the same concerns: reliability, supply, delivery, and prices."

Just as Computer Automation is trying to reduce its dependence on a few companies, its customers are concerned about sole sources: "Our customers are seriously dependent on us. We could sink a customer if we ran into problems," admits Methvin, and he adds, "we really have to work with them. They can talk directly to me."

"We have to live with our OEM customers and recognize their problems. We realize that our customers' new R&D products sometimes slip, and we don't scream if their orders slip as a result. Projections made on new products are typically not met. We know that, and we plan for it. We get very close to both technical people and management. We have nondisclosure agreements and sometimes know a year in advance about their new products," Methvin says. Part of this confidence may result from the customers' knowing that Computer Automation isn't going to compete with them, which is also part of Computer Automation's strategy. "We've had customers madder than hell because their suppliers have gone into business against them," he adds.

Why are companies buying computers rather than making them themselves? One reason, says Methvin, is the time it takes to develop a computer. This adds to the time it takes to get a new system product to market. Another reason is cost. "If the customer designs his computer," says Methvin, "he locks himself into that cost, or has to spend more to keep current, while prices in the minicomputer industry are declining."

Methvin says that for a large quantity of computers, the user might think it worth the risk, but there's an alternative: "We offered to let a major company build the computers themselves after 4,000 units. They'd get the best of both worlds. They can get in the market quickly with a proven design, yet know that they can build the computers if they think they can save money on high quantity."

Methvin admits that he doubts that the customer will build the computer. "By the time we get there, the price will probably have dropped."

How to make it. Computer Automation has pushed its prices down, he says, by looking hard at all the components in the computer. The Alpha, for example, uses injection molding instead of metal for the front panel. "You can't use it for only a few hundred computers," Methvin says. "We watch component price curves, too, and squeeze each piece. We tell engineers, 'don't make it especially fast; don't make an engineering monument.' We say 'make it at half the cost!' "

Computer Automation emphasizes reliability, burning-in and testing all incoming components, then doing the same for the finished computer. All computers go through an accelerated test Methvin says is equivalent to three months of actual service.

This kind of intensive testing, in fact, led to the only system the company sells, though Methvin calls it a product rather than a system. It's the Capable tester for printed-circuit boards. "We backed into the Capable tester, but no one in that business was a customer of ours, and it's for a limited number of users."

Ubiquitious minicomputer. A large cloud on the horizon of all minicomputer makers, the reason that many minicomputer companies are seeking end-user business, is the development of computers on a few semiconductor chips. These microprocessors have taken little business from minis so far, but with increasing capability, the minicomputer hardware business may increasingly belong to "people with furnaces." Methvin agrees that microprocessors can be used in many applications that don't need full minicomputer capabilities. But he thinks that many of the microprocessors will end up talking to minis, and "there are many places where you can't use a microcomputer." □

Commercial electronics

Lasers start to shine in industry

As automation and mass production cut their cost, coherent-light devices begin to replace other components and increase efficiency in many systems

by Paul Franson, Los Angeles bureau manager

The laser, once described by its inventor, Ted Maiman, as "a solution looking for a problem," is emerging as an OEM component with a market estimated at $20 million this year and rising to $115 million in 1980.

This is the prediction of Richard P. Roemer, manager of laser product sales at the Hughes Aircraft Co. Electron Dynamics division, Torrance, Calif. The major reason for the recent surge in applications is price. Automated manufacturing techniques, particularly at Hughes, the RCA Corp. Electronic Components division, Lancaster, Pa., and Spectra Physics Inc., Mountain View, Calif., have reduced the price of a gas laser (without its power supply) to between $80 and $100 in large quantities.

Philip H. Vokrot, RCA marketing manager for gas lasers, sees prices falling to "$25 to $40," depending on volume. Spectra Physics Laser Products division sales manager David S. Evans attributes the rapid decrease in prices to high-volume production and a drop in research and development costs.

Present users, although widely diversified, do not yet require particularly large volumes, but that may change soon. Hughes is quoting quantities of 10,000 to 100,000 a year to some users, says Roemer. The large-volume applications may include data readers, credit verifiers, facsimile, and new consumer products. In applications such as these, the lasers are regarded as system components—more expensive than integrated circuits, but comparable in price to the digital panel meters that form similar subsystems.

Right now, however, sales are confined to a variety of small-volume users. "Construction is the biggest market," says Roemer. The major suppliers of laser systems for the construction industry are Laser Alignment, Grand Rapids, Mich., Blount & George Inc.'s Laser Grade Light division, Jacksonville, Ark., and Spectra Physics. The systems cost up to $8,000.

Blount & George was the first firm to use the laser for construction work, beginning in 1964, says a company spokesman. The first product was a laser alignment system for controlling grade and direction of sewer lines. Today, sewer-line control accounts for $6 million to $7 million annually, he says.

Blount & George's most recent product is a laser tracking level, used in surveying. A laser at a remotely controlled station tracks automatically a level rod held by a surveyor, shines a dot on the rod, and the surveyor reads the elevation directly from the rod.

Bill Carson, president of Constructors Supply Co., Santa Fe Springs, Calif., says his firm has had a laser alignment system on the market for three years, but "it's still somewhat novel." The biggest applications, says Carson, are in laying and aligning gravity-flow pipes, leveling suspended ceilings, and aligning plumbing, partitions, and tunneling. Carson's company uses RCA lasers in its instruments, which sell for about $1,500, but Carson sees a reduction to a range from $600 to $900 in a few years.

Like alignment, inspection and measurement are popular uses for lasers. Charles Nater, president of Laser Image Systems, Mountain View, Calif., says his company has been using gas lasers for two-and-a-half years, principally in a laser micrometer that measures to within 1 microinch at high speeds.

Other uses of lasers are more complex. Control Data Corp.'s Special Products operation, Rockville,

Lasers on line. At RCA's plant in Lancaster, Pa., an operator measures the beam strength of helium-neon lasers typical of those used in construction alignment.

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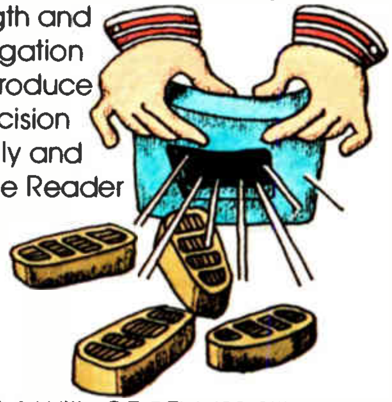

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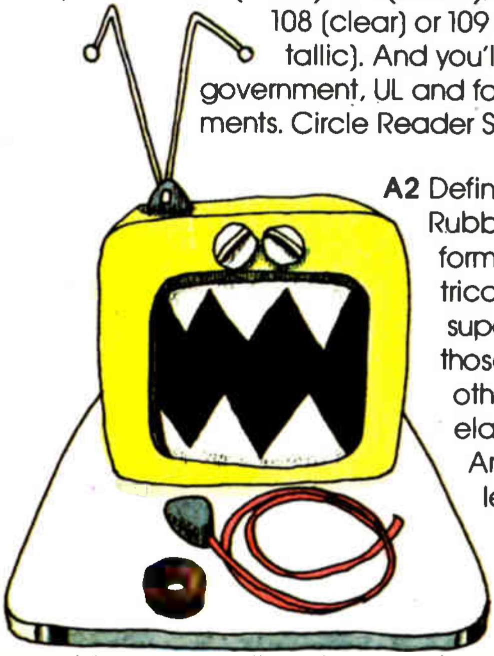

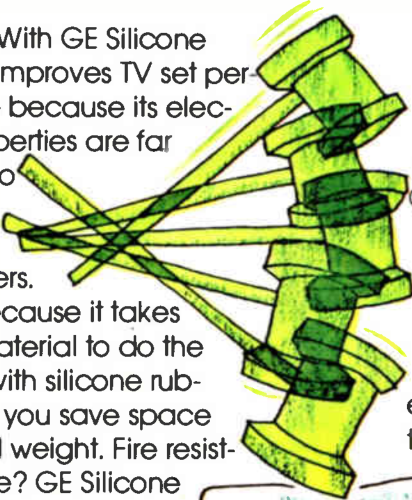

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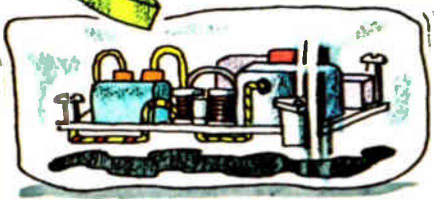

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Md., is using inexpensive gas lasers as scanning-light sources in its model 921 document reader. An official there says the laser replaces cathode-ray tubes used as flying-spot scanners, and it has replaced some incandescent lamps. CDC turned to the laser primarily because of "its cost-effectiveness. It's cheaper than a CRT, it's a good high-energy light source, and of course, is monochromatic."

Optical Data Systems, Mountain View, Calif., uses a gas laser in its Holoscan System 200, a read-only memory with a capacity of 12 million bits and access time of 2 seconds. Optical Data Systems has plans for further laser uses, including the credit-verification business, which the company plans to enter in a few months. A spokesman sees future applications in facsimile machines, home entertainment devices, and a phonograph "needle."

A similar application is reading package labels. Computer Identics Corp., Westwood, Mass., has many applications for its scanning systems, which are based on the laser's ability to work with conventional printed labels, rather than the expensive reflective ones required with other light sources. "If the contents of a box are worth about $25, it is not economical to pay 3 or 4 cents for a reflective label, whereas a label for a laser scanning system may cost only ⅓ cent," says a spokesman. He adds that improvements in laser systems have increased their life span from 5,000 to 10,000 hours.

Laser transmitters. Data communications by lasers has attracted the attention of a number of firms. One is Laser Communications Inc., a Cleveland-based subsidiary of Quandia Inc. The company uses lasers to transmit black-and-white video signals over distances up to four miles without repeaters. Developed by Dr. Yo-Han Pao at Case Western Reserve University, the Quandia system uses a helium-neon laser that costs about $150, says general manager David La Fleur.

The company has been manufacturing systems to replace cable and microwave-communications links for about two years: "The lasers and a transmitter/receiver package are tied into TV applications, law-enforcement systems, telemedicine for consultation and education, and industrial applications.

Several applications derive from the laser's unique features. One is the security of communications that can be achieved, especially if data on a laser beam is run through fiber optics, because of the difficulty of interception. A California company largely involved in classified Government work finds lasers especially useful here. The same firm also uses lasers in alignment to replace lights, photocells and line-of-sight equipment, which were more cumbersome and not as precise. □

Still searching for standards

As the push begins to market laser systems, two groups are at work on developing laser hazard standards: the American National Standards Institute Inc. (ANSI), New York City, and the Bureau of Radiological Health, a division of the Department of Health, Education, and Welfare. The Electronics Industries Association, Washington, D. C., is working with both groups.

Four basic classifications of lasers being considered:

- lasers that pose no hazard for long-term direct viewing,
- lasers that are unsafe for long-term viewing, but have a low probability of causing injury in the event of a single short accidental viewing,
- lasers that present a high probability of causing eye damage in a single short exposure, and
- lasers that constitute a hazard both to the eye and the unprotected skin.

The EIA has voted against the proposed ANSI Z-136 standard that would have limited output of class 2 lasers (above) to 1 milliwatt. Allen Wilson, EIA manager of engineering, feels that the 1-mW limit "is unnecessarily low and could be significantly raised," to about 4.5 mW, which is the typical maximum output for helium-neon lasers. The class 2 laser constitutes about 90% of those now sold commercially. Specific wavelengths and emissions for the other classes are unavailable.

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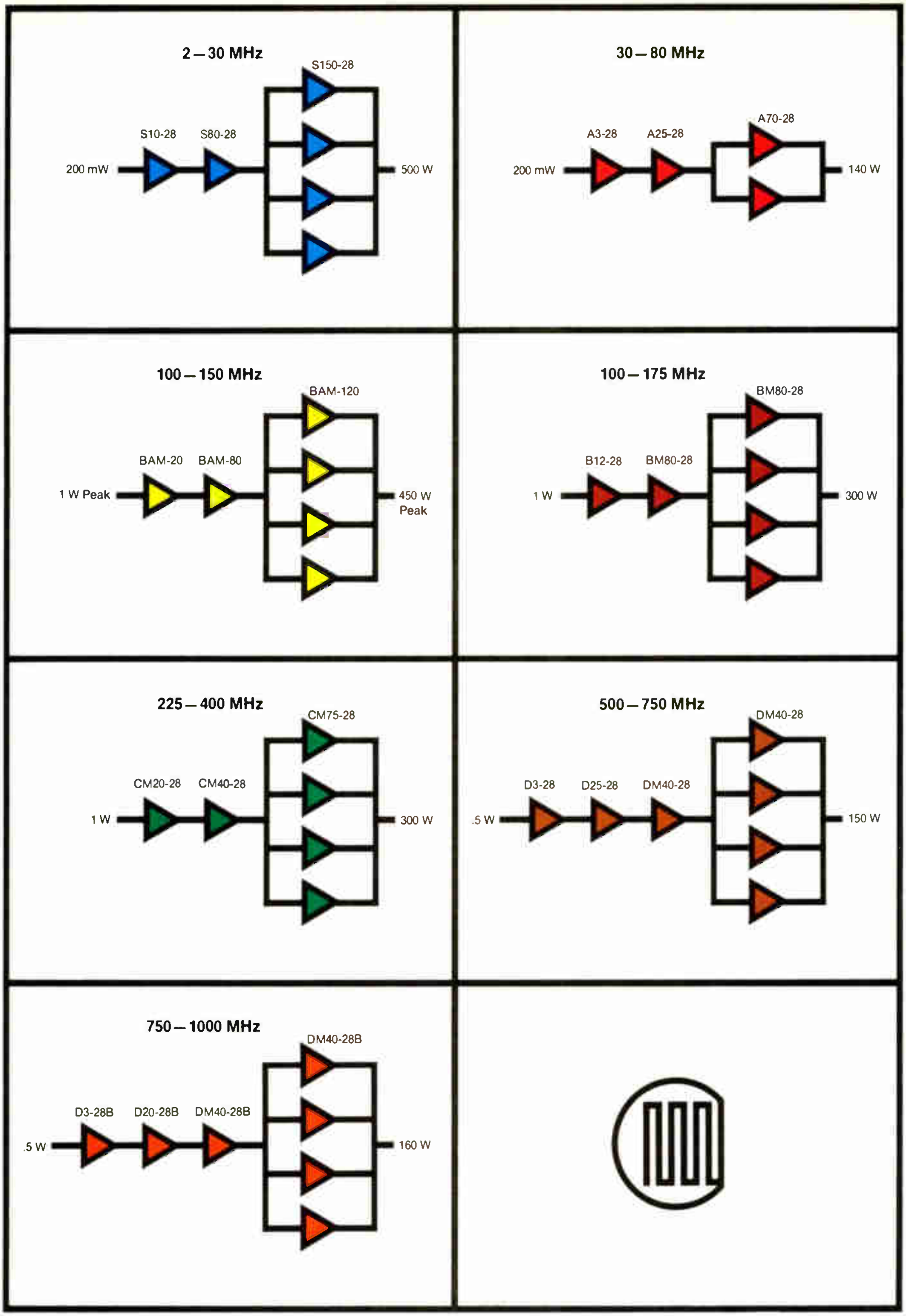
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BAM-20
BAM-80
1 W Peak
450 W Peak
100 — 175 MHz
BM80-28
B12-28
BM80-28
1 W
300 W
225 — 400 MHz
CM75-28
CM20-28
CM40-28
1 W
300 W
500 — 750 MHz
DM40-28
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Circle 154 on reader service card

Penetration color tubes are enhancing information displays

Varying the voltage of a single gun shooting through a multilayer phosphor screen produces various colors that are easy on the eyes and provide a high density of easily distinguishable graphics data

by André F. Martin,
Thomson-CSF, Groupement Tubes Electroniques, Paris, France

Colorful. Four-color display, with keyboard and light pen, is part of surface-traffic-control system designed by CIT-Alcatel of France.

☐ Although color is extremely effective for displaying visual information, most cathode-ray-tube displays designed for scientific or industrial graphics applications show only black-and-white pictures. This is surprising, since color can increase the legibility of a display while reducing the time needed to read it.

The reason for the lag is that most color-CRT development work to date has been for color television, and the characteristics of a good color-TV CRT, such as a shadow-mask tube or Trinitron, do not fit the requirements for a good information-display tube (see table).

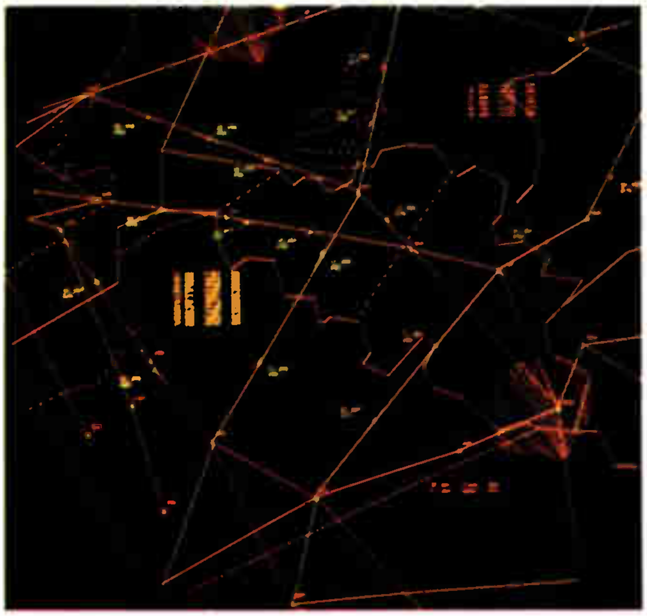
A relatively new class of device—the penetration color tube—has now been developed to the point where it fulfills those requirements. By controlling the voltage of a single gun through a multiphosphor screen, several colors can be produced. This development indicates that color is destined to take as big a place in professional display as it has already taken in printing, photography, TV, and motion pictures. Thomson-CSF has produced several tubes that are now commercially available, and development is proceeding on several other types.

Applications abound

Penetration color tubes have many potential applications in such diverse areas as aviation (both in the air and on the ground), production control, and hospital patient monitoring. As an example, an air-traffic control display—the Orly UAC display system—has been developed by TVT, a subsidiary of Thomson-CSF. The system is a computer-controlled multiradar information display that shows aircraft, labels, tracks, and air routes simultaneously and in different colors (Fig. 1).

Experiments with the new system show that it allows much more information to be displayed at one time than any monochrome system—even one under the control of a highly skilled operator. And recognition with the color system is much easier and faster.

Similarly, airborne displays have been found to benefit greatly from color: they can present more data to the pilot in a clear and legible form (Fig. 2). The illustration shows one of these displays in the Electronic At-

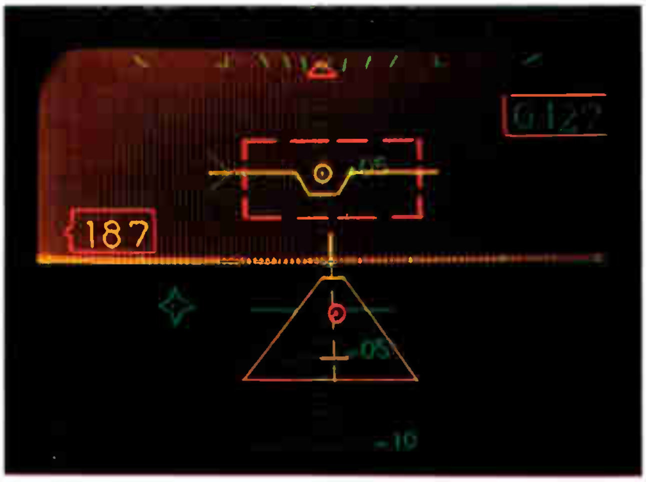


1. Air-traffic control. Synthetic radar display consists of a map of Eurocontrol's Northwestern European upper-air traffic area, showing air routes, aircraft positions, and identification symbols.

titude Director and Indicator (EADI), which was designed by AVS, the avionics division of Thomson-CSF. The display uses a special penetration color tube with enough brightness and contrast to make it possible to read the flight information under high ambient illumination. The display contrast exceeds 1.4 at an illumination of 70,000 lux.

Several weeks of flight-simulator testing have demonstrated the validity of the EADI display system. It has overcome the problems encountered by monochromatic displays that have attempted to perform the same function, and it seems to be pointing the way to the future. Its potential benefits from reduction of fatigue and human errors in air-traffic control alone may well be beyond our ability to calculate.

Despite its ability to display large amounts of meaningful information, construction of the penetration color CRT is simple. And its color characteristics enable an operator to use it for long periods at a time with min-



2. Airborne. This is one of three displays in Thomson-CSF's electronic attitude director and indicator. It uses a special high-bright-ness tube that allows it to be read under very strong ambient light.

Why color-TV tubes won't do

Two well-known color-TV tubes are the conventional shadow-mask tube and the new Trinitron. To show why these tubes are not suitable for a professional display, the operation and characteristics of these devices are reviewed briefly.

The shadow-mask tube uses a dotted tricolor screen (a). It achieves color separation by means of a metallic shadow mask positioned just behind the screen and containing about 400,000 holes—one for each trio of red, green, and blue phosphor dots. This structure has some immediately obvious advantages and disadvantages:

- Color purity is good when the signals feeding the tube are properly adjusted. However, the tube is very sensitive to microphonics and stray magnetic fields.
- Brightness is correct because high-voltage (25-kV) operation is possible, and improved phosphors are available.
- Resolution is poor because of the periodic structure of the screen and the need for convergence of the three electron beams.
- Circuitry must be provided to maintain dynamic convergence of the three beams: this is easy with a repetitive fixed-frequency raster, but very expensive with random scanning.
- Deflection angle is generally 90°, although some 110° tubes are available. The tube is difficult to drive with deflection amplifiers.
- Range of colors is fairly good for TV pictures, but the dot pattern is objectionable for short-distance viewing.

This tube is the world standard color-TV tube today. It has improved gradually over the years. New phosphors have improved its brightness, tighter manufacturing tolerances have improved its color uniformity, new temperature-compensated masks have improved its color stability, and improved electron optics have improved its resolution. Despite these undeniable advances, the shadow-mask tube is still mainly suitable only for color TV because of the previously mentioned inherent characteristics of its design.

The Trinitron tube differs from the shadow-mask tube mainly in that it replaces the 400,000-hole mask with a metallic grill, the elements of which are perpendicular to the TV lines (b). Instead of using a dotted tricolor screen, the Trinitron uses a vertically striped tricolor screen: this improves the vertical resolution and eliminates the moiré patterns generated by the interaction of the raster and the mask. The number of phosphor elements allows a horizontal resolution of about 700 TV lines.

The Trinitron's electron guns differ markedly from those of the shadow-mask tube. Instead of a delta-shaped arrangement of the three guns, the Trinitron in-line configuration emits three independently modulated coplanar beams. This allows the tube to employ only one focusing system for all three beams.

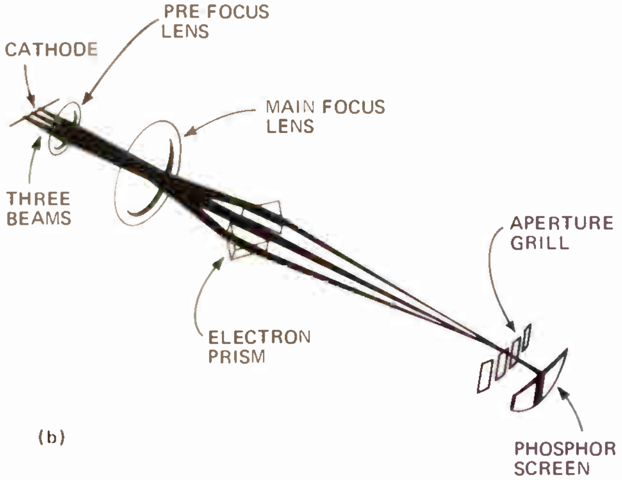
Because the angles between the beams are smaller than those encountered with shadow-mask tubes, and because the beams are coplanar, the dynamic convergence problem is greatly simplified. Very simple circuitry is all that is needed to provide it. For the preceding reasons, the Trinitron shows the following operating characteristics:

- Color purity is good when properly adjusted; the tube, however, is sensitive to stray magnetic fields and microphonics.

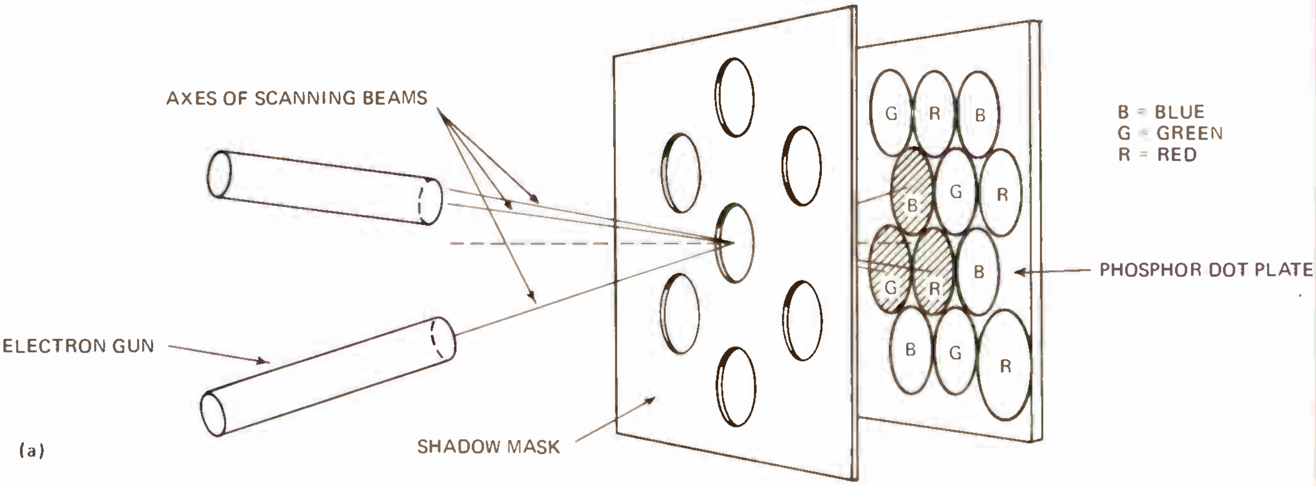
■ Brightness is even better than for the shadow-mask tube because the grill has a transparency of 20% (vs 15% for the shadow-mask tube) and the operating voltages are about the same.
■ Resolution is medium because of the periodic structure of the screen, which is composed of trios of vertical phosphor stripes.
■ Circuitry is needed to maintain dynamic convergence; this is easy with conventional TV raster scanning, but it can get expensive with random scanning.
■ Deflection angle is 90°.

The performance of the Trinitron differs from that of the shadow-mask tube in two important ways: Its resolution is better, and its demands on the convergency circuitry are relaxed. Basically, however, there is no fundamental difference between these tubes in the principles behind their color-separation techniques.

The most important differences between the two tubes discussed here and the penetration color tube are summed up in the chart.

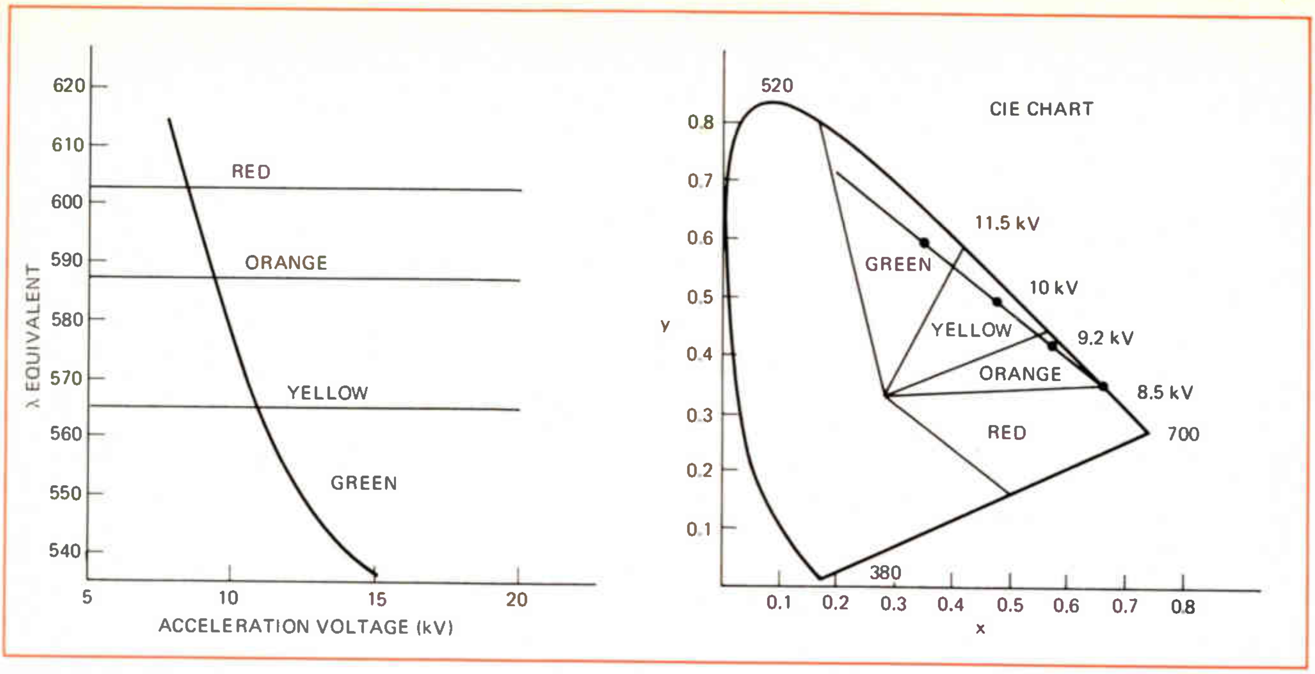


(b)



(a)

COMPARISON BETWEEN SHADOW MASK, TRINITRON, AND PENETRATION TUBE			
	Shadow mask	Trinitron	Penetration tube
Basic phosphors	Green, blue, red	Green, blue, red	Green and red or red and white or special phosphors
Type of screen	Dots	Stripes	Layers
Number of guns	3	3	1
Number of colors displayed when used for a display console	>5	>5	At least 4
Full screen brightness	100 cd/m²	200 cd/m²	200 cd/m²
Resolution TV lines by raster height	550	650	1,000 to 1,500
Type of scanning	TV raster compulsory	TV raster compulsory	TV raster or random scanning
Needs for use	Convergence coils and associated circuitry, special deflection yokes	Convergence coils, as for the shadow mask, and special deflection yokes	High-voltage switching and associated deflection correction, standard deflection yokes
Sensitivity to earth and stray magnetic fields	Important	Important	Very small displacements without any loss of purity
Moiré or interference patterns	Important	Moderate	None
Sensitivity to shock and vibrations	Important	Important	Very small



6. Short swing. A swing of only 3 kV—from 8.5 kV to 11.5 kV—changes the output of the E20 screen all the way from red to green.

characterized by the absence of any internal mechanical device for the separation of colors and by its need for only one electron gun. Its main characteristics, therefore, are:

- Good resolution—more than 1,500 TV lines.
- High brightness in the high-voltage mode, good brightness in the low-voltage mode.
- No convergence circuitry needed to superimpose the elements of a picture (uses only one electron gun).
- Deflection angle not limited by the color-separation device, since it's built into the screen.

In addition to the four preceding characteristics, the penetration tube has a quality that sometimes is an advantage and at other times is a disadvantage. This is the impossibility of producing more than one color at one time. Because it is a one-gun device, the penetration tube can only select colors in a sequential fashion; the appearance of a simultaneous selection is accomplished by the persistence of the eye.

