Radio-Electronics®

PHONE-SYSTEM PRIMER

$1.95 OCT. 86
IN CANADA $2.50

TECHNOLOGY - VIDEO - STEREO - COMPUTERS - SERVICE

A GERNSBACK PUBLICATION

BUILD THIS SATELLITE-TV DESCRAMBLER
For the Telease-Maast scrambling system

SATELLITE JAMMING
How Captain Midnight took on HBO

OSCILLATORS
Circuits you can breadboard

DELAY LINES
A circuit cookbook

BUILD AN OLD TIME CRYSTAL RADIO
Vintage circuitry and vintage looks

BURN YOUR OWN EPROM's
With R-E's easy-to-build programmer

ALL ABOUT TELEPHONES
A phone-system primer

PLUS:
- ★ Ask R-E
- ★ PC Service
- ★ Antique Radios
- ★ Robotics
- ★ ComputerDigest
- ★ Video News

New GPS Series: Tek sets the pace with SmartCursors™ and push-button ease.

Work faster, smarter, with two new general purpose scopes from Tektronix. The four-channel, 100 MHz 2246 and 2245 set the new, fast pace for measurements at the bench or in the field. They're easy to use and afford, by design.

On top: the 2246 with exclusive integrated push-button measurements. Measurements are accessed through easy, pop-up menus and implemented at the touch of a button. Measure peak volts, peak-to-peak, ± peak, dc volts and gated volts with new hands-off convenience and on-screen readout of values.

SmartCursors™ track voltmeter measurements in the 2246 and visually indicate where ground and trigger levels are located. Or use cursors in the manual mode for immediate, effortless measurement of waveform parameters.

Both scopes build on performance you haven't seen at the bandwidth or prices. Lab grade features include sweep speeds to 2 ns/div. Vertical sensitivity of 2 mV/div at full bandwidth for low-level signal capture. Plus trigger sensitivity to 0.25 div at 50 MHz, to 0.5 div at 150 MHz.

Accuracy is excellent: 2% at vertical, 2% at horizontal. And four-channel capability includes two channels optimized for logic signals.

Best of all, high performance comes with unmatched convenience. You can see it and feel it—in the responsive controls and simple front-panel design, in extensive on-screen scale factor readouts, and in simplified trigger operation that includes Tek's Auto Level mode for automatic triggering on any signal.

Contact the Tektronix office or sales representative nearest you for complete details. Each scope is backed by Tek's three-year warranty, plus excellent documentation, training programs and outstanding service support—worldwide.

Features	2246	2245
Bandwidth	100 MHz	100 MHz
No. of Channels	4	4
Scale Factor Readout	Yes	Yes
SmartCursors™	Yes	No
Volts Cursors	Yes	No
Time Cursors	Yes	No
Voltmeter	Yes	No
Vertical Sensitivity	2 mV/div	2 mV/div
Max. Sweep Speed	2 ns/div	2 ns/div
Vert/Hor Accuracy	2%	2%
Trigger Modes	Auto Level, Auto, Norm, TV Field, TV Line, Single Sweep	
Trigger Level Readout	Yes	No
Weight	6.1 kg	6.1 kg
Warranty	3-year on parts and labor including CRT	

Featuring four channels, flexible triggering, extensive CRT readouts and push-button ease of use, the new Tek 2246 (left) and 2245 (above) bring high-quality, low-cost analysis to diverse applications in digital design, field service and manufacturing.

Tektronix
COMMITTED TO EXCELLENCE

CIRCLE 92 ON FREE INFORMATION CARD

October '86

Radio-Electronics
Electronics publishers since 1908

Vol. 57 No. 10

BUILD THIS

TECHNOLOGY

CIRCUITS AND COMPONENTS

RADIO

COMPUTERS

EQUIPMENT REPORTS

DEPARTMENTS

RADIO-ELECTRONICS, (ISSN 0033-7862) October 1986. Published monthly by Gernsback Publications, Inc., 500-B Bi-County Boulevard, Farmingdale, NY 11735 Second-Class Postage paid at Farmingdale, NY and additional mailing offices. Second-Class mail registration No. 9242 authorized at Toronto, Canada. One-year subscription rate U.S.A. and possessions $16.97, Canada $22.97, all other countries $25.97. Subscription orders payable in US funds only, international postal money order or check drawn on a U.S.A. bank. Single copies $1.95
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A stamped self-addressed envelope must accompany all submitted manuscripts and or artwork or photographs if their return is desired should they be rejected. We disclaim any responsibility for the loss or damage of manuscripts and or artwork or photographs while in our possession or otherwise.

COVER 1

Our cover story this month is part of our continuing coverage of one of the most important issues in the field of satellite TV: signal scrambling and descrambling. The descrambler shown on the cover will decode programming encrypted using the Telease-Maast system. The theory behind the encoding is discussed and, of course, we describe how to restore the video to its proper form.

Before you build the descrambler, you should be aware that it may be unlawful to decode some scrambled satellite transmissions. But it's certainly not unlawful to learn as much as you can about descrambling! To learn more, turn to page 50.

NEXT MONTH

THE NOVEMBER ISSUE IS ON SALE OCTOBER 2

BUILD A CLOSED-CAPTION DECODER
It decodes closed-captioning and Line 21 Teletext

BUILD AN EPROM PROGRAMMER
Part 2 shows you how to add a hex display and gang-programming capability. The solder side of the main board appears in PC Service.

BUILD A LATCHING CONTINUITY TESTER
Find those intermittent shorts and opens.