Models of modern penetration tubes

All of the preceding discussion has been aimed at the desirability and characteristics of a red-to-green penetration color tube. And, indeed, development work at Thomson-CSF laboratories has borne fruit in the form of several tubes that are now commercially available. But many other types of phosphors may be used to make other penetration tubes for a wide variety of applications. For example, phosphors with different persistences can be combined to yield special variable-persistence tubes for radar displays.

Advances in the important red-to-green tubes have been many and rapid over the last few years. Line brightness of 2,500 candela per square meter for the red 610-nanometer line can now be achieved; two years ago, such a level was unthinkable. Corresponding improvements in color range and color uniformity over the whole screen area have also come along. And perhaps more important, the voltage change needed to switch colors has been reduced to an acceptable level.

Thomson-CSF's screen E20 can display four colors with a total voltage swing of only 3 kV (Fig. 6). Although this screen produces its deepest red color at 7.5 kV and its purest green at 12.5 kV, four distinct colors can be produced at 8.5 kV for red, 9.2 kV for orange, 10.0 kV for yellow, and 11.5 kV for green. Several types of CRTs with screens E20 and E21 are currently available. E21 is a brighter, higher-voltage screen.

A penetration red-to-white screen has also been made. This type of tube can produce ordinary monochrome TV pictures, and the red color is used to underline or encircle areas of particular interest. Brightness and resolution are equivalent to a conventional black-and-white tube.

The dream of every radar manufacturer and user has always been a variable-persistence tube that would allow the display of low-repetition-rate information, such as radar video, on a long-persistence screen, and, at the same time, allow the display of such rapidly moving information as labels and position symbols on a short-persistence screen.

For small cockpit-size radar displays, the direct-view storage tube has provided a realization of that dream. But, until now, no solution has been available for larger displays—of more than about 10 inches in diameter. Variable-persistence penetration screens can provide a solution for these special display problems.

In applications such as radiological TV, noise can severely limit the amount of information that the operator can glean from the display. A long-persistence phosphor can effectively integrate the signal, thus reducing the noise, but it can also cause smearing of the picture. A penetration tube combining a medium-persistence phosphor with an anti-flicker phosphor of the same color provides a partial solution to this dilemma. Manual selection of the tube's screen voltage allows the operator to make the optimum tradeoff between noise reduction and smearing for each individual situation. □

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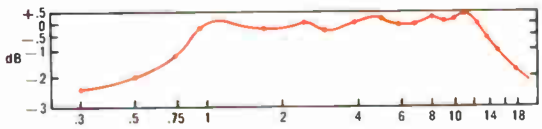

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CCDs in perspective

Three years ago come March, the charge-coupled device was introduced by Willard Boyle of Bell Labs at a sparsely attended panel discussion in the 1970 IEEE International Convention in New York. Boyle, co-inventor of the technology along with George Smith, briefly described the CCD structure and sketched out its potential for imaging, memory, and analog delay applications. The audience asked no questions, Boyle volunteered no additional information, and the panel moved on.

But if the IEEE audience was not listening, Boyle's counterparts at major laboratories were, and rightly read the message: apparently here was a technology no more difficult to implement than MOS, and conceptually simpler, that could be used for three major areas of application. And unlike magnetic bubbles, charge-coupled devices could be built with the same semiconductor processes that everyone already had set up in their laboratories—the same silicon and silicon dioxide materials, the same fabricating techniques and rules. But it was a basically simpler technology, in that transfer and storage functions were performed with minority carriers, whereas conventionally data is stored in the minority state and transferred in the majority state, and diffusions are required to go from one state to the other. Moreover, because CCD technology was conceptually simpler, it could yield devices that were smaller, faster, and potentially cheaper to build than was possible with MOS.

That was the evaluation three years ago. Today, research at some half-dozen laboratories has largely confirmed it. CCDs will indeed have a major impact on the course of semiconductor development, and in all three predicted target areas: imaging, memory, and analog delay. But their influence will not be felt uniformly.

For imaging, the impact will be immediate and big, mostly because there's almost no other competing semiconductor image technology. And CCDs do fit the solid-state image requirements in all the major application areas, because arrays of charge-coupled elements can be operated without the electron-beam scanning mechanism and high-voltage vacuum technology of conventional vidicons.

In charge-coupled imagers, a scene incident on the surface of the array is transformed into a distribution of charge packets corresponding to the details of the image. To read them out, the array is addressed by sequential pulses, which transfer the charge packets stored in each array element across the device, producing a video output signal. This technique can be

Charge-coupling improves its image, challenging video camera tubes

As versatile, long-lived image sensors for television, facsimile recording, and character recognition, charge-coupled devices show great promise once they can be produced to high enough fabrication standards

by M.F. Tompsett, W.J. Bertram, D.A. Sealer, and C.H. Séquin, *Bell Laboratories, Murray Hill, N.J.*

☐ One of the most exciting applications of charge-coupled devices is in solid-state image sensing. Like every other electronic image sensor, the CCD converts light quanta into charges that can be stored on a point-to-point basis and then read out in sequence. But unlike present-day television camera tubes, it does not need the complex, power-consuming apparatus of a scanning electron beam to do so.

True, most of the performance problems in commercial-TV cameras have now been solved. But the cameras are still bulky and suffer from drift and misalignment, and tube life continues to be short. Color-TV cameras suffer from the added complications of having to register separate electron beams and reduce the effects of electron-beam lag. So engineers are still seeking to replace the tube with a solid-state device.

Even apart from television, applications abound for a compact, inexpensive, reliable yet sensitive all-solid-state camera. Examples are card readers, facsimile recorders, Picturephones, and character recognition.

Approaches other than charge coupling can be applied to solid-state image sensors. But though, for instance, linear devices with shift-register address and area devices with X-Y address have been fabricated, they suffer from nonuniformity and switching transients, both of which worsen with increasing size. On the other hand, charge-coupled devices become relatively more attractive as the size requirement becomes larger and the application more demanding.

In CCDs, the basic charge-coupling principle is very simple. It consists of storing carriers in the inversion regions or potential wells under depletion-biased electrodes, and of moving these carriers from beneath one electrode to beneath the next by appropriate pulsing of the electrode potentials. To do this charge-transfer oper-

[illegible]

—Laurence Altman

ation, the neighboring electrodes must be close enough to allow the potential wells between them to couple and the charges to move smoothly from one well to the next.

In imaging, charges are introduced into the device when light from a scene is focused onto the surface of the device. As in all semiconductors, the absorption of light quanta creates hole-electron pairs which, under the influence of the potential beneath each storage electrode, are collected as a charge packet. The quantity of charge thus stored is proportional to the intensity of the image. In this manner, a spatial charge representation of the scene is stored in the device. It is transferred off the device when clock voltages are applied to the electrodes, moving each charge packet serially from storage site to site until all charges reach the output diode.

The storage and transfer of charge for the three-phase planar device are shown in Fig. 1a and b. In this structure, all the electrodes are on one level and are normally separated by about 3 micrometers. Figure 2 shows a section of an imaging device built with this type of structure and having 500 triplets of electrodes. Used as linear imaging devices, two displays that were made by line scanning are also shown in the figure, along with a more recent, 1,500-element linear device that was made to give greater resolution over a full 8-by-11 inch page.

Although the results obtained with the planar, three-phase devices with a single metal level have been remarkably good, such devices have three principal problems. From the standpoint of commercially acceptable production, the most pressing need is to make spacings or gaps between electrodes on the order of 2–3 micrometers in width, while avoiding short circuits between electrodes over the very long total length of such gaps. Also, the requirement for three phases imposes certain

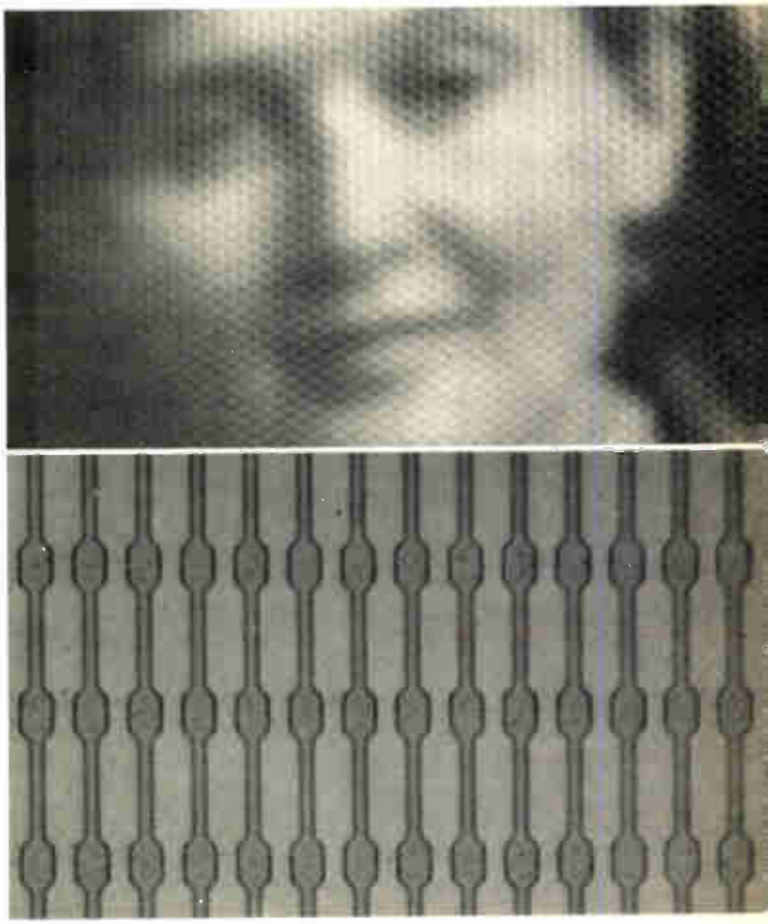
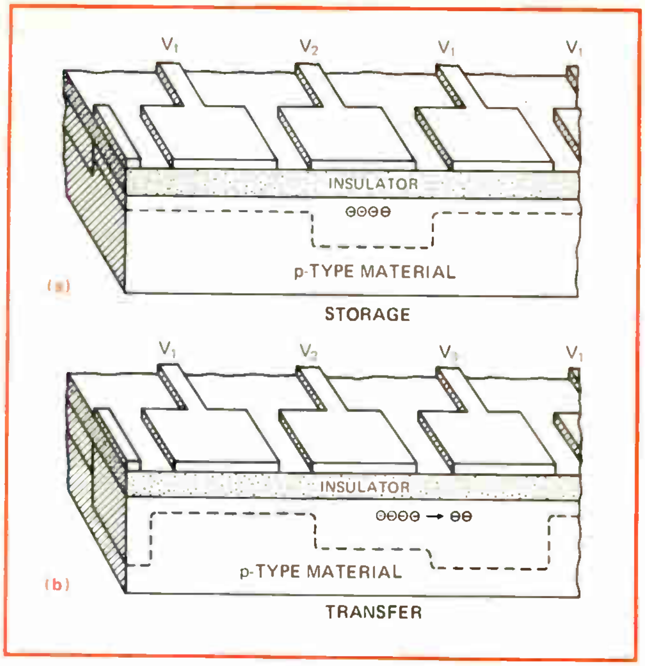


Image on a chip. Charge-coupled image sensors are changing camera design, being suitable for facsimile, information display, and commercial-television vidicon systems. Picture was imaged through an area device, of which part is shown here.



1. Basic CCD. In three-phase charge transfer, charge is stored in a potential well, formed by a voltage V_2 larger than V_1 as shown in (a). Charge transfer (b) is accomplished by applying a voltage V_3 greater than V_2, thus causing the charge to spill over.

geometrical restrictions on the design so that cross-unders are required to address at least one set of electrodes. Finally, the exposed oxide surface in the gaps can assume potentials that affect the performance of the devices adversely.

Multilevel metalization

As one method of avoiding the shortcomings of single-level devices, two-level metalization structures are now being built. These devices, which have completely sealed channels, are either four- or two-phase, as illustrated in Fig. 3. In the four-phase device (Fig. 3a), charges may move in either direction depending on the pulse sequence, so it's necessary to arrange the pulse sequence so that charge always flows in the desired direction. In the two-phase device (Fig. 3b), on the other hand, since neighboring electrodes can be connected in pairs and directionality governed by the asymmetry, the direction of charge flow is built into the device. Here the smaller surface potential underneath the thicker oxide always causes the charge to move in one direction.

The necessary asymmetry to obtain directionality and simple two-phase clocking can also be obtained in ways other than the double-metal approach. An example is the use of an ion-implanted barrier under the electrodes as shown in Fig. 4a. This is done by implanting a p-type barrier region which forms a potential step underneath each electrode that defines the direction of charge flow. This implant method has the significant advantage of requiring only one level of metal and no overlapping electrodes, but still suffers from the problems associated with small, unprotected gaps between electrodes.

All the devices described so far rely on charges transferred along a silicon-to-silicon-dioxide interface, and these surface CCDs exhibit certain performance limitations—a reduced transfer efficiency and increase in noise because charge is trapped in interface states at the surface. These limitations can be eliminated by using a buried-channel CCD, which involves building an ion-implanted silicon layer of opposite polarity in the bulk silicon to a depth of about 1 micrometer below the oxide-silicon interface. Now a potential well can be generated in the bulk material rather than at the surface. Result: no surface trapping, although bulk traps still inhibit the performance.

The principle is illustrated in Fig. 4b. Here the channel is built with implanted p material—a region which defines the charge path. Any standard electrode structures can be used to generate potential wells in these buried-channel devices. The only difference is that now charge packets are stored and transferred through the bulk silicon. And because the charge is stored across a thickness of depleted silicon as well as the oxide, the charge-handling capability of a buried-channel device is considerably less than that of presently fabricated surface-channel device.

How they perform

In all CCDs, since charges generated by the incident light are stored in the potential wells under transfer electrodes, an estimate of signal levels can be obtained by knowing the total capacitance under each electrode. The capacitance per unit area of, say, a 1,200-angstrom thick oxide would be 2.8×10^{-8} farads per centimeter. If the area under an electrode storing charge is considered to be 10×10 μm^2, and the change in voltage across the capacitor when this charge appears is half the typical applied voltage of ± 10 volts, then each signal charge packet Q_s would be 0.14 picofarads. With a drive frequency f_0 = 1 megahertz, delivering just 10^6 packets per second, the signal current would be 140 nanoamperes. Clearly, no problem will be encountered detecting a signal of this level, provided the equivalent noise current is significantly lower.

The signal-to-noise ratio in this output signal is determined by shot noise, transfer noise and noise in the output preamplifier. These theoretical signal-to-noise ratios are plotted in Fig. 5. One attractive aspect of charge-coupled image sensors, when compared to camera tubes or other X-Y addressed devices, is their very low output capacitance, on the order of 1 pF, that can be obtained by bringing all the charges to one small output diode. Signal-to-noise ratio improves as the inverse of the capacitance (assuming the limit to the signal-to-noise ratio is thermal noise in the input resistance of the preamplifier and this resistor is optimally adjusted to maintain the required bandwidth).

Transfer efficiency

Transfer efficiency is a key parameter in any charge-transfer imaging device since low efficiency will limit the number of elements through which charge can be transferred and hence will limit the resolution of the device. Charge-transfer ineffiency, ϵ, is defined as the fraction of the signal charge left behind at each transfer. In CCDs there are two sources of transfer inefficiency. At high frequencies, the biggest problem is simply the time it takes for the charge carriers to move between electrodes. The values of ϵ for n- and p-channel devices at

2. By the line. Linear charge-coupled imagers for both printed and pictorial information have been built. Device on left is a three-phase 500-element linear array. On the right is a 1,500-element array which is capable of far greater resolution.

two frequencies, as a function of electrode length, are shown in Fig. 6.

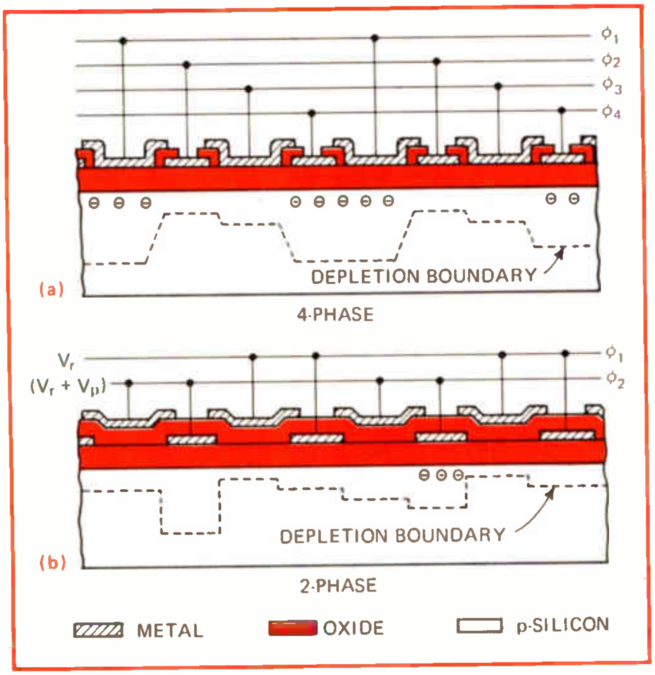
A more serious limitation on transfer efficiency in surface-channel CCDs is the effect of interface states. Here, as each charge packet passes along the device, it can fill an interface state (a place in the oxide-silicon boundary that can trap charge) and then, when it moves on, these states can empty as shown in Fig. 7. Some of the charges emitted from the interface state return to the correct charge packet, but others empty into trailing packets and give rise to transfer inefficiency.

For a three-phase device with electrodes 10 μm long in the direction of transfer, a value of $\epsilon = 2 \times 10^{-4}$, arising from the uncompensated effects of interface states, has been both calculated and measured. This value of inefficiency is low enough for most applications of image sensors. Values less than on the order of 10^{-4} have been measured in buried-channel devices.

Sensitivity

In terms of sensitivity, the CCD has essentially the same light response as any silicon device under corresponding conditions, with allowance for geometrical factors. If a quantum efficiency of unity is assumed (as is nearly achieved in silicon-diode-array camera tubes), then the CCD has a sensitivity of 500 microamperes per lumen. This value is comparable to that of most commercial vidicons. And by exploiting the response of silicon out to wavelengths of 0.9 μm, a still greater sensitivity can be achieved.

3. Many levels. Using two layers of metalization makes fabrication easier because it removes the need to have very narrow gaps between electrodes. Either two- or four-phase devices are possible; charge direction is built into the two-phase type, simplifying clocks.



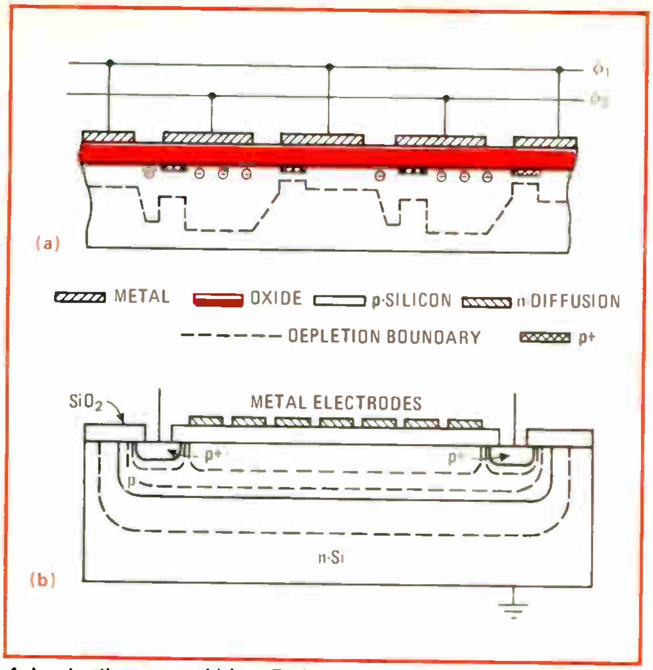
These figures assume that the silicon slice is thinned down, as in silicon camera tubes, and that the optical image is formed on the back of the device. A rather lower sensitivity is obtained if the light falls on the front surface, typically the case for most experimental devices fabricated so far. In such cameras, light has been passed only through the gaps between the metal electrodes or through thin polysilicon transfer electrodes.

The dark current is an important characteristic of most image sensors and must normally be held to a small percentage of the signal. In the CCD, the dark current arises from recombination-generation centers both in the bulk and at the silicon-to-silicon-dioxide interface. A rapid method of assessing the magnitude of this current can be obtained from the relaxation time of an MOS capacitor when it is pulsed to the same potential as is used in the CCD. Now the signal charge in the CCD is stored over perhaps a quarter of the total area contributing dark current, and a full signal packet holds about half the charge per unit area that is contained in the fully discharged MOS capacitor. Consequently, the MOS relaxation time will be an order of magnitude greater than the integration period multiplied by the required ratio of the signal to the dark current. When this relationship is applied to a dark current of 1% of the signal current and a total integration and storage time not exceeding 30 milliseconds, the MOS capacitor must have a relaxation time of 30 seconds, a value easily obtainable in correctly processed MOS capacitors.

Building CCD imagers

Although there are several possible basic organizations of charge-coupled image sensors for both area-and line-sensing applications, two important requirements must be met by all sensing arrays. Since light is continuously incident on the array across which charge is being moved, some method of avoiding smearing must be employed. Secondly, in order to minimize the effect of preamplifier noise and pickup from the pulsing electrodes, all charges should be brought to a single, small output diode.

In line sensors, the problems are relatively easy. A configuration in which charges are integrated in a central photosensitive region and subsequently gated into



4. Implanting a good idea. By implanting a p+ region beneath electrodes (a), a barrier is formed which prevents charge from flowing in the wrong direction. This results in the necessary directionality in a single metal system with simple clocking. Implants can also be used to build buried-channel devices (b); here, an implant of p material forms the channel, confining the charge to the bulk during transfer, eliminating surface state loss and promoting transfer efficiency.

two shift registers, one on either side of the central region, is shown in Fig. 8a. The charges are then moved to a common output while the next line of information is being integrated in the central region.

The lateral transfer process overcomes the problems of light smearing since the charge-transfer region is shielded from light. Furthermore, the use of two shift registers means that only half as many transfers must be made for each charge packet, reducing by half the total length of the device for a given number of resolution elements and set of fabrication tolerances.

Using this principle, a 1,500-element four-phase line-sensing device with two levels of tungsten metalization has been fabricated that has 3,000 electrodes in each of two transfer sections. The self-scan direction is horizontal and the mechanical scanned direction is vertical. The measured value of transfer inefficiency on this device is an impressive 7×10^{-5}.

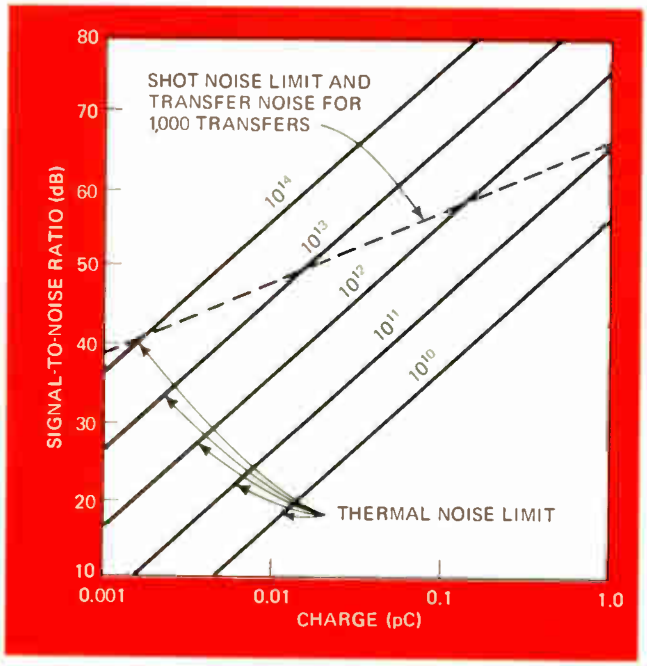
In area arrays, two designs in particular satisfy the requirements and have received most attention. One is the line-addressed structure shown schematically in Fig. 8b. It consists of an array of charge-transfer lines to which the transfer pulses can be applied via switches operated by a line-address shift register. Each horizontal line of information is read in serial form into the vertical register and transferred to the output diode. Such a system has been demonstrated in a 32-by-44 array using bucket-brigade shift registers, but its principle is applicable equally well to charge-coupled structures.

The other principle used successfully in imaging arrays is that of frame or field transfer. In such an array, shown schematically in Fig. 9, charge is integrated in an array of vertical registers with common horizontal electrodes. The array may be considered as consisting of three functional parts. The top part is the integration region, or image area, on which the light falls and where the generated carriers are collected. At the end of the integration period, all electrodes are pulsed, and the whole frame/field of information is moved rapidly into the lower storage section, while the integration of a new frame/field starts in the upper part. Then the whole frame/field is moved down the storage section, one line at a time, with the lowest line of charge being read into the lower serial readout register (video out) and transferred horizontally to the output diode.

The standard TV format requires two interlaced fields per frame. These may be obtained by using the frame-transfer sensor in a simple but effective way. By integrating the charge packets alternately underneath different electrodes for subsequent fields, the number of samples taken in the vertical direction can be doubled, without the number of elements being altered. The centers of charge collection for these samples are shifted from one field to the next, so that two interlocked sets of scan lines may be used in the display. This interlace scheme is therefore capable of giving both the correct geometrical representation and the increased vertical resolution.

A frame-transfer device having 106 vertical registers, each 128 elements long, has been fabricated with the three-phase charge coupling technique. A photograph of the device is shown in Fig. 10. The vertical transfer regions are defined by vertical bars of a channel stop diffusion.

In order that the device can also be used for test purposes as a serial memory with electrical input, the serial shift register has been placed at the top of the array as well as the bottom. The total number of elements is 13,780. The element size is 30 × 32 μm^2, and the active



5. Shot noise limit. Plot of theoretical signal-to-noise ratio as a function of charge quantity shows that the S/N ratio is fundamentally limited by shot noise rather than the thermal noise in the input resistor that is characteristic of the preamplifier effect.

area of chip is 3 × 5 mm^2.

An image reproduced with such a device operating at an element frequency of 1 MHz in the frame/field-transfer mode is shown in Fig. 11. In this mode the number of elements used to form the pictures is 64 × 106. By increasing the integration time and accepting additional smearing, the full 128-by-106 elements may be used as an image sensor.

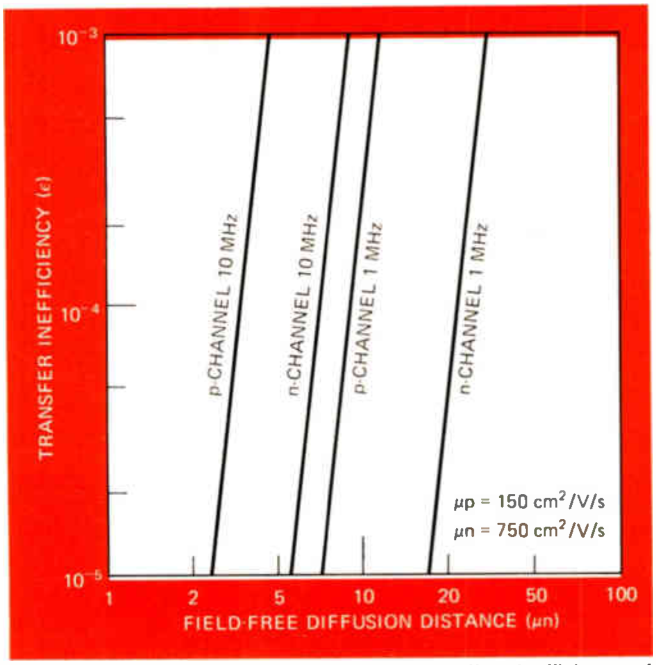
Defects

It is evident from the white spots in Fig. 11 that there are some physical defects in the imaging devices. A reduction in the incidence of such defects must be a major consideration in the design and fabrication of commercial imaging devices, because a microscopically small defect in charge-coupled devices can have a macroscopic effect on the display image. For example, defects could give rise to noticeable white or black lines in the picture. There must also be a complete absence of short circuits between the metallized electrodes in all parts of the array, or the device cannot be made to operate.

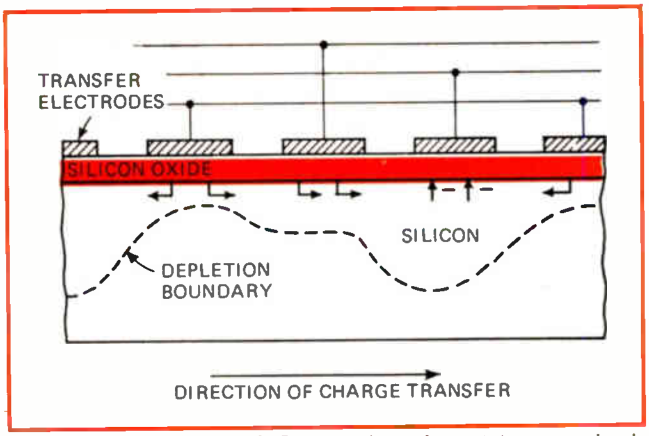
There are various types of nonkilling defects. Localized regions of high dark current in the integration or storage area give rise to bright spots and bright streaks in the display. Pinholes in the oxide will allow charge to be drained from the channel to the electrodes and will cause black streaks in the image. A black streak also occurs if the channel-defining diffusion inadvertently bridges the transfer channel and therefore prevents transfer.

One problem that must be overcome in commercial devices is blooming. Blooming is caused by the lateral spreading of charge from an intense spot of light. In the frame/field-transfer type of imager, excess charge spills preferentially along the transfer channel in the vertical direction, causing objectionable white bars in the display.

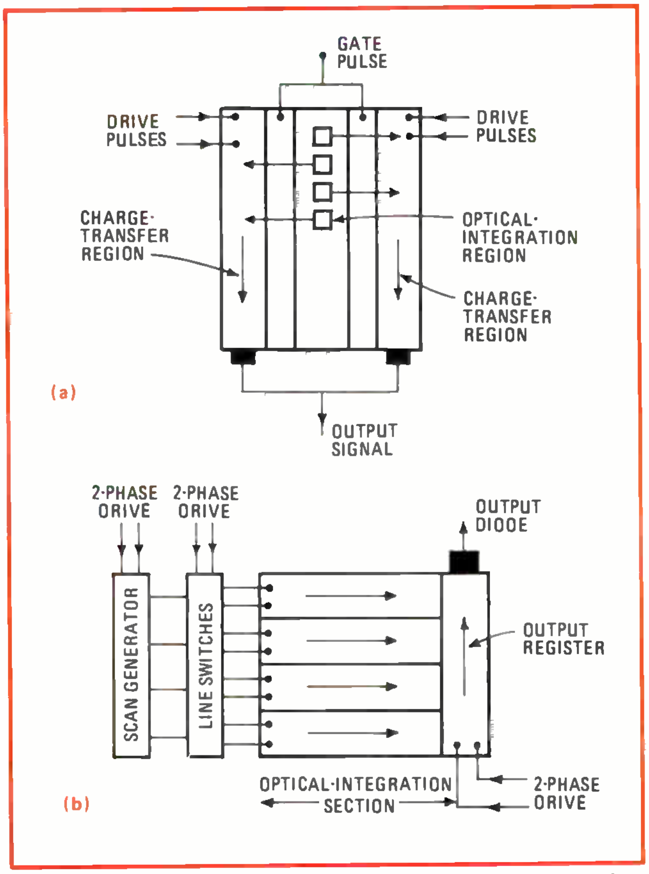
This effect can be readily prevented by introducing an overflow drain, which provides a well-defined path to leak off excess minority carriers when the integrating potential well is filled. These drains would be placed between adjacent vertical transfer channels and combined into a single outlet at the top end of the device. A



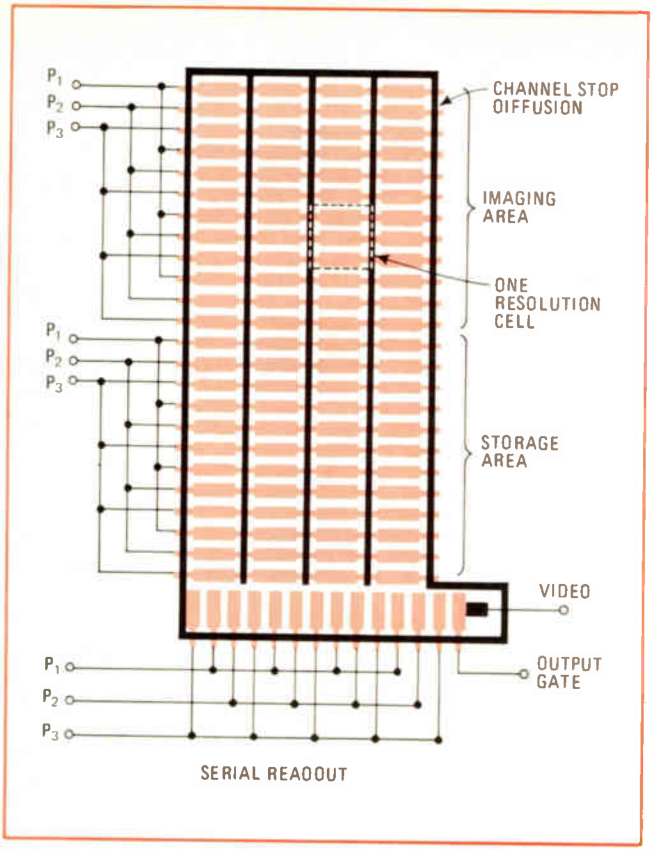
6. Minimizing inefficiency. Two factors that affect inefficiency of charge transfer in CCDs are electrode length and speed of operation. For an n-channel device a reasonbly small transfer inefficiency is obtained at 10 MHz with an electrode length of 50 μm.



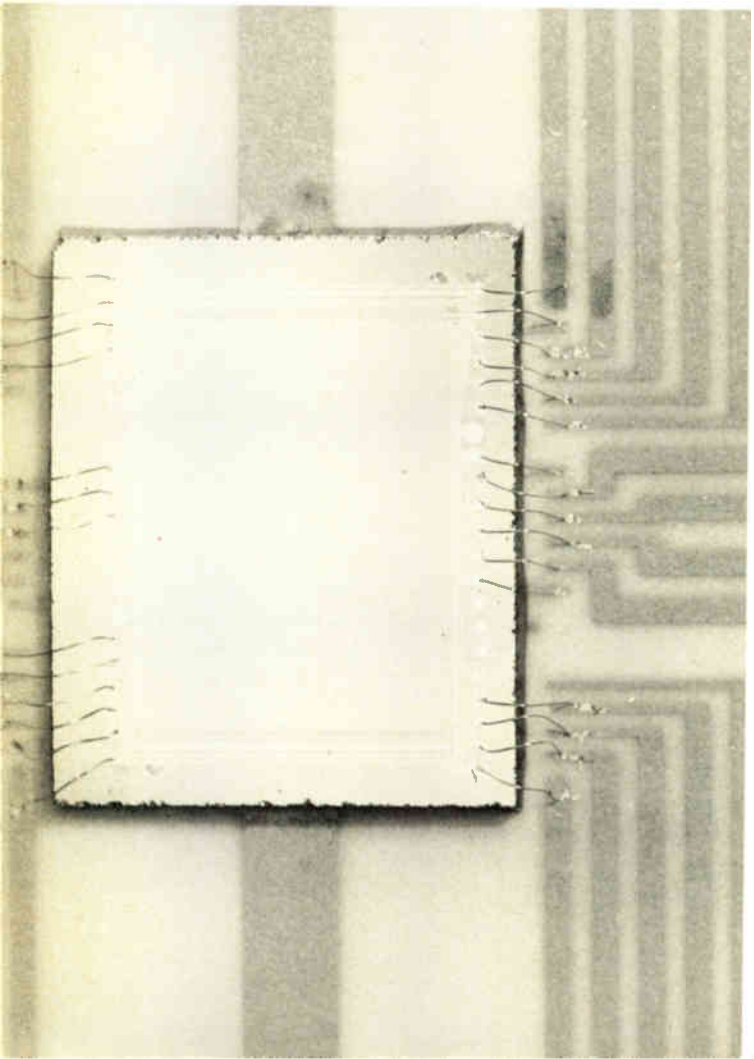
7. Surface states are bad. Changes in surface states occurring in the oxide-silicon interface are killers of transfer efficiency. They happen when charge is captured during storage and then released after transfer. Since the release is random and can occur in subsequent transfers, noise may appear and may blur the signal.



8. Reading out. In linear devices (a), the image can be read out from a central photosensor region into two flanking shift registers. The charges are then moved to common output while the next line is being integrated. In an area device, a line-addressed structure (b) could be used, with each line of information being read serially into a vertical register, then transferred serially to the output diode.



9. Framed. Another good scheme for area imagers is to transfer one frame at a time. With this three-section device, the scene is sensed in an imaging area, passed to a storage area, and then moved out a line at a time through the video output section.



threshold potential is formed between the region under the storage electrode and the overflow drain so that only excess charge above a predetermined level flows into the drain.

Designing a charge-coupled image sensor

For small devices, with about 30 × 30 elements, the choice of structure is not critical. X-Y addressing or charge-transfer devices can be used with almost any organization discussed above, and satisfactory results and yield obtained with current technology. However, in the design of arrays for more ambitious applications, such as those requiring 50,000 picture elements and a 1-MHz bandwidth, or commercial TV with each of these figures increased by a factor of five, considerations of performance and yield become critical.

For large arrays, the conductivity of the transfer electrodes must be maximized. This is to prevent the driving pulses from attenuating before they reach the ends of the transfer electrodes, causing nonuniform charge distribution across the array. In addition, any attenuation would appear as undesired heating on the array. Suitable candidates for electrode material are polysilicon, or a refractory metal such as tungsten, or a highly conductive one like aluminum.

Any one of these metal systems may be used with either buried- or surface-channel CCDs. It is initially thought that the buried-channel CCD would have the higher performance, but this is not true in all cases. Indeed, there are penalties. The charge density that can be handled by a buried-channel device will be less than in surface-channel devices—though this limitation may be somewhat academic, since the surface-channel device can in fact handle more charge than is needed in most applications. Also, the additional junction area necessary for buried-channel operation can introduce extra dark current, and this, combined with the lower stored-charge density, can reduce the ratio of signal to dark current in these devices.

Fortunately, it is unnecessary to decide absolutely between these two types of CCD at this time. The same electrode structure may be used in both surface- and buried-channel devices. Indeed, a surface-channel device may be converted to a buried-channel device by a suitable ion implant. The choice of one over the other will depend on the application and the empirical results obtained in suppressing dark current. In a low-light-level TV application, for instance, the tradeoffs will be very different from those in line image sensing or studio TV, and the buried-channel device should do better.

In any case, from the standpoint of designing an area image-sensing device, the choice between a line-addressed and a frame- or field-transfer organization is a more fundamental one. The latter has been preferred in recent devices. One reason is that in the frame-transfer units, interlace effectively doubles the utilization of each element of the integration section and halves the size of the storage section.

What's more, the line-addressed structure requires an

10. Getting the picture. This area imager has 106 by 128 elements on an active chip area of 3 × 5 mm². A CCD image chip with 250 by 250 elements will be needed for Picturephones, a 550-by-550-element structure for pictures of commercial-TV quality.

additional vertical scan generator and gating on the chip to address the individual lines. This increases the number of small contact holes on the array and sets a limit to the minimum dimensions. Also, the electrode structure is more complicated, an anti-blooming structure is not easily incorporated into the array, and the pickup to the output varies because lines must be addressed during the readout of a previous line and this gives rise to noise.

In any case, one thing is certain: power dissipation in CCDs is small. With present dimensions, the maximum energy dissipated by the carriers per transfer is about 1 picojoule. On an array suitable for commercial broadcast TV (with, say, 500-by-500 storage elements) the fundamental power dissipation would be less than 100 microwatts, with some extra power going on resistive losses along the leads and the transfer electrodes. In fact, the pulse drivers promise to be the major source of power dissipation, using up several watts.

Charge-coupled cameras

Any camera that is built around any CCD array promises to be extremely compact. To date, transistor-transistor logic has been used to generate the appropriate sequence of pulses and sync signals required by CCDs. The pulses are then passed to drivers, which interface directly with the device.

Part of the logic function involves counting the number of transfers that have occurred on the array, but this could be replaced by passing count-charge packets along separate transfer regions on the array itself and using these to control the logic operation. All the logic functions, drivers, preamplifier, and sensing array would be integrated onto a very few chips that could be bonded onto a common ceramic substrate a few square centimeters in size. The lens would then most likely be the bulkiest part of the camera.

The small size and low power requirements of CCD cameras clearly indicate that both linear- and area-imaging devices will have a strong impact in the field of image sensing. Although the ultimate goal of making a sensor for commercial TV is some way off, devices for less demanding applications will certainly be available in the near future.

For example, card reading, optical character recognition, visual aids for the blind, and a replacement for the silicon-diode-array camera tube are all well within the scope of present CCD technology. Low-light-level TV with CCDs is also an attractive prospect because of the high quantum efficiency of silicon over a broad spectral range and the low output capacitance of the readout stage. Expected, therefore, are CCDs with sensitivities that compare favorable with present low-light-level camera tubes operating in the same visible and near-infrared spectral range. The ease with which CCDs can be cooled to reduce dark current should also increase their low-light-level capability in special IR applications. This asset, plus the zero lag and the accuracy of the position on the target to which each emergent charge packet can be assigned, could give these image sensors wide application in the field of particle detection.

Further development of charge-coupled technology will, again, most certainly lead to TV cameras which will be simpler, more compact, and will require less power than present video cameras. The new models will be more rugged and have a longer life than current video cameras. Nor will they require warm-up time.

11. Blemishes. Defects in CCD images show up as white spots. Reducing such imperfections is a major requirement in CCD imaging because a microscopic defect will have a macroscopic effect on the displayed image. Fabrication standards therefore must be high.

For color TV there are several major advantages. Because of its fixed geometry and self-scanning capability, the charge-coupled image sensor completely overcomes the problems of alignment and registration of the scanned areas which are found with color cameras using three tubes and which give rise to color fringing. The CCD should permit drift-free, unattended operation. Moreover, it should eliminate image lag, another problem with conventional cameras that gives rise to color fringing in moving objects. All these factors should eventually allow color cameras to be built that are much simpler and less expensive than conventional ones.

An exploratory, all-solid-state color-TV camera that indeed bears out these high hopes has already been demonstrated in the laboratory. The image is shown on the cover. In this camera, the standard electron-beam-scanned camera tubes are replaced by three charge-coupled image sensors. The light from the scene being viewed is split into three colors (red, green and blue) and focused onto the image sensors. □

Synchronous ramp generator maintains output linearity

by D. M. Brockman
Boeing Co., Seattle, Wash.

With complementary-MOS analog switches, a synchronous ramp generator can be built without the need for expensive ladder networks or costly amplifiers. This circuit is intended for use in a multichannel analog-to-digital converter system where digital words must be developed to represent transducer outputs.

When triggered, the circuit generates a linear ramp having time and voltage parameters that are independent of component tolerances, power-supply voltage, and clock rate. The ramp output is synchronous with a binary or binary-coded-decimal counter and always runs from a negative reference voltage at the counter's zero state to a positive reference voltage at the counter's full-scale state. The generator's ramp output can be used as the reference signal for comparator-type analog-to-digital converters.

The ramp is generated by integrator A_1. Switch S_2 is initially closed, and switches S_1 and S_3 are open, clamping A_1's output to $-V_{ref}$. The counter is kept reset by flip-flop FF_1.

When the circuit is triggered, the counter begins to run, S_2 is opened, and S_1 is closed. Integrator A_1 begins to charge linearly at a rate determined by time constant R_1C_1 and the output voltage produced by integrator A_2.

After the counter reaches full scale, switch S_1 opens and stops the ramp, while switch S_3 closes and starts the comparison cycle.

During the comparison cycle, A_1's output is inverted by amplifier A_3 and summed with $+V_{ref}$ by integrator A_2. If the sum is not zero, A_2 charges toward a voltage (and polarity) that will make the sum zero at the next comparison cycle. When the counter reaches full scale for the second time, the comparison cycle is ended, switch S_3 is opened, switch S_2 is closed, and the counter and flip-flop FF_1 are reset.

This generate/compare process is repeated each time the circuit is triggered. And, after a few cycles, the output voltage of integrator A_2 will be just large enough to drive integrator A_1 to $+V_{ref}$ in the time required for the counter to reach full scale.

Inverter A3 is provided with a gain adjustment to compensate for tolerances on integrator A_2's summing resistors and to allow the peak ramp voltage to be set exactly to $+V_{ref}$. Time constant R_1C_1 must be chosen so that integrator A_2 does not saturate. And time constant R_2C_2 must be selected for circuit stability:

$$R_2C_2 = T^2/R_1C_1$$

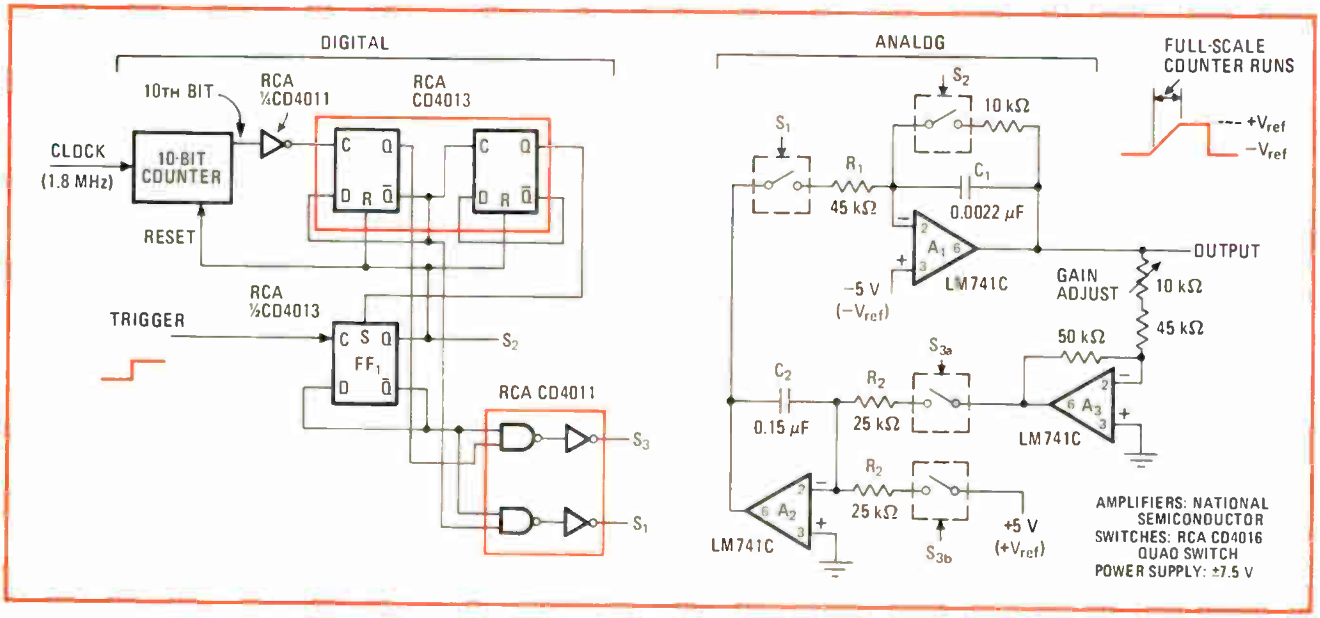
where T is the ratio of the full-scale count to the clock rate.

The circuit's stability factor becomes:

$$S.F. = R_1R_2C_1C_2/T^2$$

If the stability factor is equal to one, the circuit will respond to step changes in $+V_{ref}$ without overshoot. If the factor is greater than one, the generator's response will be underdamped.

The component values shown are for a 1.8-megahertz clock rate and a full-scale count of 1,024. □



Automatic compensation. Synchronous ramp generator uses low-cost complementary-MOS analog switches instead of high-priced ladder networks. Closed-loop circuitry automatically corrects ramp slope for small changes in component values, clock rate, or supply voltage. Ramp output climbs from $-V_{ref}$ to $+V_{ref}$ as counter runs from its zero state to its full-scale count. For this circuit, clock rate is 1.8 megahertz.

Astable multivibrator needs only one capacitor

by Glen Coers
Texas Instruments, Dallas, Texas

Two large capacitors are required for most astable multivibrator designs. But, by using a programable unijunction transistor (PUT), one of these can be eliminated, and only one inexpensive Mylar capacitor is needed.

The multivibrator in the diagram, for example, is designed to operate at 1 hertz. Its output symmetry can be adjusted with timing resistors R_1 and R_2—resistor R_1 controls the negative output pulse width (t_1), while resistor R_2 controls the positive output pulse width (t_2). The values of R_1 and R_2, along with the value of capacitor C, determine the output pulse durations:

$$R_1 = 1.4t_1/C$$
$$R_2 = 2.5t_2/C$$

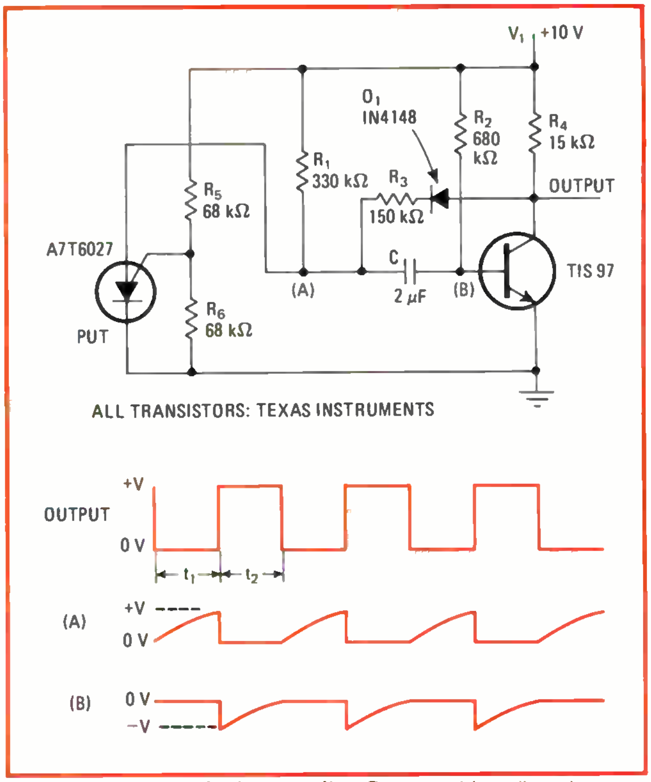
At the start of the circuit's cycle, the PUT is off, the bipolar transistor is on, and capacitor C charges through resistor R_1. When the PUT's peak-point emitter voltage (V_p) is reached, the PUT triggers and turns off the bipolar transistor, allowing this device's collector voltage to go toward the supply level.

Diode D_1 and resistors R_3 and R_4 provide latching current for the PUT. The value of resistor R_3 can be determined by:

$$R_3 = [V_1 - (V_V + V_D)]/I_V$$

where V_1 is the supply voltage, V_D is the diode drop, V_V is the PUT's valley-point voltage, and I_V is its valley-point current.

When capacitor C discharges through resistor R_2, the bipolar transistor is turned on so that the latching current is removed from the PUT. This device's gate voltage (V_G) then rises to the level set by the voltage divider formed by resistors R_5 and R_6. The PUT then turns off, capacitor C again begins to charge through resistor R_1, and the cycle repeats.



Trimming down to single capacitor. Programable unijunction transistor (PUT) eliminates the second capacitor in astable multivibrator circuit. When PUT is off, bipolar transistor is on and capacitor C charges through resistor R_1 until PUT triggers, turning off the bipolar. As capacitor C discharges through resistor R_2, the PUT remains on until the bipolar conducts. Capacitor C then charges again.

The value of timing resistor R_1 must be small enough to meet the PUT's peak-point current (I_p) requirement. And the value of the other timing resistor, R_2, must be small enough to assure that the bipolar transistor will turn on. □

Automobile ignition system is rugged and reliable

by J.P. Thomas
Litton Industries, Litton Systems (Canada) Ltd., Rexdale, Ont., Canada

Capacitive-discharge ignition systems permit engine performance to be maintained over an extended period by reducing automotive component degradation due to mechanical wear. With a capacitive-discharge system, ignition voltages are high, allowing sparkplug gap spacing to vary considerably without affecting engine performance. But ignition point current is kept low so that point erosion is significantly reduced.

The failure of a capacitive-discharge ignition system can usually be attributed to erratic triggering of the silicon-controlled rectifier, the heart of the circuit. Erratic triggering can generally be traced to either poor design of the trigger circuit or improper elimination of point bounce.

In contrast, here is a capacitive-discharge ignition system that provides reliable SCR triggering over a broad range of operating conditions and offers an engine overspeed cutout as an additional feature. The system can operate over the temperature range of −70°F to +150°F and over the supply-voltage range of 7 to 20 volts.

Unijunction transistor Q_1 generates trigger pulses for the SCR by discharging capacitor C_1 when transistors Q_2 and Q_3 are both saturated. Engine overspeed protection is provided by transistors Q_3, Q_1, and Q_5, diodes D_1, D_2, and D_3, and a speed limit set by the values of resistor R_1 and capacitor C_1. Transistor Q_1 and its associated components act as a current source that charges capacitor

C_1 at a predictable constant rate when the points close. Transistor Q_6 discharges C_1 when the points open.

Unless capacitor C_1 is charged to a voltage that equals D_3's zener voltage plus Q_5's base-emitter voltage, transistor Q_3 remains off so that the SCR trigger pulses are inhibited. If the time between successive point openings is less than C_1's charging time, the ignition system is inhibited, thereby providing overspeed protection. The circuit's cutoff point is precise so that there is no erratic behavior at the edge of the protection speed and the possibility of engine damage due to transient mechanical loads is eliminated.

When the ignition points open, transistor Q_3 is in saturation, and transistor Q_2 will go into saturation as transistor Q_7 turns off and transistor Q_8 saturates. After the time elapse (about 5 microseconds), determined by the time constant of capacitor C_2 and resistor R_2, transistor Q_6 is driven into saturation, removing any charge remaining on capacitor C_1.

At some time during this sequence, the voltage across C_1 falls below the level required to keep transistor Q_5 on, forcing this device, as well as transistor Q_3, to turn off. After the time (around 20 μs) established by capacitor C_3 and resistor R_3 has passed, transistor Q_4 saturates, causing transistor Q_6 to turn off and removing the base drive from transistor Q_2.

When the points close, transistor Q_7 saturates, and transistor Q_8 turns off, maintaining transistor Q_2 in its off state. Capacitor C_3 begins to discharge through resistors R_3, R_4, and R_5 and Q_9's base-emitter junction. The time constant of this network is long enough to keep transistor Q_9 saturated during a point-bounce cycle, but short enough to discharge capacitor C_3 completely during a normal point-dwell cycle.

Transistors Q_{10} and Q_{11}, the transformer, and the bridge rectifier form a dc-to-dc inverter that charges the 1-microfarad discharge capacitor, C_4, to about 375 V. This voltage level provides a spark energy that is an order of magnitude larger than what is available from a standard ignition system. A conventional ignition coil is used as a pulse transformer to raise the discharge voltage to about 40 kilovolts, which is approximately four times greater than the voltage provided by conventional ignitions.

For a four-stroke engine, the value of resistor R_1 can be initially chosen as:

$R_1 = 18/NMC_1$

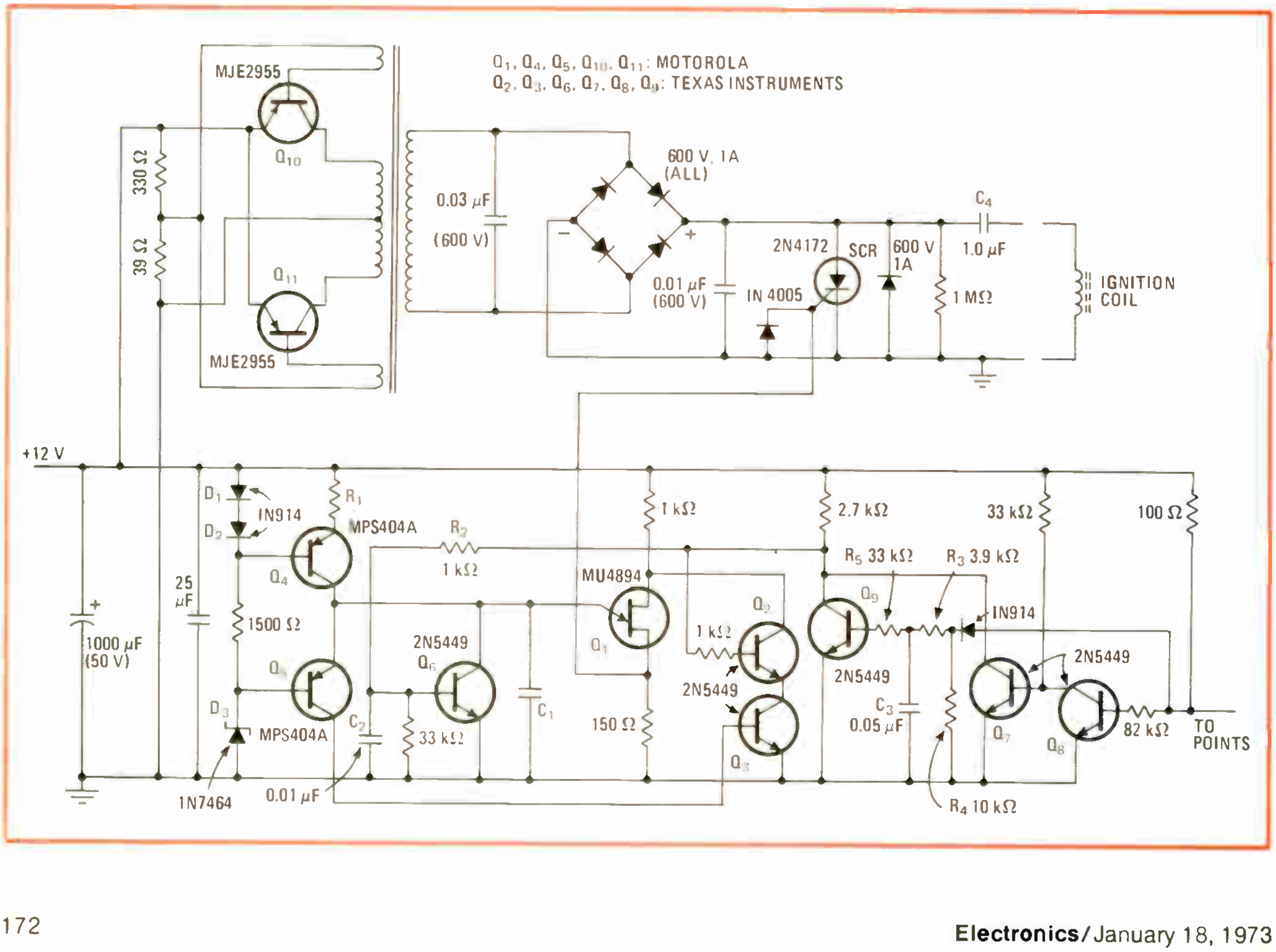
where N is the number of cylinders, M is the maximum engine rpm, and C_1 is expressed in farads. For a two-stroke engine, the initial estimate for R_1 is:

$R_1 = 9/NMC_1$

The value of capacitor C_1 is somewhat arbitrary, but it should be at least 0.1 μF and not more than 0.5 μF. After choosing C_1, the value of R_1 must be adjusted to give the precise speed limit desired. □

Designer's casebook is a regular feature in Electronics. We invite readers to submit original and unpublished circuit ideas and solutions to design problems. Explain briefly but thoroughly the circuit's operating principle and purpose. We'll pay $50 for each item published.

Sure firing. Automobile capacitive-discharge ignition system performs reliably at 7 to 20 volts from −70 F to +150 F, in addition to providing engine overspeed protection. Unijunction transistor Q_1 generates trigger pulses for the SCR by discharging capacitor C_1. When points close, C_1 is charged; when points open, C_1 is discharged. The discharge capacitor, C_4, accumulates about 375 V for high spark energy.



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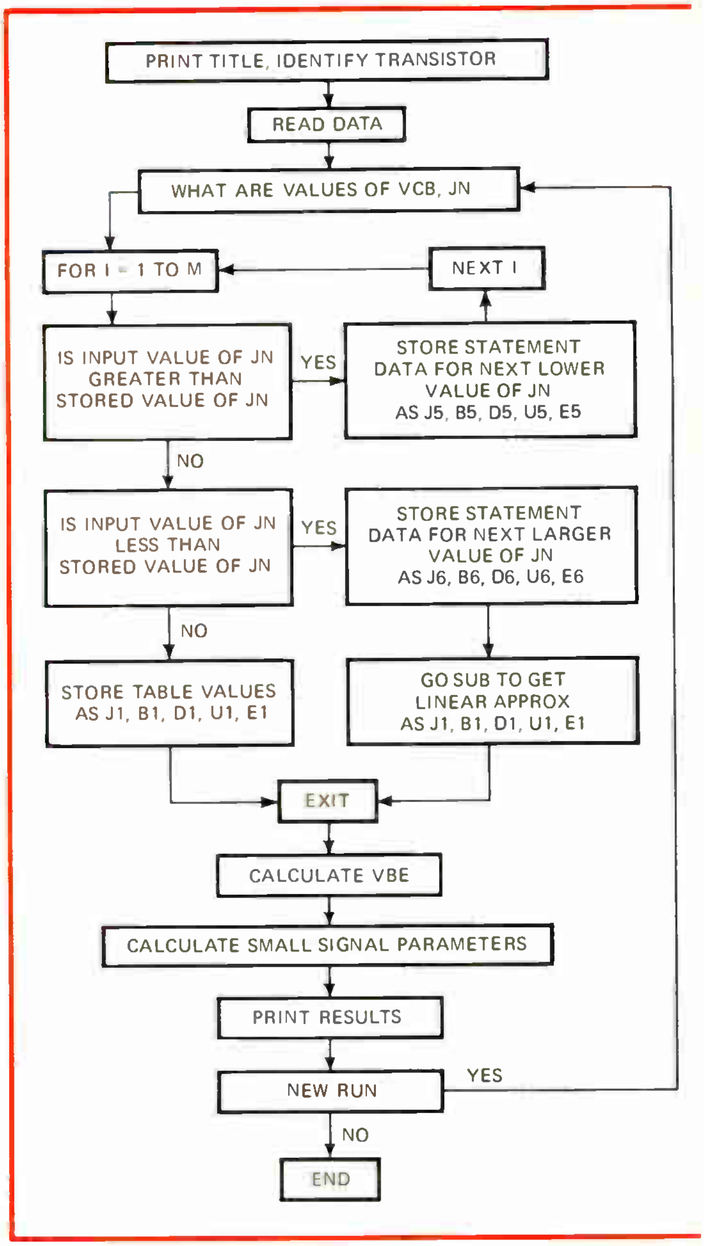
Easy-to-use Hypi program makes possible transition from nonlinear to linear transistor model

Acting as an interface between linear and nonlinear analysis programs, a new computer program called Hypi converts parameters of nonlinear charge-control transistor model to those of linear hybrid-pi model

by John R. Greenbaum, *General Electric Co., Syracuse, N.Y.*



☐ Most nonlinear computer programs can analyze circuits only in the time domain, while linear computer programs perform analysis in the frequency domain. However, practically all available transistor performance data is in nonlinear form, making it inappropriate for the linear programs. Consequently, an intermediate program is needed to convert nonlinear transistor models to linear models, so that the linear programs can be used for frequency analysis.

A new short program, which is called Hypi (pronounced high-pie), enables the user to describe his circuit with a nonlinear transistor model, but perform his analysis with a linear computer program, like Cornap (Cornell network analysis program), ECAP (electronic circuit analysis program), ACnet (ac network analysis

1. Hypi computer program. Flowchart outlines how Hypi converts nonlinear charge-control transistor model to linear hybrid-pi transistor model. The user simply supplies data for transistor collector current and base-collector voltage. Previously stored table contains data for charge-control model parameter values. (Linear interpolation is used to bridge table values.) After reading user input data, Hypi solves equations relating charge-control parameters to hybrid-pi parameters. Sample program develops model for type 2N1711 transistor.

```
HYPI1*

100 PRINT"PROGRAM TO DERIVE SMALL SIGNAL HYBRID PI FROM LARGE SIGNAL"
110 PRINT "DATA"
120 PRINT "*************************************************************"
130 REM R1=RB,R2=RC,R3=RE,A1=A1,A2=A2,I1=IC,I2=IES,I3=ICS
140 REM P1=PHI1,P2=PHI2,T1=THETA F,T2=THETA I,N1=N1,N2=N2
150 REM V1=VCE, V2=VBC, V3=IBE, J1=JN, J2=JI, J3=JC, J4=JE
160 REM C1=CDE,C2=CDC,C3=CTC-C4=CTE,C5=CE,C6=CC,G1=GME,R4=RBE
170 REM R5=RCC
180 REM C(I)=JN, B(I)=BN, D(I)=BI, U(I)=TCN, V(I)=TCI
190 PRINT "MODEL 2N1711"
200 PRINT"..............
210 DATA 23.,7.,.001,27.E-12,21.E-12,1.62E-13,.42E-13
220 READ R1,R2,R3,A1,A2,I2,I3
230 DATA 1.0,.9,39.7,37.E,.45,.37
240 READ P1,P2,T1,T2,N1,N2
250 LET R5=1.E7
260 DIM C(50),B(50),D(50),U(50),V(50)
270 LET M=22
280 PRINT
290 REM DATA TABLE IN MONOTONIC INCREASING CURRENTS
300 DATA .0005E-3,2.,.56,5.E-10,3.E-6
310 DATA .001E-3,2.,.56,5.E-10,3.E-6
320 DATA .005E-3,13.,.56,5.E-10,3.E-6
330 DATA .01E-3,20.,.56,5.E-10,3.E-6
340 DATA .02E-3,25,.56,5E-10,3E-6
350 DATA .03E-3,28,.58,5E-10,3E-6
360 DATA .05E-3,30.,.65,5.E-10,3.E-6
370 DATA .07E-3,38,.67,5E-10,3E-6
380 DATA .1E-3,42.,.74,5.E-10,3.E-6
390 DATA .2E-3,55,.72,5E-10,3E-6
400 DATA .3E-3,65,.70,5E-10,3E-6
410 DATA .4E-3,82,.64,5E-10,3E-6
420 DATA .5E-3,78.,.67,5.E-10,3.E-6
430 DATA 1.E-3,96.,.62,5.E-10,3.E-6
440 DATA 2E-3,105,.57,5E-10,3E-6
450 DATA 3E-3,117,.53,5E-10,3E-6
460 DATA 5.E-3,130.,.5,5.E-10,3.E-6
470 DATA 7E-3,140,.47,5E-10,3E-6
480 DATA 10E-3,145,.42,5E-10,3E-6
490 DATA 20E-3,158,.38,5E-10,3E-6
500 DATA 30E-3,160,.36,5E-10,3E-6
510 DATA 50E-3,160,.33,5E-10,3E-6
520 FOR I=1 TO M
530 READ C(I),B(I),D(I),U(I),V(I)
540 NEXT I
550 PRINT"YOUR VALUES FOR VCB,JN ARE";
560 REM VCB=V2 IN VOLTS   JN=J1 IN AMPS
570 INPUT V2,J1
580 PRINT
590FOR I=1 TO M
600 IF J1=C(I) THEN 670
610 IF J1<C(I) THEN 730
620 LET B1=B(I)
630 LET D1=D(I)
640 LET U1=U(I)
650 LET E1=V(I)
660 GO TO 1000
670 LET J5=C(I)
680 LET B5=B(I)
690 LET D5=D(I)
700 LET U5=U(I)
710 LET E5=V(I)
720 GO TO 960
730 LET J6=C(I)
740 LET B6=B(I)
750 LET D6=D(I)
760 LET U6=U(I)
770 LET E6=V(I)
780 LET Y1=B5
790 LET Y2=B6
```

```
HYPI1* CONTINUED

800 GO SUB 1270
810 LET B1=Y3
820 LET Y1=D5
830 LET Y2=D6
840 GO SUB 1270
850 LET D1=Y3
860 LET Y1=U5
870 LET Y2=U6
890 GO SUB 1270
900 LET U1=Y3
910 LET X1=E5
920 LET Y2=E6
930 GO SUB 1270
940 LET E1=Y3
950 GO TO 1000
960 NEXT I
1000 LET V3=LOG(J1/I2)/T1
1010 LET J2=I3*(EXP(T2*V2)-1.)
1020 LET J3=J2/D1-J1
1030 LET J4=J1/B1-J2
1040 LET C1=T1*U1*(J1+I2)
1050 LET C2=T2*E1*(J2+I3)
1060 LET C3=A2/(P2-V2)^N2
1070 LET C4=A1/(P1-V3)^N1
1080 LET C5=C1+C4
1090 LET C6=C2+C3
1100 LET G1=T1*J1
1110 LET R4=B1/G1
1120 PRINT
1130 PRINT
1140 PRINT"FOR VCB=";V2;",JN=";J1
1150 PRINT"-----------------------------------------------------------"
1160 PRINT"RB=";R1,"RC=";R2,"RE=";R3,"RBE=";R4
1170 PRINT "RCC=";R5,"CC=";C6,"CE=";C5,"GME=";G1
1180 PRINT"VBE=";V3
1190 PRINT
1220 PRINT" IF YOU WANT A NEW RUN TYPE 1, FOR NO NEW RUN TYPE 0"
1230 LET X=2
1240 INPUT X
1250 IF X=1 THEN550
1255 STOP
1260 REM SUROUTINE FOR LINEAR APPROXIMATION
1270 LET A = (Y2-Y1)/(J6-J5)
1280 LET B=Y1-A*J5
1290 LET Y3 =A*J1+B
1300 RETURN
1310 END
```

program), or any one of several other programs.

Developed at General Electric, Hypi can be run on a time-shared basis and is written in Basic language. It converts the parameters of the nonlinear large-signal Beaufoy-Sparkes charge-control transistor model to the parameters of the familiar linear small-signal hybrid-pi transistor model. The panel, "From charge-control to hybrid-pi," shows the two models and the conversion equations.

There are several ways to solve these equations. For instance, they can be solved directly, if not very conveniently, with the nonlinear program, Sceptre (system for circuit evaluation and prediction of transient radiation effects) [*Electronics*, Aug. 16, 1971, p. 72]. Alternatively, Hypi can be used alone, after the values for two of the parameters for the charge-control model, current density J_N and base-collector voltage V_{BC}, have been computed manually. Or, again, the nonlinear program, Circus (circuit simulator), can be used to find the J_N and V_{BC} values, and then Hypi used to finish the conversion.

Examining Hypi

Hypi's flowchart (Fig. 1) is a generalized description of how the hybrid-pi model data is obtained. The program identifies the transistor type being examined, reads the data describing the charge-control transistor characteristics, and then asks the user for the operating conditions specific to his circuit's performance.

Hypi represents the charge-control model parameters of forward gain β_N, inverse gain β_I, normal time constant τ_N, and inverse time constant τ_I, as points on the curves normally used to describe these functions. (This data can be obtained from published transistor literature.) The Hypi program automatically provides linear interpolation between adjacent parameter values when necessary. Therefore, a proper result is obtained when an evaluation is requested for a value of current density J_N that does not exactly correspond with one of the listed entries.

User input data is examined to determine whether it agrees with the charge-control model data previously stored or whether an interpolation is required. The charge-control model equations are then solved, and the results inserted in the conversion equations for the hybrid-pi model. The outcomes of these computations are labelled with the hybrid-pi parameter descriptions.

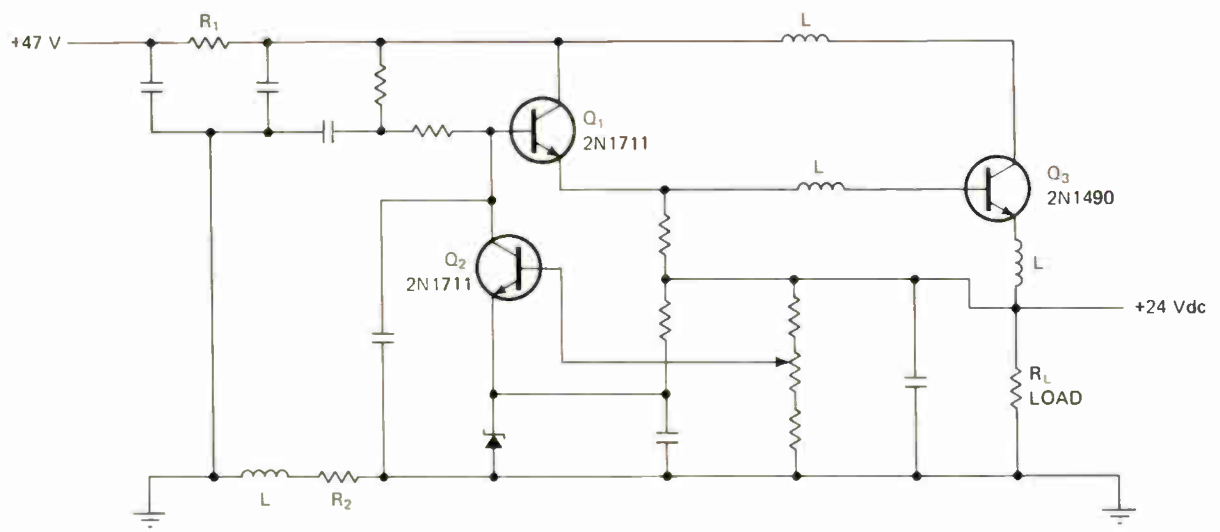
A sample Hypi program is also included in Fig. 1. Statements 100 through 200 identify the program, the transistor that is being evaluated (in this case, type 2N1711), and the variables in the program. Statements 210 through 540 cause the data describing the transistor to be read into the program. By changing this data, different transistors can be modeled.

The charge-control model parameters are called out in statements 210 and 230. Statement 210 provides data for base bulk resistance R_{BB}, collector bulk resistance R_{CC}, emitter bulk resistance R_{EE}, base-emitter capacitance A_1, base-collector capacitance A_2, saturation emitter current I_{ES}, and saturation collector current I_{CS}. Statement 230 enters data for intrinsic base-emitter potential ϕ_1, intrinsic base-collector potential ϕ_2, and constants θ_1, θ_2, N1, and N2.

Statement 270 indicates the number (m) of different collector current values to be stored in the program. Statements 300 through 510 list these various values of current J_{Nm}, in addition to the values for forward gain β_{Nm}, inverse gain β_{Im}, normal time constant τ_{Nm}, and inverse time constant τ_{Im}. This creates a data table, with the current values given in increasing order.

User input data for current J_N and voltage V_{CB} is requested by program statements 550, 560, and 570. With this input information, Hypi searches its data table to determine if the input current value agrees with a stored current value. If no agreement is found, a linear interpolation is performed between the two stored current values between which the input current value falls.

This procedure is described in statements 590 through 960. The lower data point values for β_N, β_I, τ_N,



ALL INDUCTORS (L) AND RESISTORS R_1 AND R_2 ARE DUE TO LEAD LENGTHS

NONLINEAR TRANSISTOR OPERATING CONDITIONS

R_L (Ω)	Q_1		Q_2		Q_3	
	V_{BC} (V)	J_N (A)	V_{BC} (V)	J_N (A)	V_{BC} (V)	J_N (A)
25	−5.54	0.0132	−13.90	0.0027	−6.16	0.996
50	−12.40	0.00536	−14.00	0.00626	−13.00	0.519
125	−16.70	0.00228	−14.10	0.00848	−17.30	0.220
250	−18.20	0.00151	−14.10	0.00924	−18.80	0.119

2. Sample analysis. Voltage regulator can be examined for potential instabilities. Nonlinear Circus program is used first to determine collector currents and base-collector voltages of all three transistors for four different load conditions. Table shows results of Circus analysis of the transistors for load resistances of 25 to 250 ohms, which cause load current for the 24-volt regulator to vary from 1 to 10 amperes.

From charge-control to hybrid-pi

When a transistor operates under varying conditions, a nonlinear model is needed to describe device behavior properly. One such model, a simplified version of the Beaufoy-Sparkes charge-control transistor model, is shown along with a tabulation of its parameters and some typical values.

The equations to determine the current generators for the model are:

$$I_1 = (1/\beta_N + 1)J_N - J_I$$
$$I_2 = -J_N + (1/\beta_I + 1)J_I$$

where:

$$J_N = I_{ES}[\exp(\theta_N V_{BE}) - 1]$$
$$J_I = I_{CS}[\exp(\theta_I V_{BC}) - 1]$$

The depletion and diffusion capacitances for the model can be expressed as:

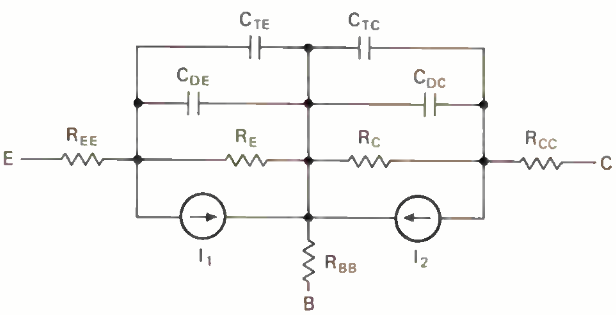
$$C_{TE} = A_1/(\phi_1 - V_{BE})^{N1}$$
$$C_{TC} = A_2/(\phi_2 - V_{BC})^{N2}$$
$$C_{DE} = \theta_N\tau_N(J_N + I_{ES})$$
$$C_{DC} = \theta_I\tau_I(J_I + I_{CS})$$

The accuracy of nonlinear transistor modeling and the convenience of linear problem-solving can be combined by converting the nonlinear charge-control model parameters to the parameters of the linear hybrid-pi model shown. Four equations must be solved:

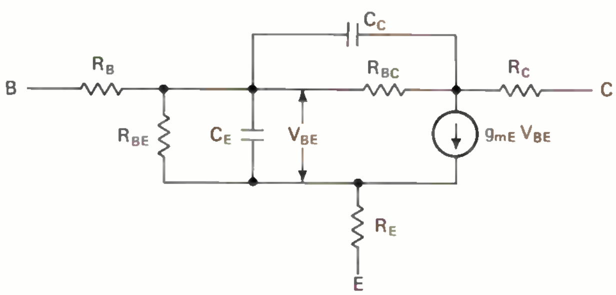
$$g_{mE} = \theta_N J_N$$
$$R_{BE} = \beta_N/\theta_N J_N = \beta_N/g_{mE}$$
$$C_C = A_2/(\phi_2 - V_{CC})^{N2} + \theta_I\tau_I(J_I + I_{CS})$$
$$C_E = A_1/(\phi_1 - V_{CE})^{N1} + \theta_N\tau_N(J_N + I_{ES})$$

Generally, base-collector resistance R_{BC} is assumed to be so large that it can be neglected.

NONLINEAR CHARGE-CONTROL MODEL



LINEAR HYBRID-PI MODEL



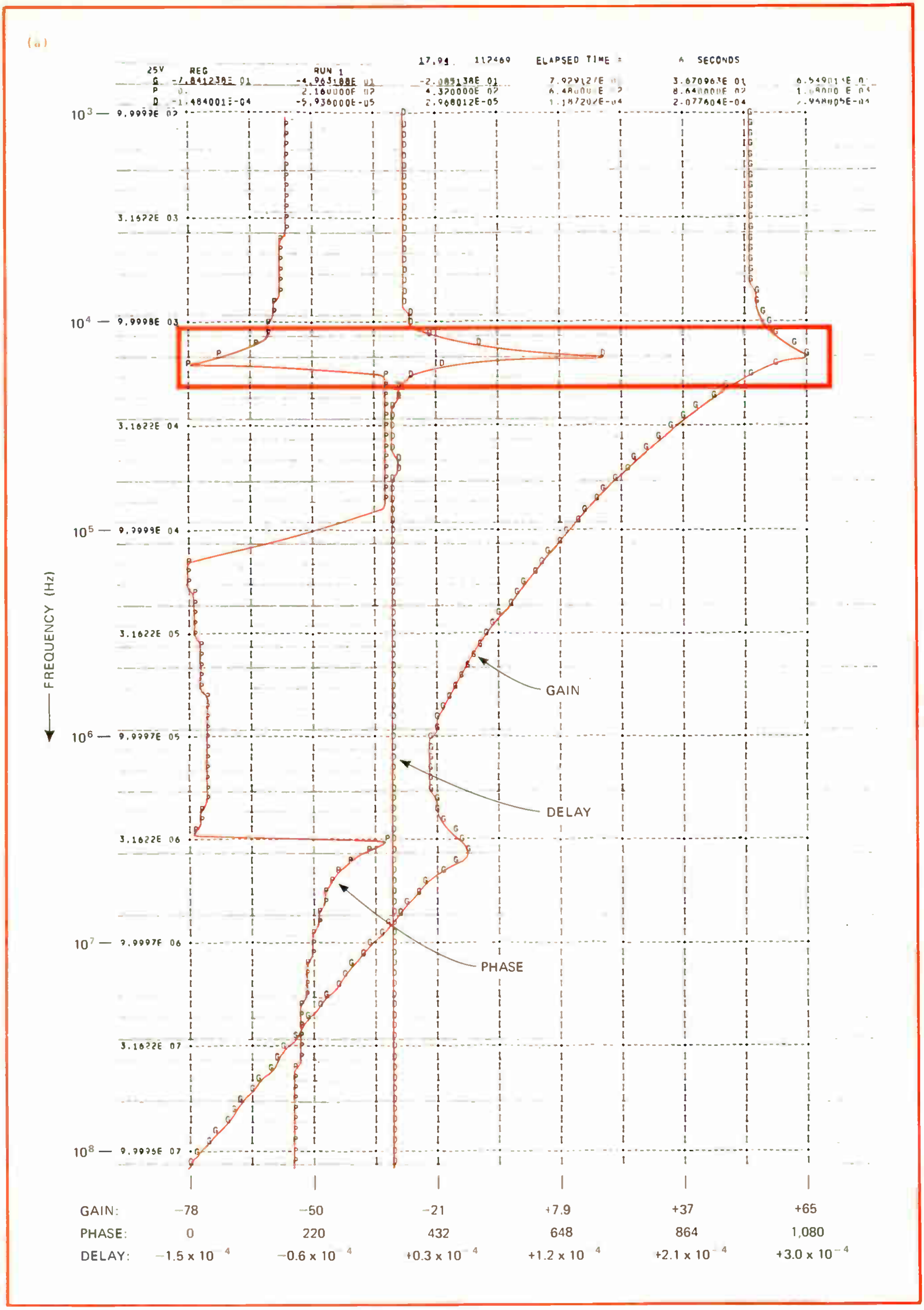
CHARGE-CONTROL TRANSISTOR PARAMETERS		
Parameter	Definition	Sample value
R_{BB}	Base bulk resistance	55 Ω
R_{CC}	Collector bulk resistance	5 Ω
R_{EE}	Emitter bulk resistance	1 mΩ
R_C	Collector reverse-bias leakage resistance	10 MΩ
R_E	Emitter reverse-bias leakage resistance	30 MΩ
C_{TC}	Collector depletion capacitance	–
C_{TE}	Emitter depletion capacitance	–
C_{DC}	Collector diffusion capacitance	–
C_{DE}	Emitter diffusion capacitance	–
I_{CS}	Saturation collector current when $V_{BE} = 0$	0.485 pA
I_{ES}	Saturation emitter current when $V_{BC} = 0$	3.5 fA
J_N	Forward current generator	–
J_I	Inverted current generator	–
β_N	Normal beta with $V_{BC} = 0$, $V_{BE} = 0$	72
β_I	Inverse beta	0.62
A_1	Base-emitter capacitance	3.7 pF
A_2	Base-collector capacitance	3.3 pF
ϕ_1	Intrinsic base-emitter junction potential	1.1 V
ϕ_2	Intrinsic base-collector junction potential	1.1 V
θ_N	q/mkT, $1 < m < 2$, $T = 25°C$	40.1 V^{-1}
θ_I	q/mkT, $1 < m < 2$, $T = 25°C$	29.4 V^{-1}
N1	Constant, 0.33 (graded junction) to 0.5 (step junction)	0.34
N2	Same as N1, usually N2 ⩽ N1	0.10
τ_N	Normal storage time constant	120 ps
τ_I	Inverted storage time constant	35 ns

and τ_I are stored as J5, B5, D5, U5, and E5, respectively. Upper data point values for these same parameters are stored respectively as J6, B6, D6, U6, and E6.

The values for the hybrid-pi model parameters are calculated with the equations listed in statements 1000 through 1100. Printout instructions for these computed values are given in statements 1140 through 1180. Statements 1220 through 1250 allow additional circuit operating conditions to be examined and, therefore, other parameter values to be generated at the user's option. If no further modeling is required, the program stops.

Using Hypi

A design example will illustrate how the Hypi program can simplify circuit analysis. The voltage regulator of Fig. 2 is to be examined to identify any potential cir-



(a)
FREQUENCY (Hz)
GAIN
DELAY
PHASE
GAIN: −78 −50 −21 +7.9 +37 +65
PHASE: 0 220 432 648 864 1,080
DELAY: −1.5 x 10⁻⁴ −0.6 x 10⁻⁴ +0.3 x 10⁻⁴ +1.2 x 10⁻⁴ +2.1 x 10⁻⁴ +3.0 x 10⁻⁴

(b)

```
17.94    112469    ELAPSED TIME =    4  SECONDS

25V      REG                    RUN 1

TRANSFER FUNCTION CRITICAL FREQUENCIES - HZ

OUTPUT VARIABLE - I RL1
SOURCE VARIABLE -  I4

GAIN CONSTANT IS    5.9664833D-03
```

POLE POSITIONS / ZERO POSITIONS

POLE REAL PART	POLE IMAGINARY PART	ORDER	ZERO REAL PART	ZERO IMAGINARY PART	ORDER
-2.7480649D 08	0.	1	-2.7480622D 08	0.	1
-5.3880355D 06	0.	1	1.3145697D 06	0.	1
-5.6950299D 06	-2.3229797D 07	1	-5.6977901D 06	-2.3199971D 07	1
-7.4132548D 05	4.0710722D 06	1	-6.6625225D 05	-4.2086433D 06	1
-7.0530964D 05	3.5812489D 06	1	-1.8070639D 06	4.5857293D 05	1
-2.2069888D 06	0.	1	-6.0152818D 05	0.	1
-1.2590207D 04	0.	1	-3.5091589D 04	0.	1
-1.0208272D 03	1.3869207D 04	1			

TRANSFER FUNCTION POLYNOMIALS - RADIANS

SCALED BY 1.000D 08 IN FREQUENCY AND 1.000D 03 IN IMPEDANCE

DENOMINATOR COEFFECIENTS	DEGREE IN S	NUMERATOR COEFFECIENTS	DEGREE IN S
1.00000000000000D 00	12	1.00000000000000D 00	10
1.86421780292370D 01	11	1.82507986367618D 01	9
2.67449598281917D 01	10	1.95270645224086D 01	8
5.34455908411475D 01	9	4.44161733646198D 01	7
3.10444159315380D 01	8	1.19346783206469D 01	6
1.16988443537986D 01	7	3.59471232049698D 00	5
3.41450649468625D 00	6	4.62479670857983D-01	4
6.14875208969585D-01	5	-5.28080137906799D-03	3
8.91053839472356D-02	4	-3.88926194533646D-03	2
6.59065593013516D-03	3	-1.27993135448266D-04	1
6.06073218137769D-06	2	-2.63368067642326D-07	0
5.68339032658798D-09	1		
3.93113714331177D-12	0		

3. Frequency response. Nonlinear transistor model data computed by Circus is entered into Hypi so that hybrid-pi model and, therefore, linear program can be used to analyze regulator. Subsequent frequency analysis by linear Cornap program provides plot (a) of regulator characteristics for 1-ampere load, as well as tabulation (b) of pole-zero locations. Potential instability is outlined in color.

cuit instabilities that could cause unwanted oscillation.

First, the collector currents and base-collector voltage drops of all the transistors are found with the nonlinear Circus program for four different load conditions. In this case, load current ranges from approximately 1 ampere to 10 milliamperes, as load resistance is varied from 25 to 250 ohms. The table in Fig. 2 gives the results of this analysis.

The current and voltage values are then entered into the Hypi program; a separate run is needed for each transistor. The hybrid-pi model data supplied by Hypi can then be entered into any one of several linear analysis programs. For this example, the widely used linear program, Cornap, is chosen for convenience. With a command of only a single instruction, Cornap can provide transfer functions, pole-zero locations, and plots.

Figure 3a is a Cornap frequency-domain plot of the regulator's gain, phase and delay characteristics when load current is about 1 A. Amplitude values and peak amplitude locations vary with transistor collector current. The peak (outlined in color) in the vicinity of 14 kilohertz for all characteristics indicates the presence of a potentially critical pole.

Cornap's tabulated output format (Fig. 3b) for the regulator's frequency-domain transfer function and pole-zero locations lists the potentially troublesome pole (outlined in color) as having its real part located at 1,021 hertz and its imaginary part at 13,869 Hz. An analysis of this pole location reveals that the pole's phase angle is approximately 86°, which implies extreme sensitivity to ringing and probable oscillation if parameter values change even slightly. □

The author wishes to acknowledge J.E. Hooper's help in developing the Hypi program.

Multiplexer adds efficiency to 32-channel telephone system

Analog signals are time-division multiplexed by recently developed integrated circuits in a two-level switching scheme; the technique promises to add speed and efficiency to digital telephone systems

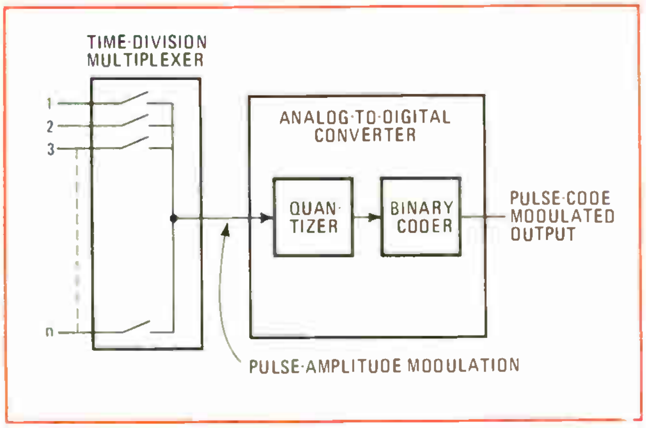
by John A. Roberts* and J.O.M. Jenkins, Siliconix Ltd., *Swansea, England*

☐ Time-division multiplexing has gained wide acceptance in recent years as a means of combining multiple telephone channels on wire-pair transmission lines that previously accommodated only one channel. Combined with pulse-code-modulation (PCM) circuitry to convert the sampled signals to a digital format, the multiplexing techniques have generally reduced size, power consumption, and costs of plant equipment.

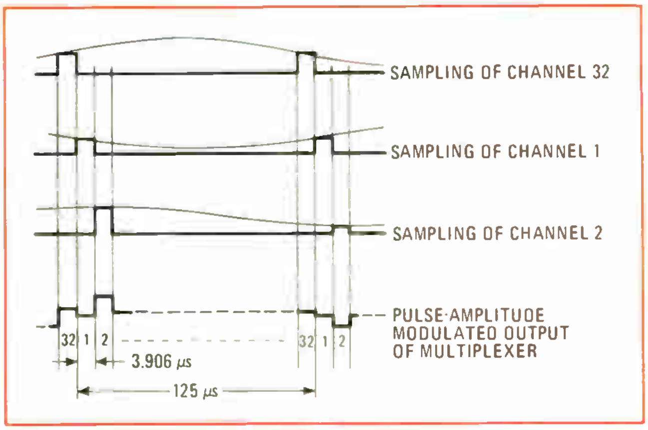
To achieve minimum signal loss and distortion in such systems, much effort has been directed toward building multiplexers that switch from channel to channel with minimum output rise and fall times. Such a multiplexer design recently built and tested provides 150-nanosecond switching time, an order of magnitude faster than presently available circuits.

This high-speed switching is achieved by applying biphase control logic to a two-level multiplexer arrangement that takes advantage of the fast rise times and the break-before-make action of newly developed integrated-circuit multiplexers.

*Now with Microsystems International Ltd., Ottawa, Canada



1. Telephone's answer. Problems in overcrowding of wire-pair telephone-transmission lines are lessened by using analog time-division multiplexers followed by a-d converters.



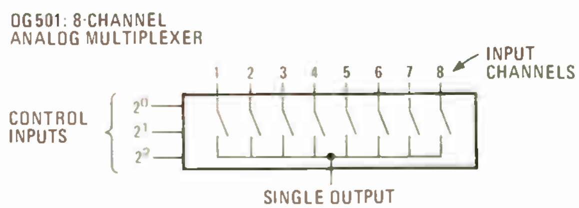
2. Tight fit. For accurate reconstruction of a 3.3-kHz telephone signal, it must be sampled at a rate of about 8 kHz, or once every 125 μs. The hierarchy of today's telephone system makes it highly desirable to multiplex 32 speech channels during this period.

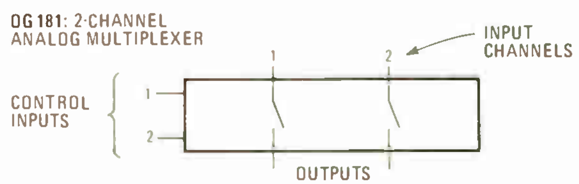
Telephone system requirements

A generalized system used to time-division multiplex voice signals is shown in Fig. 1. After the signals on each of analog channels have been sampled, each sample is quantized and coded into a PCM format. The new design focuses on the analog multiplexer, which feeds the analog-to-digital converter.

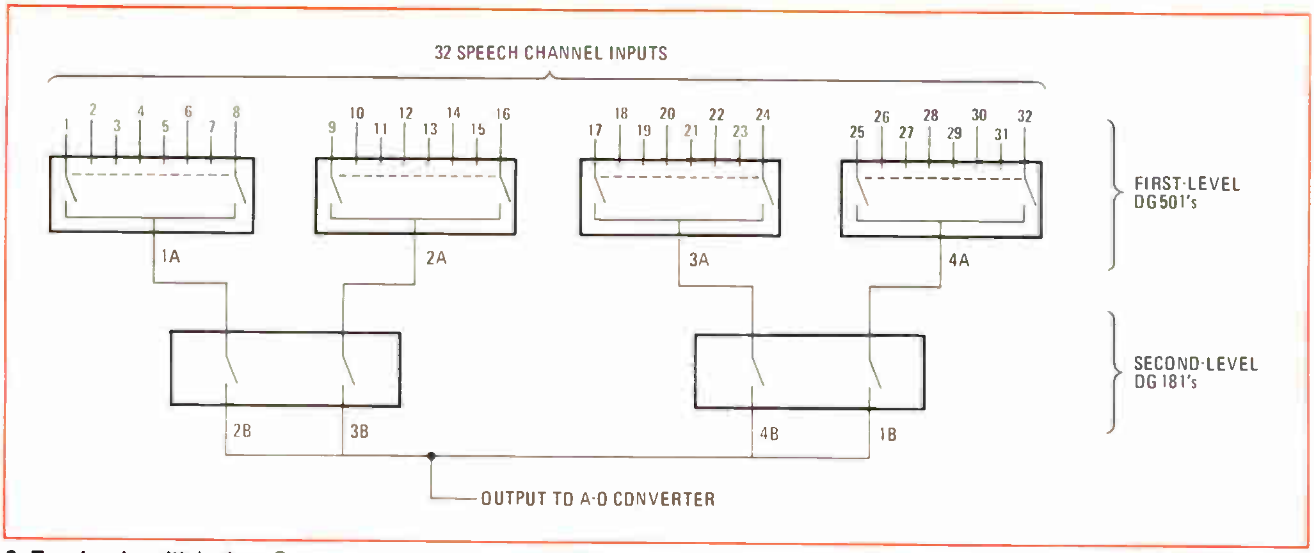
The sampling rate for each of the incoming channels is determined by the desired bandwidth of the voice signals being sampled, while sampling dwell time is fixed by the number of channels that must be sampled. Nyquist's sampling theory[1,2] states that any transmitted waveform that is band-limited to a maximum frequency of f_L can be accurately reconstructed from periodic sam-

CIRCUIT CHARACTERISTICS TABLE





DG501		DG181
500 Ω	SERIES RESISTANCE (ON CHANNEL)	30 Ω
1.5 μs	SWITCHING TIME	150 ns
40 pF	OUTPUT CAPACITANCE	20 pF



3. Two-level multiplexing. Output-node capacitance is significantly reduced when a second level of multiplexers is added. Interchannel switching time, however, is still determined primarily by the speed of the first-level switches.

ples taken at a rate as slow as $2f_L$.

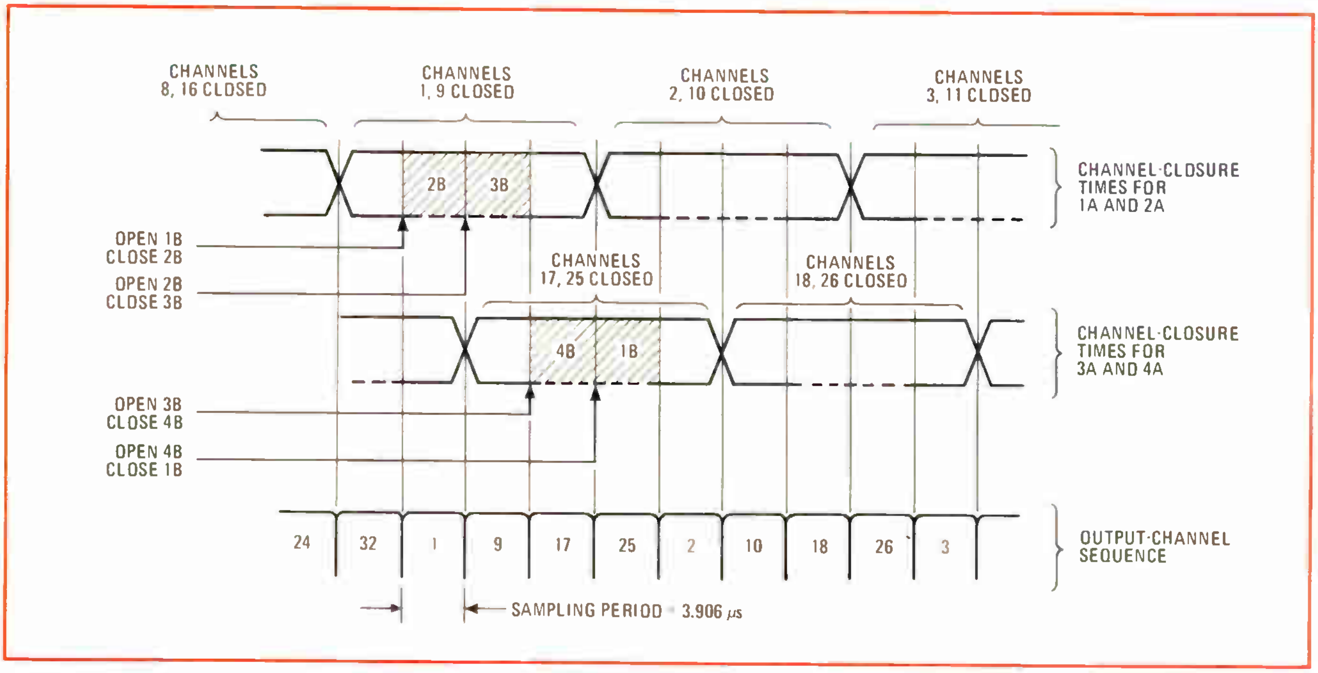
In practice, however, filters do not provide ideal cutoff at f_L, and a somewhat higher sampling rate must be tolerated. For example, to achieve less than 1% error in reconstruction accuracy, the sampling rate must be at least twice the frequency at which the unwanted signals above cutoff are reduced by 40 dB.[2,3] Thus, to relax difficult filtering requirements at the input-to-sampling circuitry, a voice bandwidth that is nominally limited to about 3.3 kHz is usually sampled at an 8-kHz rate, or once every 125 μs.

Single-level multiplexers

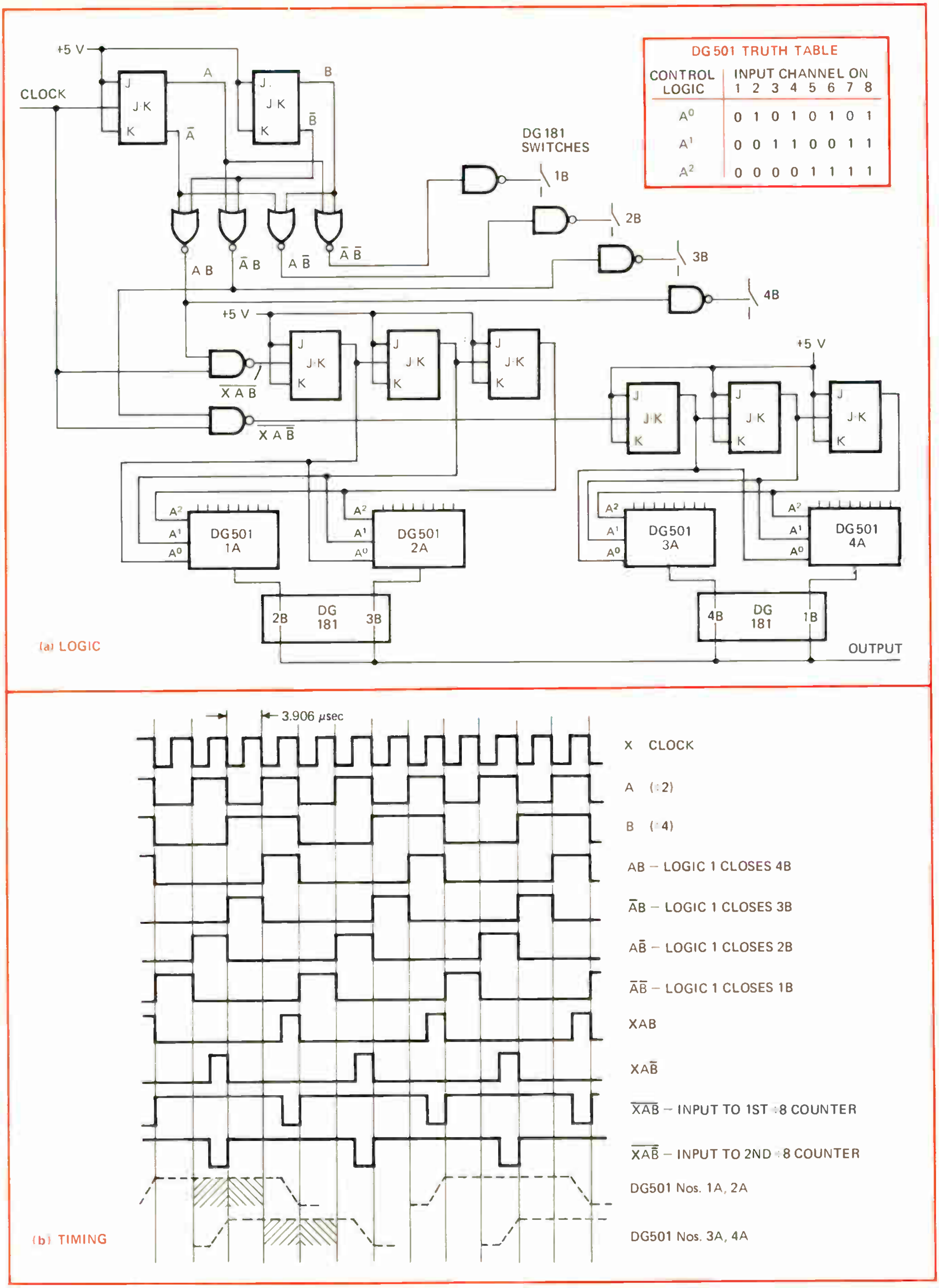
The standard configurations of today's telephone systems dictate that a fundamental group of 32 channels be multiplexed onto one line. Therefore, with a sample frame time of 125 μs, each of 32 multiplexed channels is sampled for 125/32, or 3.906 μs, as Fig. 2 indicates.

Conventional multiplexing networks can be implemented with either descrete components or integrated circuits, such as the Siliconix DG501 (see table). This circuit multiplexes eight input channels with a switching time between channels of 1 to 2 μs. A 32-channel multiplexer is constructed simply by paralleling four DG501s. Thus, in single-level switching, each of the 32 analog input channels is multiplexed through a single switching bank.

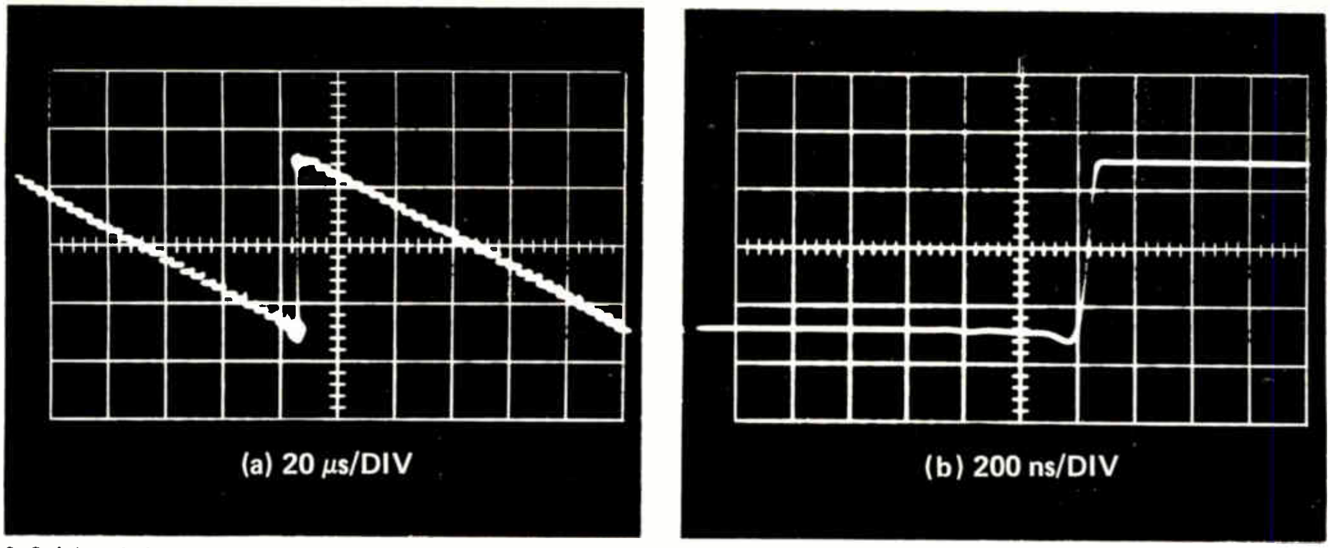
The problem with such a system stems from the relatively slow 1–2-μs switching times between channels. Depending on the design of the particular multiplexer, there can either be an overlap between sampling pulses, which leads to crosstalk between channels, or a large separation between samples, which reduces the sampling time of a particular channel. The reduced



4. Phase II timing. By adding two-phase control logic to the two-level multiplexer of Fig. 3, the full advantage of the 150-ns switching speed of the DG181 circuits is realized. Channel numbers correspond with those in Fig. 3.



5. Logic hardware. TTL control circuits (a) implement timing (b) required in two-phase, two-level multiplexing system. First-level DG501 switches are MOS circuits, and J-FET technology gives the faster switching times needed in the DG181 second-level switches.



6. Quick switch. Thirty-two dc levels are sampled in a prototype multiplexer to demonstrate switching speed of the two-level two-phase design. Largest single transition, from −3 to +3 volts, is expanded in the lower trace. Vertical scale for both traces: 2 V per division.

sampling time results in lower multiplexer efficiency.

Added to the 1–2-μs switching time is a delay associated with the increased output-node capacitance when multiple channels are combined. For four DG501s (32 channels), the added delay is about 200 ns. These delays further reduce the effective sampling time and bring some uncertainty into the timing strobe for the a-d converter. The node-capacitance problem can be eased to some extent by a high-performance sample-and-hold circuit between the multiplexer and the a-d converter. However, the 1–2-μs switching times remain, and this problem becomes acute for signals obtained from sources with output impedances of 2 kilohms and above.

Two-level multiplexing

System-response time can be improved by reducing the output-node capacitance. This is achieved by using a two-level multiplexing system as shown in Fig. 3.[4] Here, circuits with lower output capacitance (such as the DG181, with performance shown in the table) are placed in the second multiplexing level, which feeds the a-d converter.

The DG181 circuits can switch at a speed of 150 ns. The full advantages of these speeds, however, are not realized, since interchannel sampling time is still limited by the 1–2-μs rise times of the DG501s.

A timing sequence that makes maximum use of the switching rise times of the DG181s (and therefore results in extremely high sampling efficiency) can be achieved by applying control logic to the two-level multiplexer in a manner which will give the sampling sequence shown in Fig. 4. The faster switching speed and the break-before-make action of the DG181 virtually removes the possibility of overlap.

The problems caused by the relatively slow switching time of the DG501 are eliminated by ensuring that the first channels of multiplexer switches 1A and 2A (Fig. 3) are already fully closed when 2B and 3B, respectively, are closed, and that the first channels of switches 3A and 4A are fully closed when 4B and 1B, respectively, are closed. This sequence is then repeated for each of the eight channels of the DG501s, and the complete cycle is again repeated.

Two-phase control logic

The timing requirement and logic-control layout for the complete circuit are shown in Figs. 5a and 5b. Waveforms A and B are obtained from the input clock waveform by an asynchronous divider. The A and B waveforms are combined to give AB, $A\bar{B}$, $\bar{A}B$ and $\bar{A}\bar{B}$ which are needed to close the DG181 gates sequentially. Functions XAB and $XA\bar{B}$ then clock two three-bit asynchronous counters. A delay of two clock periods exists between XAB and $XA\bar{B}$ so that the count sequence applied to the second and third multiplexer is suitably delayed.

A prototype multiplexer with two-phase control logic has been constructed and successfully tested. Series 7400 TTL circuitry is used to implement the timing and control logic. First-level DG501 switches are MOS circuits, while J-FET technology gives the faster switching times needed in the DG181 second-level switches.

To simulate all 32 analog inputs to the multiplexer, a voltage-divider network of series resistors is connected across a ±3-volt supply. Thus, 32 dc voltage levels are consecutively tapped off the network and applied to the multiplexer input. The multiplexer output is displayed on the oscilloscope, as shown in Fig. 6a. As can be seen, the largest transition is from −3 to +3 V. In Fig. 6b, this 6-V transition is demonstrated as being accomplished in less than 100 ns.

If low-power TTL or diode-transistor logic is used in the control circuits, synchronous counters may be necessary to eliminate cumulative flip-flop delays. Although the system shown is designed for negative-edge-triggered J-K flip-flops, the circuitry can be rearranged quite simply for almost any bistable logic element. □

REFERENCES

1 Schwartz, M., "Information Transmission Modulation and Noise," 2nd ed., p. 174, McGraw-Hill Book Co. 1970

2 Shannon, C., "A Mathematical Theory of Communication," Bell System Technical Journal, pp. 379-423, July 1948 and pp. 623-656, October 1948.

3 English, M., "Multiplex Systems," Electronic Products, pp. 28-31, May 1969.

4 Yoder, D., "Two-Level Multiplexing for Data-Acquisition Systems," pp. 67-72 EEE, July 1970

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You probably noticed the greatly improved pictures transmitted from the surface of the moon during the Apollo XV and XVI missions. Previously it was difficult to handle detail in both deep shadow and bright sunlight. State-of-the-art camera tube technology from RCA overcomes this difficulty, while at the same time eliminating the possibility of catastrophic failure should the camera accidentally scan past the sun.

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Now you can afford to design this small size and remarkable performance into your camera. The popularity of the 4804 SIT series is rapidly increasing in space, defense, industrial instrumentation and day/night surveillance applications. RCA normally maintains off-the-shelf delivery capability of four grades of the basic 4804. You pay only for what you need: if your application demands a premium quality camera tube, specify 4804/PRE; if your blemish criteria are not ultra-stringent, order the 4804/PRO; when general surveillance is the name of the game, the RCA 4804/SUR represents an excellent buy; and finally, where price is an overriding consideration, the 4804/SCI is available to relaxed blemish and testing specifications. Potted versions, complete with high-voltage protective window, are recommended for safety and ease of use.

Check into the other low-light-level tubes in RCA's extensive camera tube line too. Isocons, 25mm and 40mm SIT tubes sizes, IV's and I^{2}V's also can be supplied, as well as Intensifier-Isocon and Intensifier-SIT coupled assemblies.

For more information, see your RCA Representative, or write, Mgr., Electro-Optics Marketing, RCA, New Holland Ave., Lancaster, Pa. 17604.

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Hand-soldering DIP circuits can save testing dollars

by William Mansfield and Herbert Perkins
Datatron Inc., Santa Ana, Calif.

Nowadays, integrated circuits are frequently mounted on printed-circuit boards by dropping their leads through plated-through holes and then flow-soldering. Although this method may yield the shortest assembly time, it is not necessarily the least expensive because the costs of product inspection and production testing can run high. Also, isolating faults on defective devices is extremely difficult, and removing installed devices risks the possibility of damage to both part and board.

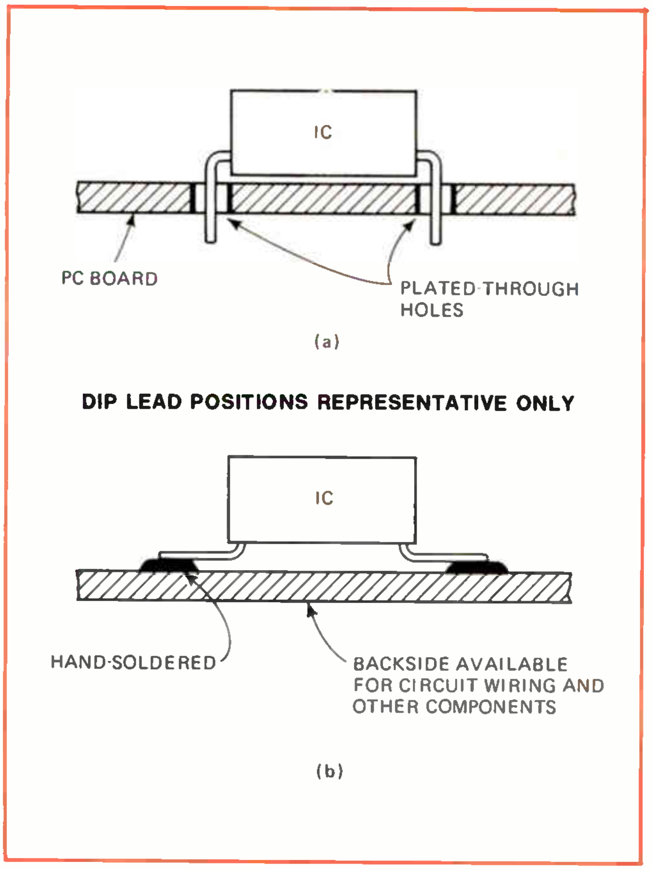
Surprisingly, a return to hand-soldering leads on only one side of the board can mean substantial savings in nonrecurring engineering costs, as well as the costs of inspection and production testing. Since most ICs are supplied in dual-in-line packages, device leads can simply be bent away from the DIP body by 90°, so that the resulting flattened package can be easily attached to the board, as shown in the figure.

Abandoning plated-through holes, moreover, releases the opposite side of the board for other circuit functions. All the real estate on the bottom becomes available for circuit paths, permitting increased density of both wiring and components. This additional real estate also enhances reliability because wider line spacing can be employed to reduce the likelihood of solder bridging.

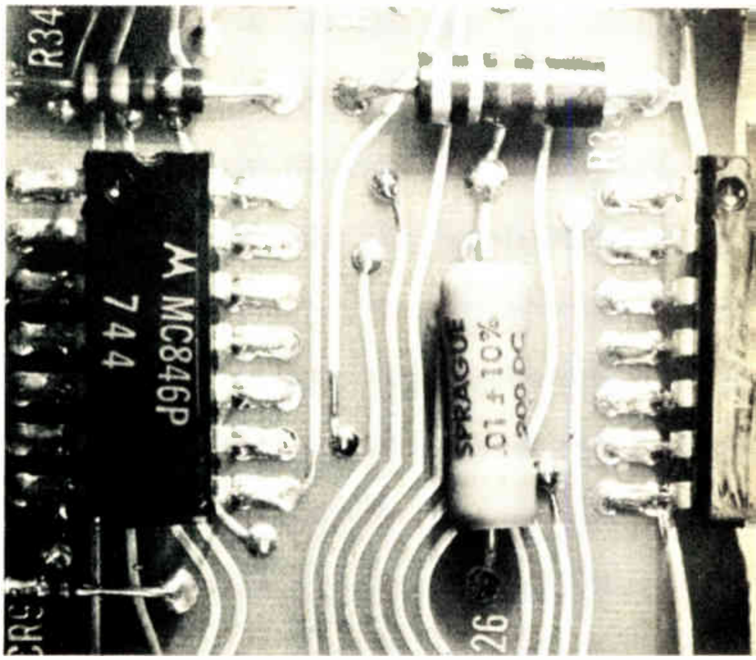
The cost penalty of hand-soldering a board containing 50 ICs—an increase in assembly time of approximately 15 minutes—can be offset by a saving of about $1.75 a board that results from fewer plated-through holes. And because layouts are more flexible, charges for engineering time can be cut by as much as 30%.

All IC leads are easily accessible for probing so that production testing and debugging is simpler. And any single IC lead can be unsoldered and lifted for fault isolation. With plated-through holes, removing an IC from the board risks debarrelled holes and raised wiring. Since repair is often unsuccessful, and the entire board must be scrapped, losses can run as high as $500 to $1,000 for a single ruined board. The savings from avoiding a scrapped board offset the cost penalty for hand-soldering some 100 boards.

Furthermore, plated-through holes are the historically weak link in the soldering operation, since they can introduce contaminants or open up during thermal cycling. Hand-soldering avoids these difficulties, in addition to providing a secure mechanical connection that can withstand the stress of exposure to shock, vibration, and direct pull. □



Hand-soldering has advantages. Plated-through holes (a) require space on both sides of printed-circuit board and make fault isolation difficult. By bending IC leads and hand-soldering (as in b), back of board becomes free for other circuit wiring, and single lead is easily unsoldered for testing. (Photo shows some mounted devices.) Cost penalty of hand-soldering is offset by savings in other operations.



Finding reciprocals easily with pocket calculators

by D.R. Wheeler
Raytheon Services Co., Burlington, Mass

Since the advent of electronic calculators, many engineers now own and use them daily. These versatile tools can perform a variety of arithmitic functions to get answers quickly and easily, but obtaining the reciprocal of a number is quite cumbersome, since most inexpensive calculators don't have a "1/x" key. Many users write the number on paper, clear the machine, enter 1, press "divide," re-enter the number and then press the "add/equal" key.

Although this method is viable, many of the pocket calculators can solve the problem more directly by using the "constant" (K) register. If n is the number, then its reciprocal, 1/n, can be found directly, as shown in the table:

- Depress and hold the "constant" key.
- Press "divide" key.
- Press "add/equal" key.
- Release the "constant" key.
- Press "add/equal" key. □

CALCULATOR OPERATIONS

Operation		Accumulator/display register	K register	K operation flip-flop
Hold K button	÷	n	clear	÷
	+/=	1 (n ÷ n)	n	÷
	+/=	1/n	clear	clear

Minicomputer controller is inexpensive

by Richard Hilton
U.S. Naval Weapons Laboratory, Dahlgren, Va.

Minicomputers are frequently used as controllers, but most commercially available models are much faster than needed and often cost more than a prospective customer can afford to spend. With the proper architecture, however, a minicomputer can be built easily. It is easy to debug, and costs hundreds, rather than thousands, of dollars. It features a 16-bit word length, 22 instructions, and provisions for up to 4,096 words of memory.

The minicomputer can be fabricated from small- and medium-scale TTL integrated circuits, including a memory array that is composed of 256-bit static random-access IC memories, like the Signetics type 2501. Package count can be minimized because the system employs a one-dimensional memory array, as well as serial data processing and routing.

The memory format requires the 16-bit references be made for each word reference. During each system memory cycle, which is made up of 16 phases, each memory module is first accessed and then optionally written into, permitting the contents of any memory location to be added to in a single cycle with only a few instructions.

The minicomputer's functional block diagram shows the accumulator to be a 16-bit right-shift register with parallel-set capabilities for input/output data and indicator lights. There is a two-part memory address register. The lower part (MARL), together with the four-bit operation register (OP), make up a 16-bit shift register that can receive the serial memory output and hold it as a 16-bit parallel word. The upper memory address register (MARU) is a 12-bit latch that can be cleared for sampling the contents of the lower memory address register when desired.

The arithmetic section is composed of a Boolean logic network (one AND gate and one OR gate), a full adder

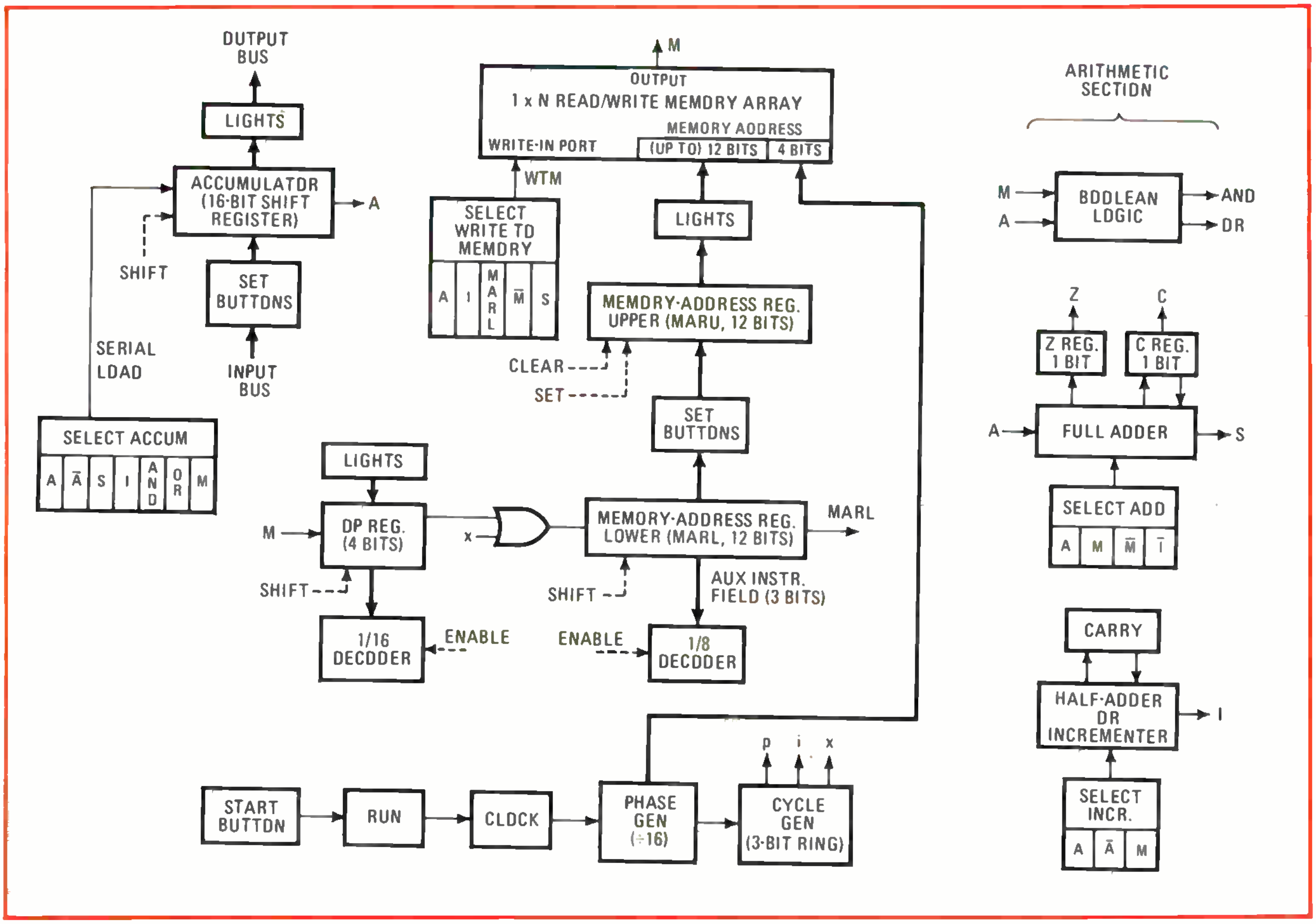
Data selection. Minicomputer controller has four data selectors that pick up input data according to the instruction being executed. As shown in the block diagram, they are located at the accumulator, the memory's write-in port, the adder, and the incrementer.

DATA SELECTOR INSTRUCTIONS

INSTRUCTION CODE (HEXADECIMAL)	ACTION	SELECT WTM	SELECT ACCUM	SELECT ADD	SELECT INCRE
0 yyy	ENTER ACCUM WITH [yyy]		M		
1 yyy	STORE ACCUM IN yyy	A	A		
2 yyy	ADD [yyy] TO ACCUM		S	M	
3 yyy	ADD ACCUM TO yyy	S	A	M	
4 yyy	COMPARE ACCUM WITH [yyy]		A	$\overline{M}$	
5 yyy	INCREMENT [yyy] AND COMPARE RESULT WITH ACCUM	I	A	$\overline{I}$	M
6 yyy	AND [yyy] WITH ACCUM		AND		
7 yyy	OR [yyy] INTO ACCUM		OR		
80 __	ONE'S COMPLEMENT ACCUM		$\overline{A}$		
81 __	TWO'S COMPLEMENT ACCUM		I		$\overline{A}$
82 __	INCREMENT ACCUM		I		A
83 __	INCREMENT ACCUM IF C = 1		I		A
84 dd	HALT FOR INPUT/OUTPUT ALERT DEVICE dd				
85 __	RIGHT SHIFT ACCUM INTO C			A	
86 __	CLEAR ACCUM				
9 yyy	INCREMENT [yyy]	I			M
A yyy	ONE'S COMPLEMENT [yyy]	$\overline{M}$			
B yyy	CLEAR [yyy]	ZERO			
C yyy	JUMP TO yyy IF Z = 1	MARL			
D yyy	JUMP TO yyy, [0] TO ACCUM	MARL	M		
E yyy	JUMP TO yyy IF C = 1	MARL			
F yyy	JUMP TO yyy	MARL			

[yyy] = CONTENTS OF LOCATION yyy; [0] = CONTENTS OF LOCATION ZERO

Minicomputer structure. Block diagram outlines the makeup of minicomputer intended for use as controller. The machine processes data serially and has one-dimensional memory array. Because it operates at a conservative speed, which is all that's needed for controller applications, it can be built for only several hundred dollars. The faster, commercially available minicomputers cost thousands.



(two exclusive-OR gates, four NAND gates, and one carry flip-flop, called the C register), and a half-adder or incrementer (one exclusive-OR, one NAND, and one flip-flop). The accumulator, the write-in port of the memory array, the full adder, and the half-adder are provided with data selectors that are only one bit wide. These pick up data from various devices, according to the instruction being executed. The table lists the instructions and settings of the four data selectors, as well as the command that is executed.

Memory location $(000)_{16}$ is used as the program counter. Every instruction goes through three memory reference cycles—p, i, and x. The phase counter is a four-stage ripple counter that goes through 16 states for each memory reference cycle and feeds its four output lines to the lowest four bits of the memory-address port of the memory array.

As the memory cycle proceeds, the contents of the memory cell specified by the 12 bits of memory address register MARU appear at memory-array output M in serial. During the p cycle, MARU is cleared and the contents of memory location $(000)_{16}$ are directed serially to the OP and MARL registers, as well as to the incrementer. The output of the incrementer is selected by the write-in port of the memory array. When the p cycle is over, the contents of the program counter are increased by one, and the old contents of the program counter lie in OP and MARL.

Next the minicomputer enters the i cycle. At the outset of this cycle, MARU samples MARL and uses that address to fetch an instruction that is placed in both OP and MARL. During the x cycle, data is routed serially, as it is needed to effect the desired instruction.

When jump instructions are executed, the contents of MARL are serially transferred to memory location $(000)_{16}$. During this transfer, the upper four bits of MARL's contents are ORed to logic 1s so that the contents of location $(000)_{16}$ are kept equal to those of the unconditional jump instruction.

The unconditional jump instruction in location $(000)_{16}$ is never used by the processor directly, but a jump-to-subroutine instruction causes the old contents of location $(000)_{16}$ to be loaded into the accumulator as the new contents are being placed into $(000)_{16}$. The programer then generates his subroutine exit by placing a store instruction into his exit location.

An index register for the minicomputer can be easily implemented with a suitable shift register—one that can be incremented during the i cycle while having its new contents added to the address that is being serially loaded into the MARL register. An interrupt structure could also be included. □

Engineer's Notebook is a regular feature in Electronics. We invite readers to submit original design, applications, and measurement ideas. We'll pay $50 for each item published.

Engineer's newsletter

A quarter of a quad gives control

Designers are finding that the inexpensive quad transistor arrays newly on the market can be **a cheap way of getting matched characteristics.** Instead of using expensive duals that are matched for a particular circuit parameter, such as temperature tracking, they buy the quads and **operate one of the transistors in the array as a diode for temperature compensation.** Or they use one or more transistors in the array as a zener to establish voltage regulation.

Automatic stud welding comes to electronics

A welding machine that's been used for years in the sheet-metal industries **can save you 25% of your stud-mounting costs** on equipment like hermetically sealed transformers and filters. The machine, the NSA-80 stud welding system manufactured by Nelson Stud Welding Company in Lorain, Ohio, 44055, will **shoot the stud into your sheet-metal housing and automatically align and weld it, all in one step.**

In CAD, older is sometimes better

Although the newer nonlinear CAD programs are the wave of the future, if you're interested in **doing frequency analysis only**, it's better to **stick with established linear programs** like ECAP or Cornap. You can probably get away with simple instructions, whereas the nonlinear programs have more complex instructions, having been written mainly for the more complex transient analysis.

Leakage current predicts reliability of display drivers

Here's a simple way to predict the reliability of solid-state high-voltage drivers for gas discharge displays—you just measure the driver's leakage current. According to Tom Kelly, chief engineer at Weston Instruments in Newark, N.J., **if the driver's I_{CBO} is low, the odds are that the unit will have a long life; if it's high, watch out.** Kelly adds, though, that the technique can't be used on zener-protected units, because the zener current is included in their leakage.

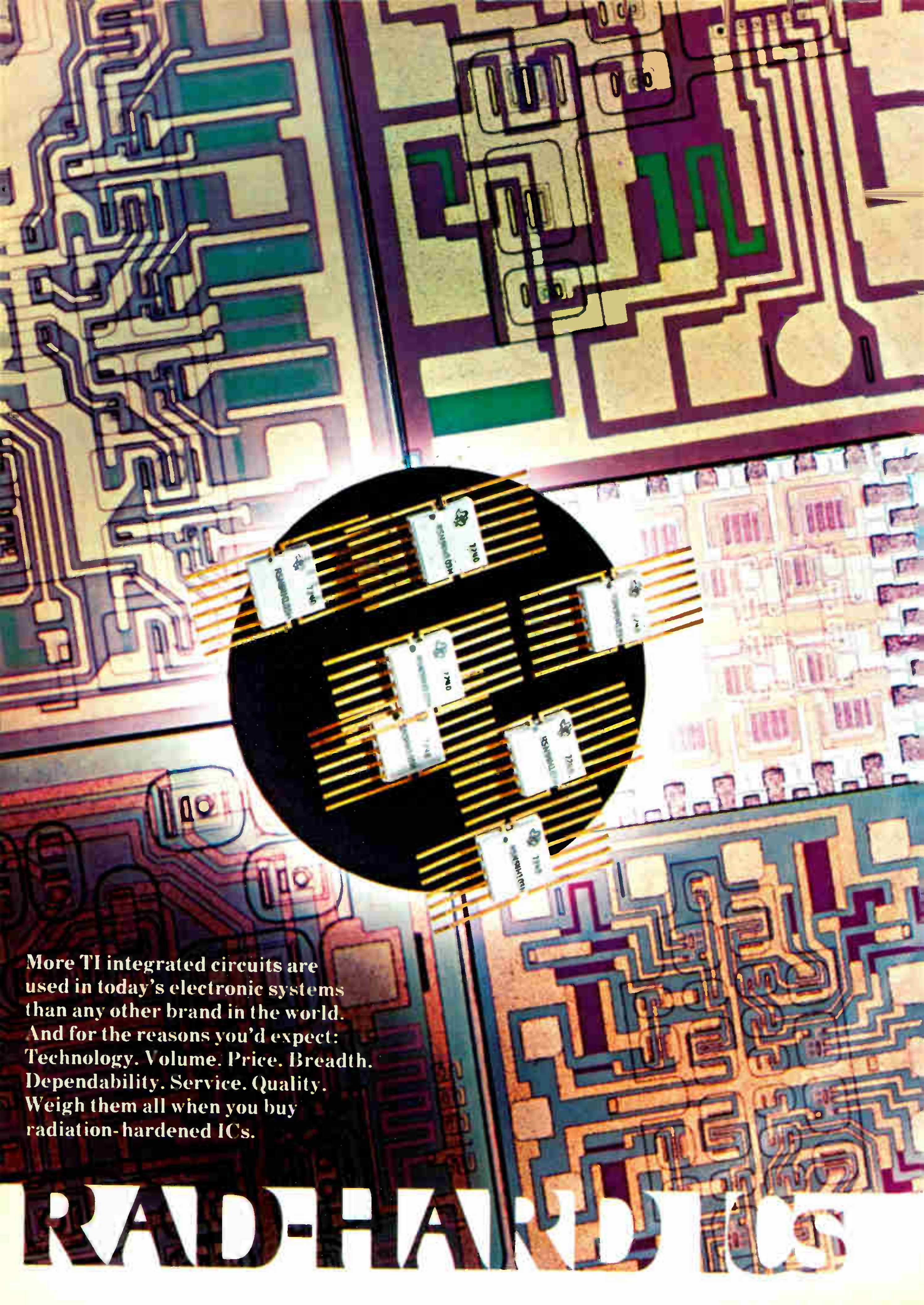
Fewer engineers are entering the education pipeline

Engineers worrying about being bumped out of their jobs by new crop of graduates will be pleased with the following statistic. According to the Engineers Joint Council in New York, N.Y., although the number of engineers of all kinds graduated from engineering colleges this year reached the highest level since 1950, **freshman enrollment dropped 14% from last year.** The relief will be particularly welcome for EEs, who head the list for bachelor's, master's, and doctor's degrees.

Another piece of good news is the declining unemployment rate for engineers. It dropped from 2% to 1.8% for the third quarter of 1972, according to the Labor Department. Nevertheless, there are still 20,000 engineers out of work.

Modems testing, testing, testing . . .

A modem trend worth watching: newer models have built-in test features that not only catch internal malfunctions (such as wrong voltage levels) but obtain external transmission-line data, too. For example, many suppliers now offer modems that can monitor transmission lines for equalization.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TI is thoroughly experienced in all technologies basic to radiation-tolerant integrated circuits, including dielectrically isolated substrates, thin-film resistors, minimum-size transistor geometries, narrow base widths, various packaging options and photocurrent compensation, where required.

Computer-aided design is now a matter of routine for both the design *and* layout of TI radiation-tolerant integrated circuits.

And TI will continue to extend its technological capability by combining radiation-hardening expertise with in-depth knowledge of MSI, beam leads and low-power Schottky TTL. (In addition, TI has depth experience in "rad-hard" discrete devices – both power and small-signal – and offers a broad line.)

Complete custom capability

In addition to its standard rad-hard line, TI has complete facilities, personnel and know-how – including all necessary R&D back-up – for the design of radiation-tolerant devices to your specifications and program requirements. A top-secret facility and storage security clearance, as well as provisions for comprehensive documentation, further strengthen TI's ability to provide full-service support.

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Hex inverter	-	RSN5404	RSN54H04	-
Triple 3 NAND	RSN54L10	RSN5410	RSN54H10	RSN15962
Dual 4 NAND	RSN54L20	RSN5420	RSN54H20	RSN15930
Single 11 NAND	-	RSN5431	RSN54H31	-
Dual 4 buffer	-	RSN5440	RSN54H40	RSN15932
Dual 4 power gate	-	-	-	RSN15944
Dual 2-wide AOI	-	RSN5456	RSN54H56	-
Single 4-wide AOI	RSN54L57	RSN5457	RSN54H57	-
Single 2-wide AOI	-	RSN5458	RSN54H58	-
Dual 3-2 AOI	-	-	RSN54H66	-
RS flip-flop	RSN54L71	-	-	-
JK flip-flop	RSN54L72	-	-	RSN15945
Dual D flip-flop	RSN54L74	RSN5474	RSN54H74	-
Dual J-K flip-flop	-	-	RSN54H103	-
One shot	RSN54L122	-	-	-
Dual 3 NAND	RSN54L130	-	-	-
Dual 3 NAND w/expander	RSN54L131	-	-	-
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7-diode array	RSN14925
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Quad 100mA NPN transistor array	RSN21886

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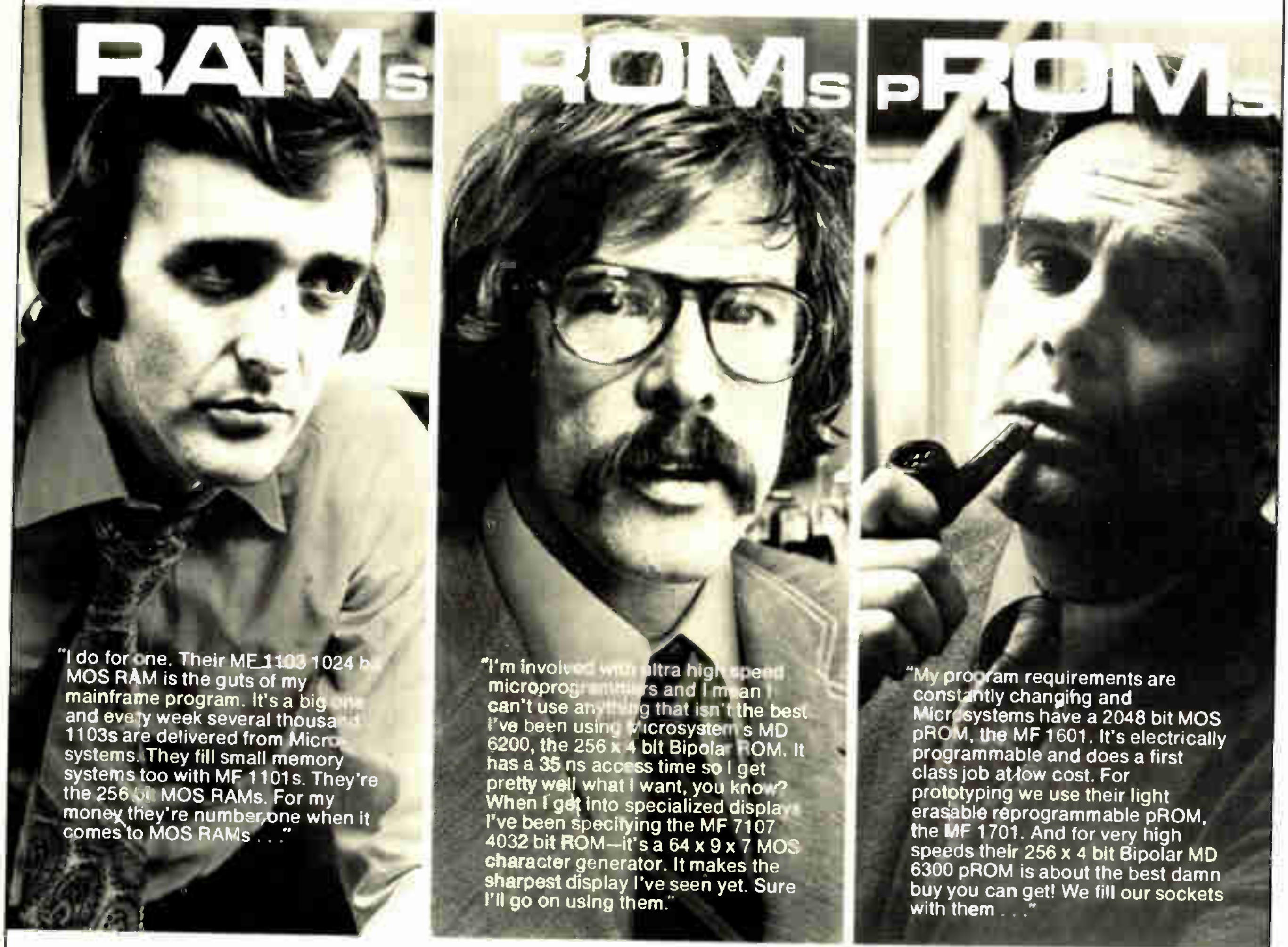

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Instrument marketing goes global

Under new policy, International Schlumberger Group produces multimeter in England, sells it worldwide under various labels

by Michael Payne, London bureau manager

Sharp competition in pricing continues to keep the electronic instrument business in ferment [*Electronics*, Nov. 20, 1972, p. 76].

Under a new policy, the International Schlumberger Group will now produce a single product of each type for world markets and make it in one plant, instead of making many similar products in many plants throughout the world. Although the electronics operation is centered in France, under this new policy a laboratory-type digital multimeter was designed and is now being manufactured by Solartron Electronics Group Ltd. in England. There, it's the Solartron type 7040, selling at 195 pounds sterling; in the U.S., it's Weston Instruments type 4444, at $585. Elsewhere, it's the Schlumberger 7040.

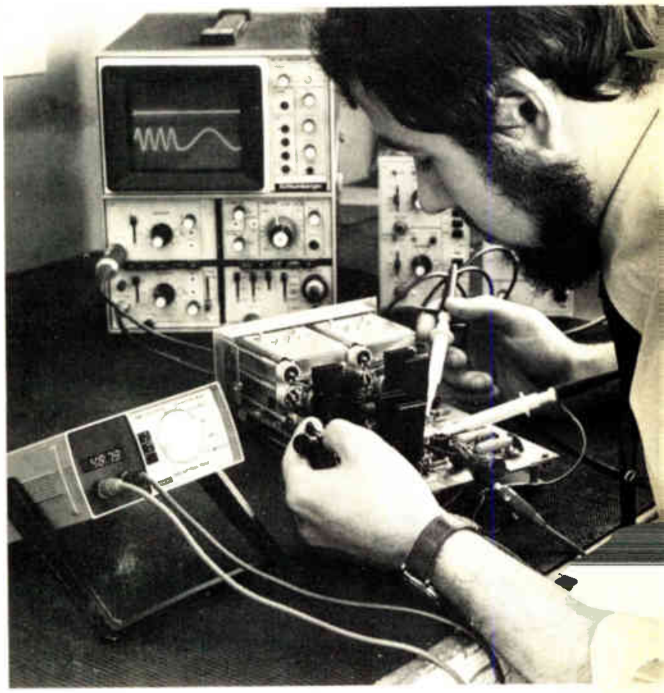
One control. The only operational control is a parameter-selection switch, for volts dc, volts ac, resistance, microamperes dc and for an rf-probe option that will be available in a few months. Range selection is completely automatic. Readings appear on the 4½-digit LED display without perceptible delay—Solartron engineers say one of their main achievements is elimination of delays in automatic range selection, which last several seconds in some instruments. The decimal point is placed automatically, redundant zeros blank out, and there is also a 10% overlap between ranges. For example, when monitoring a voltage fluctuating on each side of 1 volt, the instrument reads 999 mv, 1.000 mv, 1.001 mv, and so on, without jumping between ranges.

There are five voltage ranges, and the most sensitive, the 100-millivolt range, can resolve 10 microvolts. There are also five resistance ranges, beginning with 1 kilohm full-scale, and three current ranges, starting with 10 microamperes. Dc voltage readout is said to be accurate to 0.02% of reading, ac voltage is accurate to 0.2%, and resistance and current to 0.05%. Input resistance in the fine dc voltage ranges is 1,000 megohms, and reading rate is three per second. The key component is an LSI MOS integrated circuit with about 1,800 components, including counters, shift registers, and ROMs, on a chip measuring 24 mils by 109 mils in a 40-lead ceramic package. It's entirely designed by Solartron and manufactured by Plessey Co. The IC does all the digital functions except for some connected with the clock drive.

The measurement and analog-to-digital conversion are performed by a process called triple-slope integration, and the chip controls these processes, as well as range selection and display driving. Triple-slope integration is a further development of conventional dual-slope integration. As in dual-slope, the input is integrated for 100 ms and then counted back to zero at a fixed slope. The slope overshoots zero to the next clock pulse, and Solartron then adds its third slope, counting back to zero at a very fine slope very accurately. Because there's a third slope, the second slope can be steeper, and hence quicker, than if it were the only slope, so that there are a coarse and a fine measurement. The chip subtracts the fine reading from the coarse one.

In front of the integrator, there's a chopper-stabilized input amplifier. The reference, with which the input is compared, is a zener diode. All measurements are made to six figures; autoranging merely selects the figures relevant for display. If the input is more than 10 volts, the instrument makes one run to detect the fact and then switches in a 100-times attenuator to make its displayed reading. The display is time-shared; each digit is lighted for 200 μs, so that five digit places, plus a point diode, gives a scan time of 1.2 ms.

Weston Instruments Inc., 614 Frelinghuysen Ave., Newark, N.J. 07114 [338]



Multinational. Meter, left, is built for global market.

Instruments

Format converter is fast, precise

Digital unit with nanosecond resolution is aimed at radar, data, communications jobs

With the speed of communications equipment and data processors constantly rising and with the need for ever greater accuracy in radar systems, engineers need the fastest instruments available if they are to service their designs or surpass old levels of performance. Tau-tron Inc.'s new PFC-101 format converter offers the kind of timing resolution and speed control that are required.

Such format converters as the PFC-101 control the width, delay, offset, and amplitude of pulses fed into them. The four-channel PFC-101 does these jobs at rates from 1 pulse per second to 35 megabits per second and it can control any of the time-related parameters to within 1-nanosecond resolution, regardless of programed value. Programing is via front-panel thumbwheel switches, BCD instructions, or both.

Unlike most competing format converters, the PFC-101 has a digital design. "There seemed no reliable way to nanosecond-resolution with analog techniques," says Yohan Cho, Tau-tron president. "Accuracy sometimes was coarser than resolution, and both might vary with the input/output parameters used. So we went digital, and in the process, may have produced a converter with better performance and more channels per dollar." The PFC-101 sells for $7,900.

The format converter controls width and delay through a combination of oscillator time references, ECL counters, and tapped coaxial delay lines to reach timing accuracies to within ±0.1% and stabilities of ±0.5 nanosecond, ±0.1% of programed values.

This level of operation is adequate to handle semiconductor memories, and since a nanosecond equals one foot of range to radar engineers, the PFC-101 offers a new, simple means of fast calibration of high-resolution radar systems. The PFC-101 also should find its way into test racks for digital communications systems.

Operation of the converter is simple. At the back panel, a TTL input pulse of fixed amplitude and width is fed into the PFC-101 via a gated local oscillator and disappears, except for control signals emitted by the oscillator. A new clean pulse is reconstructed, thus eliminating any inaccuracies in the original pulse generator.

Under manual control, width of delay is set on the front panel by three-digit switches, a digit each for units, tens, and hundreds. The switch-set voltages pass through a TTL-to-DTL-level shifter and then are split among high-speed logic, using ECL counters and detectors, which yields the value of the first and second significant digits. Meanwhile, the units digit—the one that makes Tau-tron's specifications meaningful—is converted from BCD to a 10-line output signal, one output for each tap on a 10-stage delay line. This delay line yields the eventual nanosecond resolution. Tau-tron had to build its own reference delay line for production control. The company also was limited by available test equipment. The delay line is the only part of the system, except for output amplifiers, which is not strictly digital, yet it takes the place of more complex analog circuits in other systems.

Delay and width are controlled identically. Both depend on the accuracy of the input oscillator and tapped delay line. Amplitude and offset (or baseline) are front-panel adjustments. Tau-tron engineers figure that these parameters will be relatively constant in most test situations, compared to pulse width and delay, which many users wish to alter in real time.

Although it can be used with any pulse generator, the 101 is designed as a companion unit to the firm's WG-304 programable word gener-

ator [*Electronics*, Dec. 18, 1972, p. 117].
Tau-tron Inc., 685 Lawrence St., Lowell, Mass. 01852 [351]

Instrumentation amplifier produces 100 W in class A

Capable of producing more than 100 watts of power in class A operation, and up to 180 W of pulse power over the frequency range of 250 kHz to 105 MHz, the model 3100L instrumentation amplifier operates from single-phase ac power. At 70 pounds, the linear amplifier is more than 100 pounds lighter than a comparable tube type. The 3100L delivers full rated power to any load impedance. Price is $5,690.

Electronic Navigation Industries Inc., 3000 Winton Rd. South, Rochester, N.Y. [354]

Oscilloscope provides dc-to-60-MHz bandwidth

The model 1064 dual-trace oscilloscope offers a bandwidth ranging from dc to 60 MHz and provides a sensitivity of 5 mV/cm. Maximum sweep speed is 10 nanoseconds/cm. Also featured are a display measur-

ing 8 by 10 cm and calibrated delayed sweep. Integrated-circuit dual modulators help eliminate triggering problems. The unit, with two 10× attenuator probes, power cord, and 3-2 adaptor, is priced at $1,625.
Dumont Oscilloscope Laboratories Inc., 40 Fairfield Pl., West Caldwell, N.J. 07006 [355]

Rf generator provides 10-W output in S band

Designed for applications in automatic test equipment for microwave systems, an rf generator provides a minimum of 10 watts of continuous output power from 3.0 to 3.5 GHz. The model 1216H combines the rf source and a traveling-wave-tube amplifier in one unit. Small size results from a solid-state source, tunable over the entire range by a single control, a solid-state power

converter, and metal/ceramic TWT. Protective features include automatic time delay and thermal overload. Price is $4,550.
Hughes Aircraft Co., P.O. Box 90515, Los Angeles, Calif. 90009 [356]

Linear amplifier is for vhf applications

A linear power amplifier that features automatic tuning is for vhf operation. Called the model 762, the unit operates from 148 to 155 MHz and tunes itself in a maximum of 10 seconds. Output is 5 kW in fm and 2.5 kW at 90% modulation in a-m. Gain is 13 dB, and instantaneous 1-dB bandwidth is greater than 1 MHz.
Rf Communications Inc., 1680 University Ave., Rochester, N.Y. 14610 [359]

Impulse memory-voltmeter is for harsh environments

The model 5210 impulse memory-voltmeter, for use in severe electrical environments, is designed specifically to read and hold peak tran-

sient voltages of arcs, flashovers, and impulses. The unit is housed in a low-capacitance dual-shielded cabinet and makes pulse measurements where high-frequency radiation and a large number of common-mode signals cause difficulty in some instruments. Price is $1,495.

Micro Instrument Co., 12901 Crenshaw Blvd., Hawthorne, Calif. [357]

Logic circuit tester has range from ±3 V to ±30 V

A test probe for checking logic circuits provides a range from ±3 volts to ±30 V. Threshold is adjustable from 1-state to 0-state. In addition to detecting open circuits, the Acro-Probe responds from dc to pulses as short as 5 nanoseconds, positive or negative pulses, dc levels, and wave trains. The unit operates on any system supplying voltage with positive, negative, or intermediate grounding. Price is $99.50.

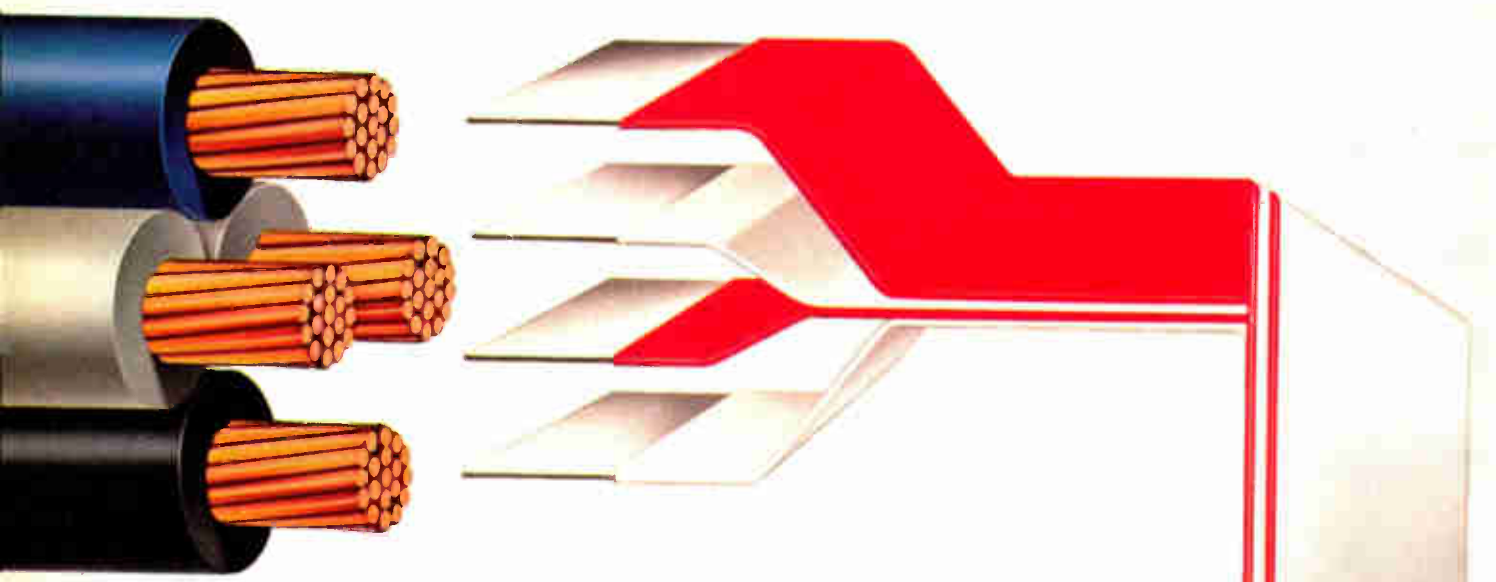
Acron Corp., 1095 Towbin Ave., Corporate Park, Lakewood, N.J. 08701 [358]

Audio frequency meter provides 0.1-Hz resolution

An audio frequency meter, the 1200A, uses LSI circuits and an LED display. Accuracy is to within ±0.01% of full scale, ±1 count, and maximum sensitivity is 20 mv rms, 10 Hz to 300 kHz; and 30 mv rms, 300 kHz to 2 MHz. Overload protection is 200 vac and 400 vdc continuous. The unit contains a crystal-controlled period generator. The lowest range extends sampling period to 10 seconds and provides 0.1-Hz resolution. Price is $245.

Linear Digital Systems Inc., P.O. Box 954, Glenwood Springs, Colo. 81601 [360]

PROBLEM:
cramming more power distribution cable into less space.



SOLUTION:
a cable that's flat instead of round.

Now you can pack more power distribution cable into less space than you ever thought possible. By using Brand-Rex's new *flat* PVCA cable. A vinyl-insulated aluminum strip you can stack, run in trays or ducts, bend at any angle for branching or to follow any contour.

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Standard terminals, including center tap, are readily available for fast, economical, air-tight, water-tight connections and splices. Yet new PVCA costs *less* than the conventional cable it replaces.

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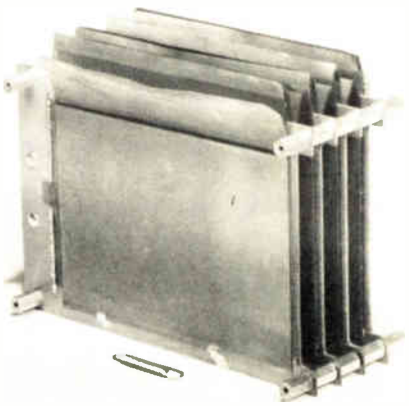
Data handling

Memory uses 2.5-mil wire

Stack for high-density applications can store 1,500 bits per square inch

Along with the much-heralded advances in semiconductor memories, other types of storage are also being improved. An example is plated wire, a technology that is making rapid progress in commercial applications because improved production techniques are resulting in lower costs for these nonvolatile memories.



In some commercial applications, however, size or noise resistance is more important than price, and for these uses, Memory Systems Inc. has developed a new memory stack using tiny 2.5-mil wire, which permits miniscule size, along with the noise-resistant nonvolatility of plated wire.

The new miniwire stack provides storage of 8,192 18-bit words in a space measuring 4 by 4 by 1½ inches, with comparable sizes for other storage. Density is 1,500 bits per square inch, roughly triple that of standard 5-mil wires.

Bruce Kaufman, president, says the stack will be used initially in high-density avionics computers, fuel-management controllers, and vehicle-positioning and control applications. In these applications, the nonvolatility and nondestructive readout of plated wire is essential because of the high electrical-noise environment and because the power supplies in aircraft and vehicles are often subject to dropout. Bits that could be dropped by core or integrated-circuit memories could result in erroneous control instructions, with possibly serious results.

Kaufman says most of these applications can benefit from custom, high-performance stacks, but says the prices in production quantities will be only slightly higher than those of the conventional 5-mil wire stacks that are designed for similar uses.

Reduction in size of the wires permits the use of 10-mil centers for sense-digit wires (formed by the plated wires), and 35 mils for the word lines. An important advantage of the miniwire is that the smaller size of the array halves the required drive currents, allowing the use of integrated-circuit word drivers, rather than the present larger and more expensive discrete semiconductor arrays. Some previous digit drivers have been made of ICs, but not for the higher-current words. The sense output is about the same as 5-mil arrays provide.

The initial products are basic stacks, without associated electronics, but Kaufman plans to supply complete systems in the future. Delivery time for standard configurations of the miniwire stacks is 60 days. Price of the memory stack depends on size and quantity.

Memory Systems Inc., 3341 West El Segundo Blvd., Hawthorne, Calif. 90250. [361]

Computer models tailored to high-level software

Two computer models developed by Modular Computer Systems Inc. are specially designed to execute the company's higher-level software operating systems. The ModComp II/10, priced at $11,500, and the II/25, priced at $12,500, offer as standard features 16,384 16-bit words of 800-nanosecond core memory, 15 general registers, 154 basic instructions (including hardware multiply/divide), power-fail-safe/auto-start, memory parity, executive features, hardware fill, and programer's control panel. The ModComp II/25 also contains a controller that can handle a paper-tape reader and most types of terminals. Additional memory can be obtained at $6,500 per 16,000-word module. OEM discounts go as high as 40%. Deliveries of the two models will begin this quarter.

Modular Computer Systems Inc., 1650 West McNab Rd., Fort Lauderdale, Fla. 33309 [363]

Recorder is compatible with any computer

A portable digital cassette recorder, model STR-200, eliminates the need for an ultraprecise drive mechanism and produces a single-track, self-clocking recording that is compatible with any digital-computer system. The unit tolerates tape-speed changes caused by cassette binding and makes character spacing noncritical. Bit-error rate is less than one soft error in 100 million bits. Price is $495 for one unit and $465 each for two to nine units. Discounts are available for quantity orders.

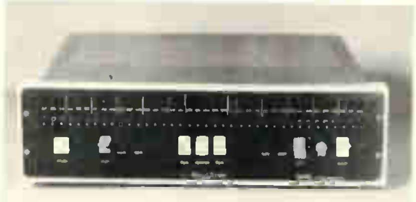
Electronic Processors Inc., 5050 S. Federal Blvd., Englewood, Colo. 80110 [364]

Simulator tests peripherals connecting to a PDP-11

The 11-simulator is a manually controlled development-diagnostic aid that exercises any standard or special-purpose peripheral that con-

New products

nects to the Unibus of a PDP-11 computer. External devices may be addressed, interrogated, or written



into under manual control, providing savings in time for writing and debugging test programs. The model 11 also enables proper operation of external interrupt and direct-memory-access logic to be verified.

Teletron Co., 40 Elliott St., Melrose, Mass. 02176 [365]

Data generators operate to 300 megabits a second

Operating from 1 bit per second to over 300 megabits per second, the DG-525 series of programable data generators produce serial bit streams of 16 and 32 bits per word, which can be increased to 64 bits per word with options. Serial data

stream is NRZ or RZ format, and output signals feature 1-volt amplitude and up to ±1 Vdc offset. Rise and fall time is 0.8 nanosecond. The units operate with an external clock signal, either sine wave or pulse. Prices begin at $4,365, depending on options.

Tau-tron Inc., 685 Lawrence St., Lowell, Mass. 01852 [367]

Terminal buffers contain a 4,000-character memory

Terminal buffers for communications and small-batch data-entry systems are designated the series

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A 2N3055 COMMERCIAL 10 AMP VERSION FOR ONLY 31¢

Solitron's new SDT 9301-09 series of 10 Amp NPN silicon power transistors are low cost replacement devices for standard 2N3055 commercial applications. These single diffused planar units meet or exceed characteristics of comparable plastic power transistors – but are packaged in a steel Ni-plated TO-3 case and cost only 31 cents each in quantities of 1000 and up. They're the lowest priced devices of their type on the market! ☐ BV_{CEO} ranges are 40 to 80 Volts. Both the typical gains of 15 min. and the V_{CE} (sat) of 1.0 Volt max. are specified in three groups: 1.0 Amp (SDT 9301-03), 2.0 Amps (SDT 9304-06) and 3.0 Amps (SDT 9307-09). They're available from Solitron stock for immediate delivery. ☐ Why settle for plastic versions of the 2N3055 when you can have much more rugged types for only 31 cents? Call or write today for information and specification sheets.

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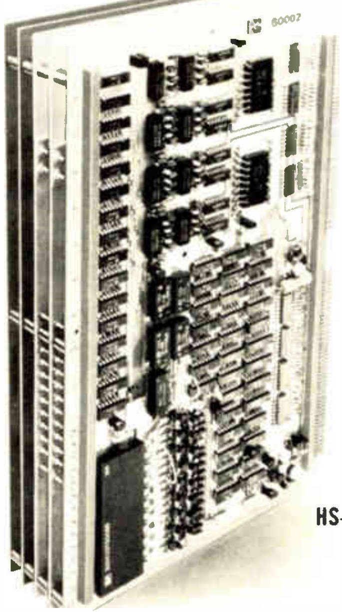
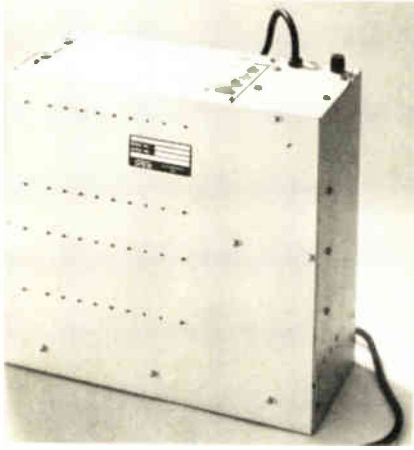
Circle 201 on reader service card



7132. They are used to mate low-priced teleprinters, such as Teletype models 33 and 38, to data links that operate at 1,200 baud or faster.



Each terminal buffer contains a 4,000-character (one-page) memory that is expandable in modules.

Pulse Communications Inc., 5714 Columbia Pike, Falls Church, Va. 22041 [366]

Multiplexer links up to 32 datasets to minicomputer

The model 1590 asynchronous communications multiplexer links as many as 32 full-duplex datasets to the SPC-16/40/45 family of minicomputers. The unit continuously monitors datasets or communications lines and assembles serial strings of bits into full characters for presentation to the computer upon program request. The 1590 executes four standard I/O instructions: data transfer out of register, data transfer into register, data transfer out of memory, and data transfer into memory. Price is $3,125.

General Automation Inc., 1055 South East St., Anaheim, Calif. 92805 [368]

Serial printer operates to 120 characters a second

An asynchronous serial I/O impact printer offers a choice of printing rates of 10, 15, 30, 60, or 120 characters per second. The OEM 120 printer provides 96 upper- and lower-case characters, and other

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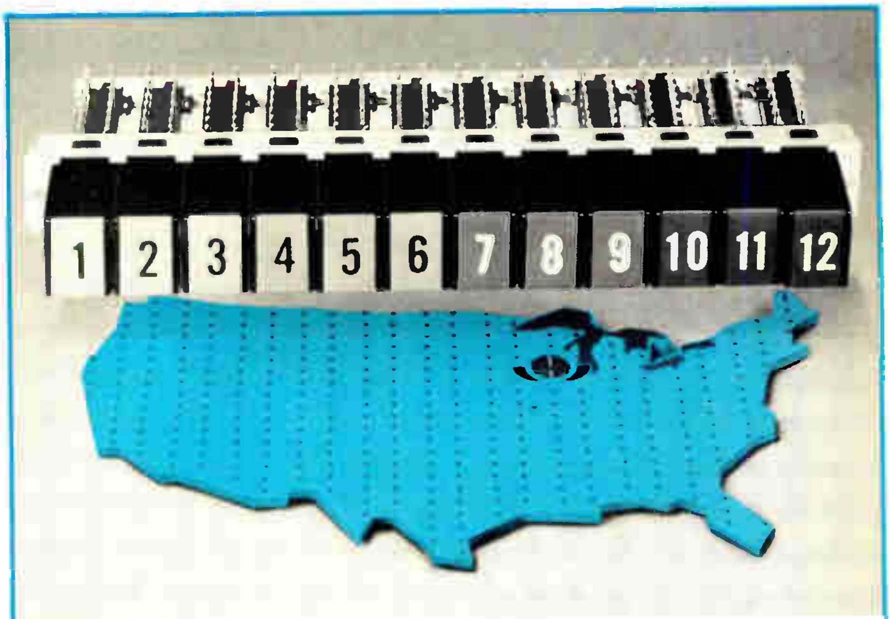
Companies in a hurry for made-to-order push button switches are taking advantage of Centralab's field assembly program, and not paying a premium for the service.



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Los Angeles 90022 ..... 213/685-5511

FLORIDA
Hammond Electronics
Orlando 32802 ..... 305/241-6601

INDIANA
Radio Distributing Co. Inc.
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MINNESOTA
Gopher Electronics
St. Paul 55113 ..... 612/645-0241

NEW YORK
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NORTH CAROLINA
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Let's say you're an engineer and you need samples of a 10-station push button switch for design mock-up purposes. A call to a Centralab Field Assembly Distributor will get you samples of 5 to 10 switches in 2 to 3 days. Now assume you're a PA and you want prototype or limited production quantities of push button switches.* A similar call will bring that initial run in a week's time.

This "hot button" service is part of Centralab's program to provide custom assembly of made-to-order push button switches as near to the customer as possible, without charging him more than he'd expect to pay for any similar factory-placed order. Now in its third year, the program has grown to include a great variety of push button options heretofore available only as special orders from the factory. The wide selection is proving to fill the lion's share of push button switch requirements.

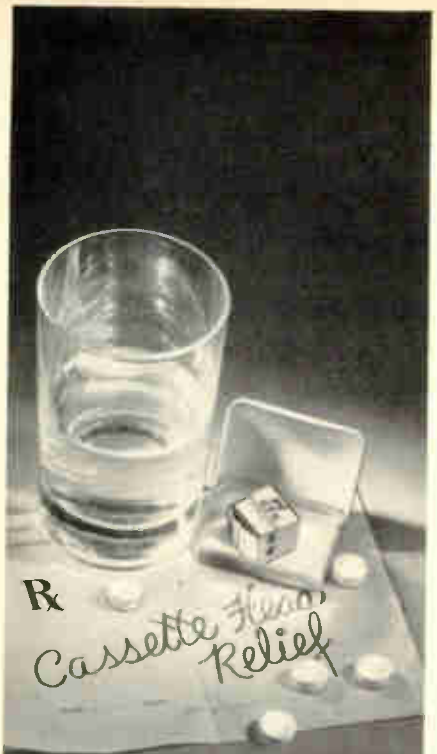
As a result, the customer can specify from a broad spectrum of these standard components and still obtain the switch that fits his particular needs. For example, you can order switches with up to 19 different stations and with 3 spacing options—10, 15 and 20 mm. You have a full choice of switching actions, such as interlocking, push push, or momentary, all available with lock-out. Electrical considerations include a choice of 2, 4, 6 or 8 pole double-throw designs and a new low profile 2 amp line switch.

Both non-lighted and lighted push button switches are available. In non-lighted, 12 button styles in 5 standard colors are offered. In lighted switches, there are 10 different colored lenses available.

For further details regarding the program, direct inquiries to the Distributor nearest you. Or write Centralab Distributor Products in Milwaukee, Dept. PB-2

* Isostat licensed.

Circle 203 on readers service card



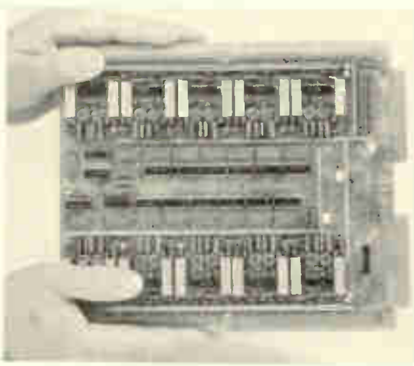
character sets are optional. The OEM-120 prints up to 132 characters per line, 10 characters per inch horizontally, and six lines per inch vertically. As an on-line terminal, data can be entered locally from a keyboard or tape cassette and re-

motely from a computer. The terminal can be operated off-line when not in transmit or receive mode, and it accepts parallel or serial data from RS-232B-compatible modems. In OEM quantities, the price is $2,088.

Litton Automated Business Systems, OEM Division, 600 Washington Ave., Carlstadt, N.J 07072 [369]

Core memory offers 650-nanosecond cycle time

A modular core memory for 20-bit computer words is designated the model 2065. The memory, designed for original-equipment manufacturers, has a full cycle time of 650 nanoseconds. The unit may be ex-



panded modularly from 8,192 to 65,526 words of 20 bits each or 32,768 words of 40 bits each. Price is less than 15 cents per bit.

Ampex Corp., 13031 W. Jefferson Blvd., Marina del Rey, Calif. 90291 [370]

Semiconductors

Diode chips are glass-passivated

Metallurgically bonded units eliminate die separation, shorting of particles

While one segment of the component industry constantly seeks lower prices, the goal of another segment is the ultimate in reliability. In small-signal switching diodes, for example, some manufacturers are supplying parts at 1½ to 2 cents apiece, but Microsemiconductor Corp.'s president Philip Frey says, "We've solved the problem of diode reliability, but not a competitive price." He talks of 30 to 50 cents in quantity.

The company's new line of diodes is a military-inspired adaptation of its present rectifiers. "We're the only company making general-purpose and switching-type voidless, metallurgically bonded diodes," Frey says, adding that they are approved as conforming to new military specifications. The firm's rectifiers compete with those made by Semtech and Unitrode Corp.

The tiny diodes, about the same size as the standard DP-34, differ from conventional diodes in having both expensive materials and unusual production techniques.

The basic construction is a semiconductor die sandwiched between two small, metal, cylindrical slugs, with the whole assembly then sealed in glass.

The metal, however, is silver-plated tungsten with flat, machined surfaces, rather than the usual copper-plated Dumet wire sheared to provide the slugs. The flat surfaces make for good contact.

The tungsten provides an excellent thermal match to the silicon and glass seal, unlike the Dumet, which does not match the length-to-diameter ratios of the glass used in most diodes.

The diode chip is a mesa device, completely glass-passivated before assembly and metallurgically bonded to the metal slugs. Because of the mesa construction, the entire top is flat and can be bonded fully (planar diodes can be bonded only to raised metal buttons). This eliminates the two major diode failure modes, according to Frey: separation of die from the metal, causing poor contact, and shorting of particles from the surface to the opposite contact.

The glass seal is a tube of alkali-free Corning 7061 or 7063 hard glass, pressure-molded to the metal and chip structure to eliminate all voids within it. This glass contains none of the free sodium ions found in the soft glass of conventional diodes. Flying leads can be of desired materials.

The company has started production of the parts, and Frey says it can supply versions of all popular 1N-type diodes. He anticipates that much of the prospective business will be custom.

The company uses the same process to make larger rectifiers, and it is starting to produce high-voltage parts from multiple dice bonded together before sealing.

Microsemiconductor Corp., 2830 South Fairview, Santa Ana, Calif. 92704 [411]

Two-digit display is aimed at inexpensive multiplexing

A two-digit LED display with 0.19-inch characters, designed for inexpensive multiplex-drive applications, has been introduced by Litronix. Called the DL-44, the display is designed for use in multidigit displays where a multiplex drive has been chosen to minimize the electronics cost. Such systems include desktop calculators and credit verifiers. The display has a brightness of 250 footlamberts at 5 milliamperes per segment, which provides good visibility at up to five or six feet.

A common-cathode design was chosen for the DL-44 to maximize yield on the digits. For multiplexing the DL-44 displays, Computer Microtechnology Inc., Sunnyvale, Calif., recently introduced a series of 50-mA constant-current TTL driver-decoders, the CM 5112 and 5113. Other drivers, such as the 9307 and 7448, can be used, but they require internal segment resistors.

The DL-44 is priced at $6.80 ($3.40 per digit) in quantities of 100. Delivery is from stock.

Litronix Inc., Cupertino, Calif. [412]

Transistor delivers 75 W at 400 megahertz

A series of 400-MHz, 28-volt linear power transistors, designed for operation in class A, AB, B or C broadband or narrowband applications, cover the range from 200 to 500 MHz and offer internal matching. The three transistors in the series are rated at 20, 40, and 75 watts, and an alternate 75-W unit is available for high-power continuous-wave or pulsed operation, or as a linear transistor. Price for 1 to 99 is $45 for the 20-W unit, $90 for the 40-W, and $135 for the 75-W.

Communications Transistor Corp., 301 Industrial Way, San Carlos, Calif. 94070 [413]

Radio receiver is on chip measuring 0.001 sq. in.

An integrated circuit, the ZN414, provides a complete a-m radio circuit on a chip with an area of less than 0.001 square inch. Components for a radio, such as transistors, diodes, and coils, can be replaced by the integrated circuit together with two resistors, a tuning capacitor and two fixed capacitors. The addition of a battery, an antenna, and a

Once maps were made by hand.

But why today?

Once, a man told another of what he'd seen and that man drew a map that all others could follow.

All of that was done by hand. That was then.

Today, a man takes a picture from an airplane of what he sees. And a second man prepares a manuscript from these photos. And then, this manuscript is transferred to film.

And then — incredibly — all of the lines that will make up the map (the rivers, the mountains, roads and streets) are *scribed* onto a negative master. By hand.

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The CalComp 745 Plotter is accurate to a rate of plus or minus .001 inch. The lines it scribes or cuts are smooth and even. (Their step size is only .0001 inch.)

And our 745 plots at a speed of 4.2 inches per second. No hand alive can do that accurately.

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Circle 208 on reader service card

CALCOMP

loudspeaker system completes a radio that can cover the medium and long wave bands. Recommended supply voltage is 1.5 v, frequency range is from 200 kHz to 1.5 MHz, and power gain is 70 dB.

Ferranti Electric Inc., E. Bethpage Rd., Plainview, N.Y. 11803 [414]

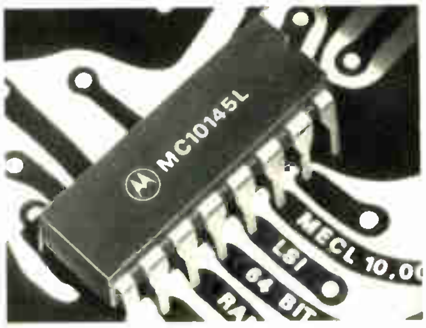
Multiplier contains two amplifiers, bias regulator

The model XR-2208 operational multiplier is a monolithic linear integrated circuit containing a four-quadrant multiplier, operational amplifier, buffer amplifier, and bias regulator. The combination of functions serves to increase dynamic performance over other types of monolithic multipliers and extends op amp operations into many computer, communications, and control applications of analog multipliers. It also reduces the cost of using monolithic multipliers, which generally require external amplifiers and up to 26 discrete components. Price in 100 lots is $4, $6.90, and $9.25 each, depending on temperature range.

Exar Integrated Systems Inc., 750 Palomar Ave., Sunnyvale, Calif. 94086 [415]

RAM's stored-data access time is 10 ns typical

A 64-bit fully address-decoded memory offering almost 150 equivalent gates on the chip is part of the MECL-10,000 logic family. The random-access memory is organized as 16 words by 4 bits. Stored-data access time is 10 ns typical, and read/write cycle time is typically 17.5 ns. Power consumption is 600



mW per package. Called the model MC10145, the high-speed RAM is in a ceramic dual in-line package. It is priced at $36 each for 1 to 14 pieces, $30 for 25 to 99 pieces and $24 for 100-lots.

Motorola Semiconductor Products Inc., P.O. Box 20912, Phoenix, Ariz. 85036 [416]

4,096-bit static ROM built for code conversion

A 4,096-bit static MOS read-only memory, organized 512 by 8 bits, is designed for microprograming and for code-conversion applications. Three-state outputs allow OR-tying for implementing larger memories, and two output-enable lines control the eight output devices without affecting the address circuitry. The model 2530 has TTL-compatible inputs and outputs and requires +5-V and −12-V power supplies. A READ input controls the entry of data from the ROM into output latches. Price is $16 in lots of 100. Programing charge is $250 when data is furnished on IBM cards.

Signetics, 811 East Arques Ave., Sunnyvale, Calif. 94086 [417]

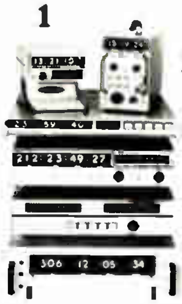
Light-emitting diodes indicate circuit faults

Designed as fault indicators for electronic circuitry, each of the 555 series of light-emitting diodes con-

Put time on your tape for $1595 ...and read it too!

New Model 8350 generates and reads serial time code with unprecedented economy. Enables you to find recorded data at search speeds up to 250 times the recording speed. Displays real time when recording and recorded time when searching. Takes only half the rack space usually occupied by generator/readers.

Tapes containing high noise or flutter can be searched reliably, because Model 8350 will disregard as many as three consecutive garbled time frames and will compensate for brief signal drop-outs.



1 2 3 4 5 6

Systron-Donner produces a complete line of time code equipment built with modern integrated circuits. Shown in the photo at left are: 1. Digital clock with BCD output and time stability of 2 parts in 10^9 per month. 2. Battery-powered time code generator for field use. 3. Model 8350 described above. 4. Generator/reader with switch selection of six different codes. 5. Bi-directional tape search control for automatic data location. 6. Precision generator with time stability of 5 parts in 10^9 per day.

Send for catalog.

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10 Systron Drive, Concord, CA 94520. Telephone (415) 682-6161

The Systron-Donner Instruments Group:

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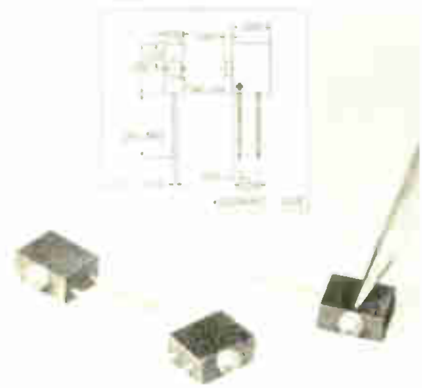
Circle 220 on reader service card



tains an internal series resistor. Pin centers are 0.100 inch apart, and the two-pin units mount into a DIP socket or on a printed-circuit board. Ten indicators can fit side-by-side in 1 inch. The units, which can be directly driven from DTL or TTL, are available in voltages from 1.7 to 14 V and currents to 10 mA. Price in 1,000-lots is 74 cents.

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

Multiplier holds error to 0.5% at 25°C

The model AD530L integrated-circuit multiplier features a maximum multiplying error of 0.5% at 25°C and 1.5% at other temperatures from 0° to 70°C. The device includes the transconductance multiplying element, stable reference, and output amplifier on a single silicon chip. The unit multiplies in four quadrants with a transfer function of XY/10, divides in two quadrants with 10Z/X transfer function, and finds square roots in one quadrant. Price of the AD530L is $27.50. Delivery is from stock.

Analog Devices, Route 1, Industrial Park, P.O. Box 280, Norwood, Mass. 02062 [419]

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Tel: 213/889-2834 TWX: 910-464-1910

Components

Trimmer pot simplifies design

1¼-inch rectangular cermet unit is interchangeable with earlier models

It's been characteristic of the trimming-potentiometer industry in the last few years to keep improving its products, and there has been a consequent proliferation of models that are basically similar, but not interchangeable. One of the trimmer companies, Spectrol Electronics Corp. is now going the other way with a new 1¼-inch rectangular cermet trimmer that, along with a similar wirewound version, replaces any of seven earlier models. At the same time, the new model 70 incorporates a number of design improvements already used in the company's model 43, a ¾-in. trimmer, giving the advantages of the small trimmer in a size that is still more popular with military users and for retrofitting. The larger size also provides slightly higher-power handling capability, 1 watt at 85°C, rather than 0.75 W at 25°C. The power capacity of the pot is derated linearly to 0 W at 150°C.

The new model uses a multifinger brush for good electrical contact to the cermet resistive element. Its slider incorporates compressed beads that maintain pressure between shoulders on the slider and its track to reduce rocking, directional effects, and transverse rotation. Maximum operating torque of the 24-turn (±5) thread is 5 ounce-inches, and rotational life is 200 cycles minimum, with maximum total resistance changes of ±2%. Standard resistance range is 10 ohms to 2 megohms, with tolerance of ±10% and temperature coefficient of ±100 ppm/°C.

The trimmer is insulated for 1,000 vac at sea level, with insulation resistance of at least 1,000 megohms. Contact variation is the larger of 3% or 3 ohms. Setability is ±0.05% of the total resistance, and end-resistance is no more than 2 ohms or 1.0%.

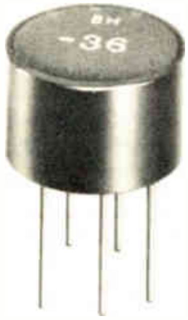
Since the part is expected to find use in military applications, its specification conform to MIL-R-22097. Environmental ratings include no more than ±1% change in maximum resistance or setting stability with 30 g of vibration in the range from 10 to 2,000 hertz, and the same change for 100 g of shock for 6 ms. The trimmer is rated for operation from −55° C(±2% resistance change) to 150 C (±3% total resistance change).

Five varieties of the model 70 are available with different terminal styles, including lead wires, two types of circuit-board spacing, solder hooks, and bushing mounts. Price is $1.90 each in 1,000-piece quantities.

Spectrol Electronic Corp., 17070 E. Gale Ave., City of Industry, Calif. 91745 [341]

SCR trigger transformers built for pc board mounting

A family of SCR trigger transformers includes the 505-36 series of round-case-encapsulated, 6-pin types designed for direct printed-circuit board mounting. The leads are spaced on a 0.600-in.-diameter circle, and the units are available open or encapsulated, with number 20 AWG tinned copper leads. Inter-

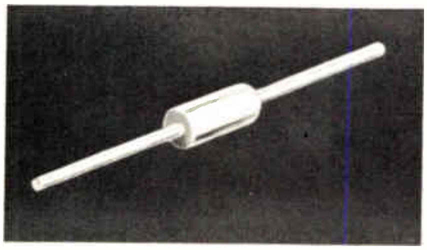


winding capacitance is low, thereby reducing the problems of false triggering. A version is available to meet any requirements in SCR power control. Standard turns ratios include 1:1, 1:1:1, 2:1, 2:1:1, 5:1, and 5:1:1. Models are available for operation from −10°C to +70°C. Delivery of the transformer is from stock.

BH Electronics, 245 East 6th St., St. Paul, Minnesota 55101 [371]

Feed-through signal coupler has 0.030-in. sleeve

For use in miniature amplifiers, a feed-through coupler measures 0.030 inch in sleeve diameter. It is designed for reliable operation in vacuum, radiation, high temperature and shock, and cryogenic environments. The inner pin is insulated from the outer sleeve by ceramic sealed with epoxy. Applications include signal transmission in pyroelectric and liquid-helium-cooled infrared and X-ray detectors. Insulation resistance is more than 10^{14} ohms, and operating temperature range is from −270 to +200 C. Capacitance is 0.6 picofarad and maximum voltage is 2,000 Vdc. The outer sleeve, which is fabricated from nickel-plated stainless steel,



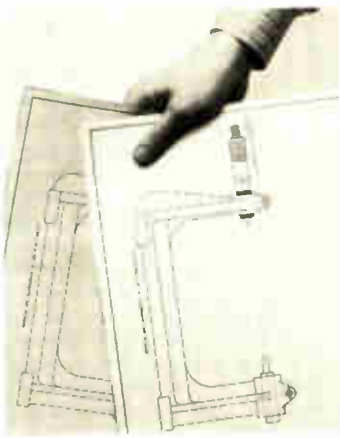
may be mounted into an assembly by soldering or using epoxy. The inner pin is gold-plated Kovar and the insulator is aluminum oxide. Connection to the pin may be made by soldering or spot welding. Price for large orders is 95 cents.

Eltec Instruments Inc., Central Industrial Park, Daytona Beach, Fla. 32014 [372]

Nonlinear low-pass filter holds phase shift to zero

A new type of filter, a nonlinear low-pass unit, attenuates frequencies above its corner frequency without introducing phase shift in-

The New Threedom.



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3. Contact.

Kodak now has three KODAGRAPH Wash-Off Films that can save you hours of redrawing time.

1. Now you can enjoy the benefits of KODAGRAPH Wash-Off Films for more of your drafting room work. With the new KODAGRAPH Wash-Off AUTOPOSITIVE Film, you get a positive reproduction from a positive original. Like all KODAGRAPH Films, it gives you high-contrast prints that make excellent second originals.

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Get the facts.

For additional information on The New Threedom, write Eastman Kodak Company, Business Systems Markets Division, Dept. DP535, Rochester, N.Y. 14650.

Kodak

Products for engineering data systems

side or outside of its passband. The filter, called the model IPI, which is selling for $100 singly, can eliminate noise spikes. Two external capacitors determine the corner frequency, which can be set from dc to 10

kilohertz. Intended applications include digital communications, amplitude demodulation, spike filtering, and noise limiting in communications receivers. First deliveries are scheduled for the end of March.

Non Linear Filters, P O Box 338, Trumbull, Conn 06611 [343]

Rotary switch measures less than 0.3 in. diameter

The series 75 rotary switch has a 36° angle of throw (10 positions), with one or two poles in a single-deck design. The switches, designed for direct insertion into printed-circuit boards, measure less than 0.3 inch in diameter, 0.7 inch behind panel in the shaft-and-bushing version, or 0.6 inch overall length in the screwdriver-operated version. The switches are rated to make and

break 200 milliamperes for 5,000 cycles of operation at 115 vac or 30 vdc resistive load. Price is 70 cents for a one-pole-per-deck screwdriver-

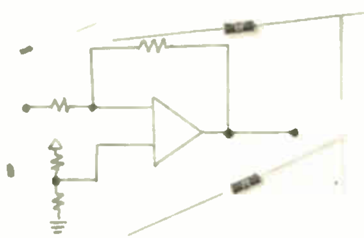
operated switch, and delivery is from stock.
Grayhill Inc., 523 Hill Grove Ave., La Grange, Ill. 60525 [344]

Trimming pots are sealed in polycarbonate case

Available with either wirewound or cermet resistance elements having 0.5% maximum nonlinearity, trimming potentiometers feature sealed construction in a clear high-temperature polycarbonate case. The units have 18 turns and measure 0.75 by 0.33 by 0.25 inch with printed-circuit terminals. The cermet-element types have four-contact wipers. Price is $1.32 each.
Harry Levinson Co., 1211 East Denny Way, Seattle, Wash. [345]

Thin-film fixed resistors maintain low reactance

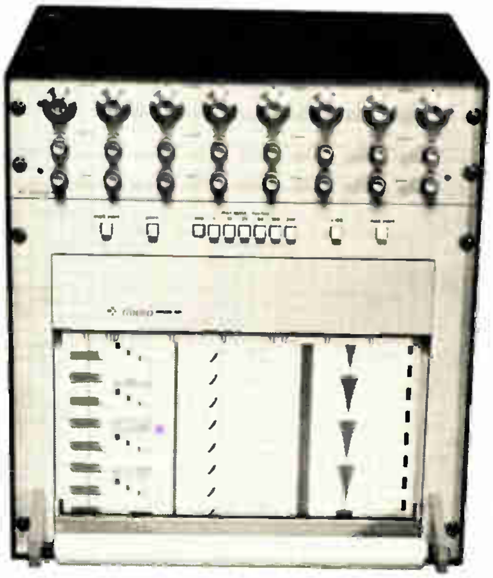
Resistors, called the MAR series, are aimed at precision applications. Available also in matched sets and module assemblies, the resistors maintain the low reactance of thin-film devices, and they have temperature coefficients, long-term stability, and tolerances comparable to those of precision wirewounds.
IRC Fixed Resistors, An Operation of TRW Electronic Components, P.O. Box 887, Burlington, Iowa 52601 [346]



Transducer combines emitter and detector

Fast, sensitive response is provided by a miniature optical-pair trans-

New. 8-channel recorder with preamps in a single box.



It's the Brush 481. For about $1000 less than the same components bought separately.

It gives you Brush quality. And Brush innovations. For example: pressurized inking system that writes dry and eliminates smudging, puddling and priming. And Metrisite® non-contact servo-loop feedback device that guarantees 99.5% linearity.

You also get 12 pushbutton chart speeds, from 0.05 to 200mm/second. 40 Hz full scale frequency response. And the built-in preamps provide a measurement range of 1mV/div to 500 V d-c full scale. With differential, balanced and floating inputs and high common mode rejection.

Finally, you get your choice of either a compact portable or rack mounted version—and accessories like chart take-up reel and Z-folder.

The only thing missing: the problems of separate preamps.

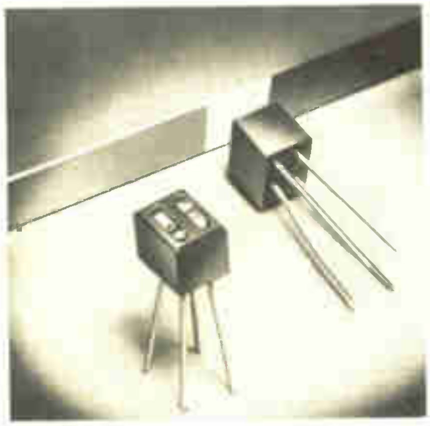
You'll certainly want more information. So contact Gould Inc., Instrument Systems Division, 3631 Perkins Avenue, Cleveland, Ohio 44114. Or Rue Van Boeckel 38, Brussels 1140 Belgium.

BRUSH INSTRUMENTS

GOULD

Circle 228 on reader service card

ducer that combines an emitter and detector in a single package. Applications include beginning- and end-of-tape-sensing, character recognition, mark sensing, and optical ignition. The units combine a gallium-arsenide infrared LED and a silicon npn phototransistor chip, with the emitter and detector elements positioned on the same perpendicular

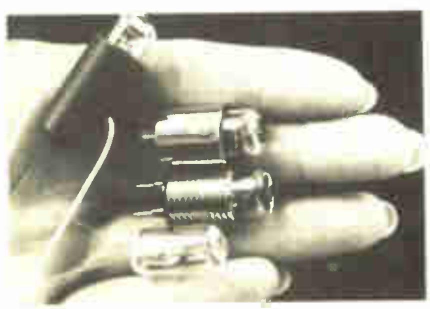


plane, thus providing response to radiation only when a reflective surface comes into the field of view of the phototransistor.

Sensor Technology Inc., 21012 Lassen St., Chatsworth, Calif. 91311 [347]

Lamps offer range of beam patterns, intensities

Offering a range of beam patterns and intensities, T-4 and TL-4 lamps are suitable for a variety of applications, including fiberoptic devices and computers. Different lamp intensities and beam patterns are determined by lens and filament types and ratings. The bulbs are available in clear, thin-lens, or heavy-lens, and filament types are bar or C-2R. Six filament ratings are offered. The lamps are available in unbased,



Why spend a bundle to automate, then fumble around with hand wiring?

You can automate right down the line, but when you get to the hand wiring you're back in the dark ages.

It's one of those costly things you always had to put up with, until Flexprint® Circuitry came along. Flexprint Circuitry saves you money on installation, and it fits into an automated system like a glove.

Recently for one customer, Flexprint Circuits saved up to $4.02 on every $6.24* wiring installation. Because Flexprint Circuits are so adaptable, no other design changes in his product were necessary. If you manufacture in quantity, the savings multiply. And there's no room for error, because the wiring design is built into every Flexprint Circuit design. You reduce repair costs, soldering costs and handling costs because Flexprint Circuitry is built to fit into your system. Consider Flexprint Circuitry while your new product is still in the concept stage. That way, you'll get maximum cost and design flexibility from the very beginning.

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*Ask to see our 8-minute film presentation on Flexprint Circuitry cost savings.

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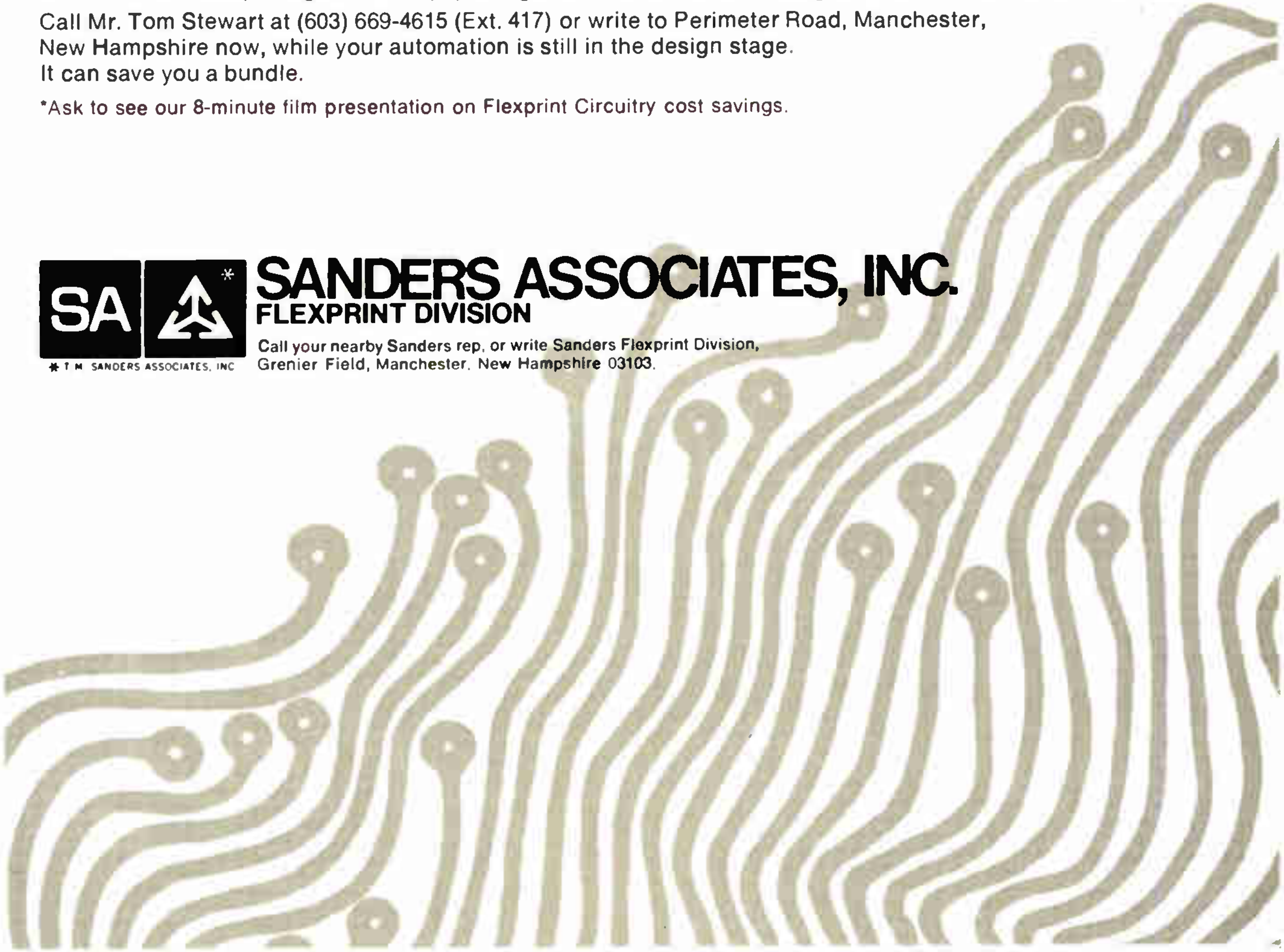


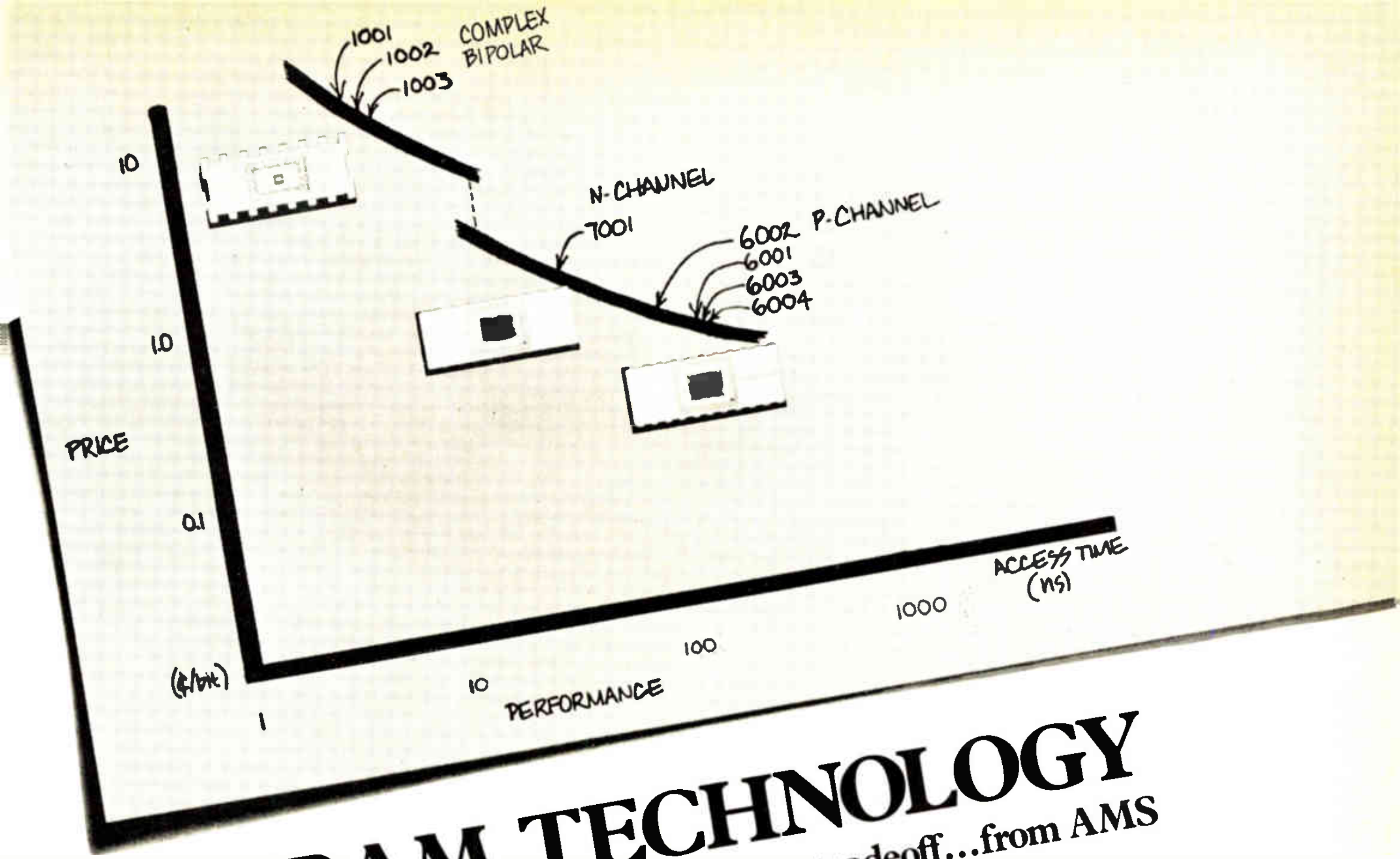
epoxy-based, brass-based, and aluminum-based versions.
Lamps Inc., 19220 S. Normandie Ave., Torrande, Calif. 90502 [348]

Varistors are rated from 1 to 4 joules

Six lead-mounted metal-oxide varistors for printed-circuit boards are rated in energy-handling capability from 1 to 4 joules for ac and dc operation. Models V130LA1 and V130LA2 handle 1 and 2 joules, respectively, with maximum ac rms voltage of 130 v; V150LA1 and V150LA2 handle 1 and 2 joules, respectively, at 150 vac maximum; and V250LA2 and V250LA5 are rated at 2 and 4 joules, at 250 vac. Quantity price is 48 cents.
The General Electric Co., Semiconductor Products Department, Building 7, Mail Drop 49, Electronics Park, Syracuse, N.Y. [349]

Coating protects resistors from transformer oil

Epoxy-coated type AS ceramic-carbon composition resistors are noninductive devices intended for high-reliability applications and where the resistors must be immersed in transformer oil-cooled packages. The epoxy coating protects the carbon composition from attack by chemical constituents of the transformer oil. Power ratings range from 15 w to 150 w.
Carborundum Co., Electrical Products Branch, Refractories and Electronics Division, P O Box 339, Niagara Falls, N.Y. [350]



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Only AMS RAM technology covers the spectrum from bipolar to N-MOS to P-MOS. Choose our highest speeds (6ns access, 8ns cycle with the bipolar AMS 1001); enjoy our lowest prices (below ½¢/bit P-MOS parts); in between, there's the N-MOS AMS 7001, which can access in 55ns, cycle in 180ns at a cent a bit. We hit all the stops in between, delivering volume-production RAMs up to 2K capacity — with a pin-compatible 4K companion soon to come. For every application, AMS technology provides the optimum solution.

Solid-state computer memory is now superior to every other main memory technology. Only one independent semiconductor memory company goes all the way from silicon to systems, always has—AMS. Result: we have delivered more monolithic memory, installed and operating worldwide, than all the other suppliers put together.

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We've got it all together, to give you better memories. In this business, if you haven't got it all together, you haven't got it.

AMS Advanced Memory Systems, Inc.
1276 Hammerwood Avenue, Sunnyvale, California 94086
AMS means advanced memories. From silicon to systems.

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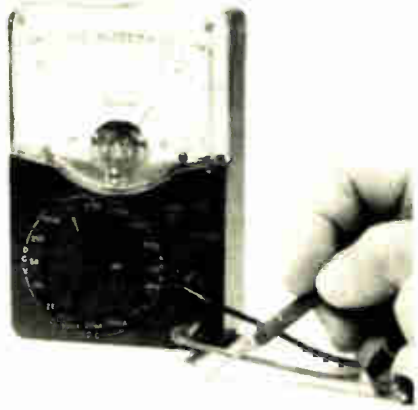
Clip and mail to us

Circle 234 on reader service card

New products/materials



An electrically conductive noncorrosive silver-alloy-filled silicone rubber, called 490, is designed for use as an rf shielding gasket or adhesive. The two-component system cures at room temperature overnight or at 65°C in two hours. It bonds to most surfaces with 490 primer, and to silicone rubber without priming. A 2-ounce kit with base, hardener and primer is $15.
Dynaloy Inc., P.O. Box 162, Hanover, N.J. 07936 [476]

A copper thick-film conductor has a resistivity of less than 2 milliohms per square mil. Leach resistance is over 10 minutes in 60/40 solder at 230°C. Processing requires a single firing under a nitrogen cover at 750° to 1,000°C, with a soak time of six to eight minutes. Applications include large-area ground planes, microstrip and microwave components, and reflow solder-chip resistor and chip-capacitor hybrids.
Owens-Illinois, 1700 Westwood Ave., Toledo, Ohio 43651 [477]

A 99.5% alumina substrate with a finish of 2 to 4 microinches for thin-film component manufacture is designated Ceramislik. The material is available in standard thicknesses of 10 and 25 mils, but other thicknesses can be supplied to customer specifications. Surface finish may also be supplied at 7 to 10 μin. Delivery is from stock.
Plessey Inc., Materials Division, Frenchtown, N.J. [478]

A series of low-temperature-curable thick-film resistor and conductor

pastes are screen-printable on most printed-circuit-board materials, including copper-clads and unclads. Once cured, Blend-Ohm is resistant to all solvents, and the material is available in resistor values of 1 kilohm to 75 ohms per square. Conductivity is 0.5 ohm per square. The pastes can also be used for trimmers or potentiometers.

Methode Development Co., 7447 W. Wilson Ave., Chicago, Ill. [479]

Clear, light-stable liquid-epoxy compounds are for encapsulating light-emitting diodes. The C74 and C75 encapsulants maintain optical clarity at continuous exposure to 125°C, and some materials survive several hundred hours at 150°C. Handling properties range from low-viscosity compounds for straight casting applications to higher viscosities for casting and the self-crowning approach to lens-forming.

Hysol Division, The Dexter Corp., 211 Franklin St., Olean, N.Y. 14760 [480]

A liquid flux cleaner is specifically formulated to remove all traces of rosin flux residues without injury to the printed-circuit board or components. Type O cleaner has a low toxicity and is biodegradable and water-soluble. The material is a low foamer and can be used under pressure or agitation with any type of cleaning equipment. The material is provided as a concentrate, and spent solution can be flushed into sewage systems without treatment.

Electro-Mechanical Division, Electrovert Inc., 86 Hartford Ave., Mt. Vernon, N.Y. 10553 [401]

A gold-filled single-component epoxy has an electrical conductivity rating of 0.0001 to 0.0003 ohm-cm. Epotek H44 is recommended for bonding semiconductor chips in hybrid circuits as well as attaching LSI and MOS chips. The material is in paste form and contains no solvents. It can be silk-screened and cures in 45 minutes at 120°C and 15 minutes at 150°C. One-half ounce trial kits are $75.

Epoxy Technology Inc., 65 Grove St., Watertown, Mass. 02172 [402]

the CTS eliminator
makes you an offer you can't resist

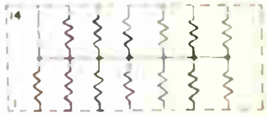
It's CTS Series 760 DIP cermet resistor networks, available "off the shelf" from authorized CTS Industrial Distributors. Thirty-five standard 760 series resistor modules (in 2 package styles) make it easy to be a time, space, and money saver. They *eliminate* lead forming, lead trimming, and individual component insertions . . . *eliminate* costly PCB real estate . . . *eliminate* up to 12 separate components.

And, we *eliminate* long delivery times too! These cost savers are stocked for immediate delivery. All have 1.5 watts power capabilities per module and provide proven CTS cermet reliability.

Doesn't it make sense to make the switch to CTS standard networks . . . non-standards are available, too, from CTS of Berne, Inc., 406 Parr Road, Berne, Indiana 46711. Phone: (219) 589-3111.

CTS CORPORATION
Elkhart Indiana

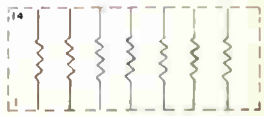
A world leader in cermet and variable resistor technology.



Model 760-1
Resistance values 100 ohms thru 22K ohms. Applications: MOS/ROM pull-up/pull-down; open collector pull-up; "wired OR" pull-up; power driver pull-up; high speed parallel pull-up; TTL unused gate pull-up; TTL input pull-down; digital pulse squaring.

Prices (±2% std tolerance):

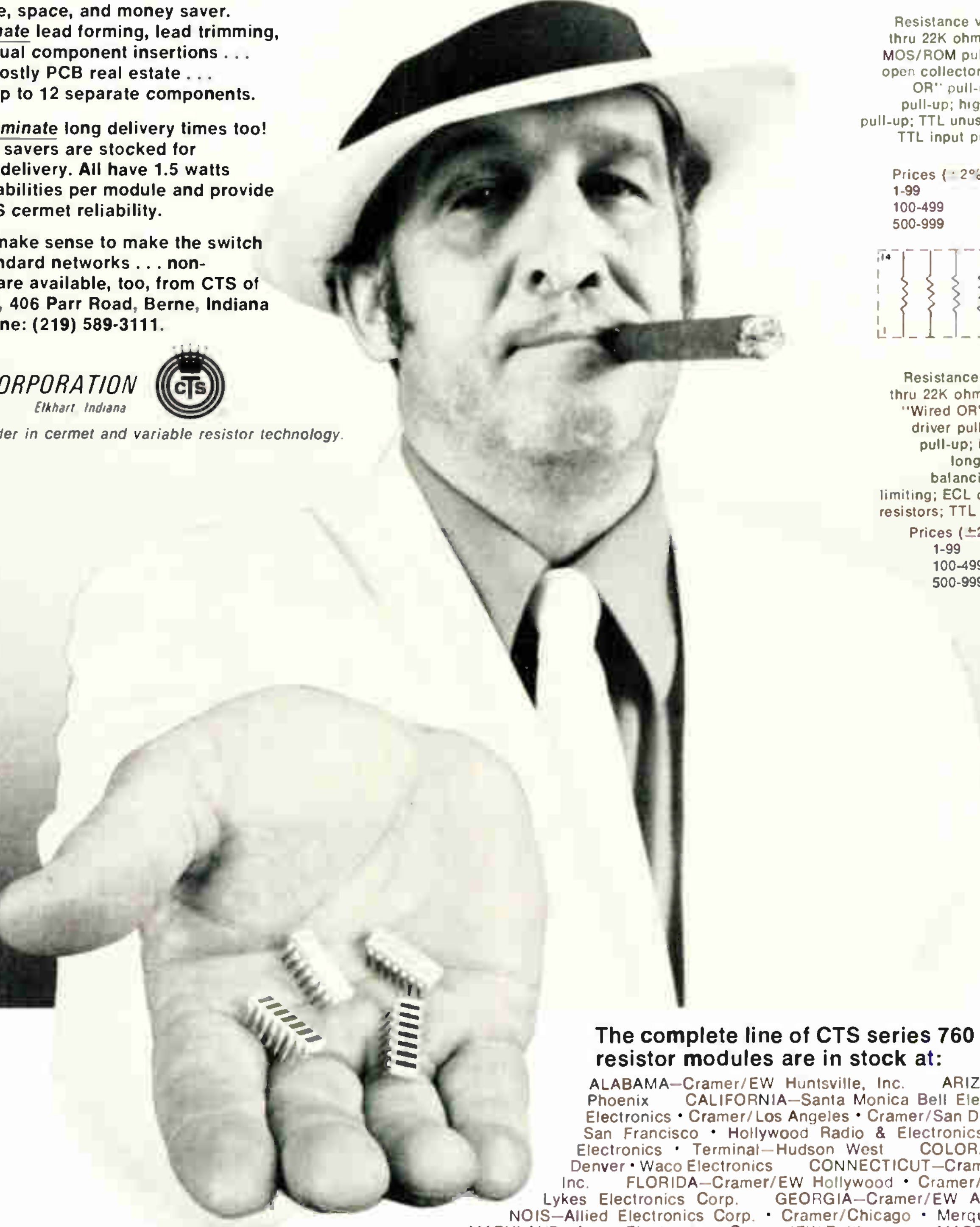
1-99	$1.45
100-499	1.24
500-999	.91



Model 760-3
Resistance values 68 ohms thru 22K ohms. Applications: "Wired OR" pull-up; power driver pull-up; power gate pull-up; line termination; long-line impedance balancing; LED current limiting; ECL output pull-down resistors; TTL input pull-down.

Prices (±2% tol standard)

1-99	$1.25
100-499	1.07
500-999	.74



The complete line of CTS series 760 cermet resistor modules are in stock at:

ALABAMA—Cramer/EW Huntsville, Inc. ARIZONA—Cramer/Phoenix CALIFORNIA—Santa Monica Bell Electronics • Bell Electronics • Cramer/Los Angeles • Cramer/San Diego • Cramer/San Francisco • Hollywood Radio & Electronics, Inc. • Rose Electronics • Terminal—Hudson West COLORADO—Cramer/Denver • Waco Electronics CONNECTICUT—Cramer Electronics, Inc. FLORIDA—Cramer/EW Hollywood • Cramer/EW Orlando • Lykes Electronics Corp. GEORGIA—Cramer/EW Atlanta ILLINOIS—Allied Electronics Corp. • Cramer/Chicago • Merquip Electronics MARYLAND—Arrow Electronics • Cramer/EW Baltimore MASSACHUSETTS—Cramer Electronics, Inc. • DeMambro Electronics MICHIGAN—Cramer/Detroit • Northland Electronics MINNESOTA—Cramer/Bonn • Electro-Com Corp. MISSOURI—Olive Industrial Electronics NEBRASKA—Scott Electronics NEW JERSEY—Cramer/Penn., Inc. • Cramer/New Jersey • Radio Electric Service Co. NEW MEXICO—Cramer/New Mexico NEW YORK—Arrow Electronics • Cramer/Binghamton, Inc. • Cramer/Long Island • Cramer/Rochester • Cramer/Syracuse • Summit Distributors • Terminal—Hudson Electronics NORTH CAROLINA—Cramer/EW Raleigh • Cramer/EW Winston-Salem OHIO—Cramer/Cleveland • Cramer/Tri-States, Inc. • ESCO Incorporated • Hillebrand Electronic Supply • Sun Radio Company OKLAHOMA—Cramer/Tulsa PENNSYLVANIA—Arrow Electronics • Cameradio Company • Cramer/Penn • Radio Electric Service Co. TEXAS—Adleta Electronics Co. • Cramer/Texas • Southwest Electronics, Inc. UTAH—W. H. Bintz Co. • Cramer/Utah WASHINGTON, D. C.—Cramer/EW Washington WASHINGTON (State)—Cramer/Seattle, Inc. • Far West Electronics WISCONSIN—Cramer/Wisconsin

Circle 239 on reader service card

New literature

Semiconductor fuses. Semiconductor Division, International Rectifier Corp., 233 Kansas St., El Segundo, Calif. A handbook to aid circuit designers in the use of semiconductor fuses is more than 100 pages long and provides graphs, ratings, tables, and circuit diagrams. Circle 421 on reader service card.

Diodes. An eight-page application note available from Hewlett-Packard Co., 1501 Page Mill Rd., Palo Alto, Calif., provides information on diode packages for hybrid integrated circuits and characteristics of each type. [422]

Temperature indicator. The installation and operation of the DT1/611 digital temperature indicator is outlined in a four-page catalog published by Thermo Electric, Saddle Brook, N.J. [423]

Chain printers. Fact sheets for the models 4335 and 4345 chain printers are available from Mohawk Data Sciences Corp., 781 Third Ave., King of Prussia, Pa. 19406 [424]

TWT amplifiers. Specifications for a traveling-wave-tube amplifier family are provided in a brochure available from MCL Inc., 10 North Beach Ave., La Grange, Ill. 60525. [425]

Relays. C.P. Clare and Co., 3101 Pratt Ave., Chicago, Ill. A 10-page booklet describes complex electronic interfacing problems and how to solve them by using dry-reed and mercury-wetted relays. [426]

Solid-state products. Spectrum Microwave Corp., 328 Maple Ave, Horsham, Pa., has issued a catalog describing solid-state amplifiers, oscillators, sources, couplers, filters, microstrip circuits, and other solid-state devices. The catalog describes a variety of products for rf through microwave applications. [427]

Switches. A catalog providing information on the company's line of illuminated pushbutton switches is available from Marco-Oak, 207 S. Helena, Anaheim, Calif. [428]

Rotary switches. A 12-page catalog from Centralab, 5757 North Green Bay Ave., Milwaukee, Wis., details the company's line of rotary switches. [429]

Delay timer. A data sheet describing the TM301 solid-state in-series delay timer for automatic control systems has been published by Regent Controls Inc., Harvard Ave., Stamford, Conn. [430]

Power head. Bulletin 440 describes a thermoelectric power head, operating from 10 MHz to 18 GHz, for use with precision microwave power meters. It is available from General Microwave Corp., 155 Marine St., Farmingdale, N.Y. 11735. [431]

Rf conductors. Nytronics Inc., Darlington Division, Orange St., Darlington, S.C. 29532, has published two data sheets describing the environmental characteristics, mechanical dimensions, voltage ratings, and inductance ratings of a line of unshielded rf inductors. [432]

Semiconductors. A 44-page condensed catalog from General Semiconductor Industries Inc., P.O. Box 3078, Tempe, Ariz. 85281, lists specifications on more than 6,000 semiconductor devices. [433]

Microwave components. Norsal Industries Inc., 34 Grand Boulevard, Brentwood, N.Y. 11717. A four-

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page brochure describes miniature directional couplers, diode switches, isolated power dividers, terminations, and 15 other stripline assemblies for use up to 18 GHz. [434]

Control system. Kepco Inc., 131-38 Sanford Ave., Flushing, N.Y. 11352. An eight-page brochure describes a digital control system, called the SN series, for regulated power supplies. [435]

Counter circuit. Mostek Corp., 1215 W. Crosby Rd., Carrollton, Texas 75006, has published a four-page applications note on the use of the MK 5009 p-MOS counter time-base circuit. [436]

Multiplex system. A 20-page brochure from GTE Lenkurt Inc., 1105 County Rd., San Carlos, Calif. 94070, describes the type 46A3 multiplex system that transmits voice and data signals over a single microwave-radio or coaxial-cable circuit. [437]

Microvoltmeter. Doric Scientific Corp., 7601 Convoy Ct., San Diego, Calif. 92111. Bulletin D-100G describes the company's line of digital microvoltmeters, consisting of 10 models. [438]

Temperature controllers. Oven Industries Inc., P.O. Box 229, Mechanicsburg, Pa. 17055, has issued a short-form catalog detailing 42 proportional zero-crossing temperature controllers. Included are units with current-handling capabilities from 0.1 to 40 amperes. [439]

Reed relays. A reed-relay catalog has been published by Guardian Electric Manufacturing Co., 1550 West Carroll Ave., Chicago, Ill., and it describes the six-series line of relays, providing specifications, dimensional drawings, schematic diagrams and applications data. [440]

Tape sensors. International Rectifier Corp., Semiconductor Division, 233 Kansas St., El Segundo, Calif. A series of high-speed silicon card-tape sensors is described in data sheet PD-6.003. [390]

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New books

Computer-Oriented Approaches to Pattern Recognition, W. S. Meisel, Academic Press, pp. 250, $15.

Pattern recognition is an area of technology that is becoming of extraordinary importance and interest to engineers. But most books on the subject reek with abstruse concepts seemingly incapable of being expressed without many mathematical equations. Rare is the author who can devote himself to explaining complex ideas without falling into the equation trap.

Professor Meisel is not one of the rare breed. His book oozes with equations, but he manages to be clear and understandable. His first chapter explains basic concepts and methods in mathematical pattern recognition. Although many of the concepts of pattern recognition involve multidimensional vectors, Meisel succeeds in either boiling these down to two dimensions or giving simplified two-dimensional examples so that the concepts can be illustrated graphically.

Other chapters deal with various topics in pattern recognition in greater detail. For example, chapter 2 is on statistical formulation—how to treat the statistics after they have been obtained. Chapter 3 describes several approaches to optimization—indirect methods, beginning with finding the extrema of a probability function and continuing with secondary evaluation via partial derivatives and other means; direct methods, such as searching for extrema by random searches or by hill-climbing methods; and use of linear programing to optimize within prescribed constraints. Chapters 4 and 5 show how to obtain a decision rule for distinguishing among several patterns.

Other chapters deal with cluster analysis and feature selection. Although all these chapters plunge somewhat deeper into the forest of equations and special symbols, they remain almost as clear and easy to follow as the opening chapter.

The book is excellent, both as an introduction to a complex subject and as a broad survey of various subtopics within the subject.

—W. B. Riley, Computers Editor

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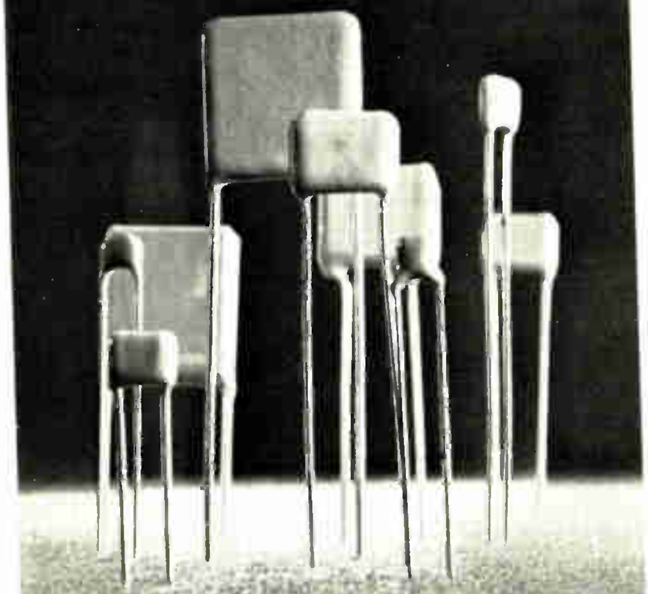

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