SATELLITE-TV SIGNAL DESCRAMBLING
Part 5 looks at the SSAVI scrambling technique.

TELEPHONE INSTALLATION ACCESSORIES
This month, you learned how the telephone system works. Next month, you'll learn how to make it work best for you.

THE EARLY DAYS OF RADIO
Another installment in our series of occasional articles on electronics nostalgia.

Radio-Electronics

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Microfilm & Microfiche editions are available. Contact circulation department for details.

Advertising Sales Offices listed on page 120.

NEW!
Lower Price
Scanners

Communications Electronics,™ the world's largest distributor of radio scanners, introduces new lower prices to celebrate our 15th anniversary.

Regency† MX7000-GR

List price $699.95/CE **price $469.95**
10-Band, 20 Channel • Crystalless • AC/DC
Frequency range: 25-550 MHz. continuous coverage and 800 MHz. to 1.3 GHz. continuous coverage.
The *Regency* MX7000 scanner lets you monitor Military, Space Satellites, Government, Railroad, Justice Department, State Department, Fish & Game, Immigration, Marine, Police and Fire Departments, Broadcast Studio Transmitter Links, Aeronautical AM band, Aero Navigation, Paramedics, Amateur Radio, plus thousands of other radio frequencies most scanners can't pick up. The *Regency* MX7000 is the perfect scanner to receive the exciting 1.2 GHz. amateur radio band.

Regency® Z60-GR

List price $299.95/CE **price $179.95/SPECIAL**
8-Band, 60 Channel • No-crystal scanner
Bands: 30-50, 88-108, 118-136, 144-174, 440-512 MHz.
The *Regency* Z60 covers all the public service bands plus aircraft and FM music for a total of eight bands. The Z60 also features an alarm clock and priority control as well as AC/DC operation. Order today.

Regency® Z45-GR

List price $259.95/CE **price $159.95/SPECIAL**
7-Band, 45 Channel • No-crystal scanner
Bands: 30-50, 118-136, 144-174, 440-512 MHz.
The *Regency* Z45 is very similar to the Z60 model listed above however it does not have the commercial FM broadcast band. The Z45, now at a special price from Communications Electronics.

Regency® RH250B-GR

List price $659.00/CE **price $329.95/SPECIAL**
10 Channel • 25 Watt Transceiver • Priority
The *Regency* RH250B is a ten-channel VHF land mobile transceiver designed to cover any frequency between 150 to 162 MHz. Since this radio is synthesized, no expensive crystals are needed to store up to ten frequencies without battery backup. All radios come with CTCSS tone and scanning capabilities. A monitor and night/day switch is also standard. This transceiver even has a priority function. The RH250 makes an ideal radio for any police or fire department volunteer because of its low cost and high performance. A *60 Watt* VHF 150-162 MHz. version called the **RH600B** is available for $454.95. A UHF 15 watt version of this radio called the **RU150B** is also available and covers 450-482 MHz. but the cost is $449.95.

NEW! Bearcat® 50XL-GR

List price $199.95/CE **price $114.95/SPECIAL**
10-Band, 10 Channel • Handheld scanner
Bands: 29.7-54, 136-174, 406-512 MHz.
The Uniden Bearcat 50XL is an economical, hand-held scanner with 10 channels covering ten frequency bands. It features a keyboard lock switch to prevent accidental entry and more. Also order part # **BP50** which is a rechargeable battery pack for $14.95, a plug-in wall charger, part # **AD100** for $14.95, a carrying case part # **VC001** for $14.95 and also order optional cigarette lighter cable part # **PS001** for $14.95.

NEW! Scanner Frequency Listings

The new Fox scanner frequency directories will help you find all the action your scanner can listen to. These new listings include police, fire, ambulances & rescue squads, local government, private police agencies, hospitals, emergency medical channels, news media, forestry radio service, railroads, weather stations, radio common carriers, AT&T mobile telephone, utility companies, general mobile radio service, marine radio service, taxi cab companies, tow truck companies, trucking companies, business repeaters, business radio (simplex) federal government, funeral directors, veterinarians, buses, aircraft, space satellites, amateur radio, broadcasters and more. Fox frequency listings feature call letter cross reference as well as alphabetical listing by licensee name, police codes and signals. All Fox directories are $14.95 each plus $3.00 shipping. State of Alaska-**RL019-1**; State of Arizona-**RL025-1**; Baltimore, MD/Washington, DC-**RL024-1**; Buffalo, NY/Erie, PA-**RL009-2**; Chicago, IL-**RL014-1**; Cincinnati/Dayton, OH-**RL006-2**; Cleveland, OH-**RL017-1**; Columbus, OH-**RL003-2**; Dallas/Ft. Worth, TX-**RL013-1**; Denver/Colorado Springs, CO-**RL027-1**; Detroit, MI/Windsor, ON-**RL008-3**; Fort Wayne, IN/Lima, OH-**RL001-1**; Hawaii/Guam-**RL015-1**; Houston, TX-**RL023-1**; Indianapolis, IN-**RL022-1**; Kansas City, MO/KS-**RL011-2**; Long Island, NY-**RL026-1**; Los Angeles, CA-**RL016-1**; Louisville/Lexington, KY-**RL007-1**; Milwaukee, WI/Waukegan, IL-**RL021-1**; Minneapolis/St. Paul, MN-**RL010-2**; Nevada/E. Central CA-**RL028-1**; Oklahoma City/Lawton, OK-**RL005-2**; Orlando/Daytona Beach, FL-**RL012-1**; Pittsburgh, PA/Wheeling, WV-**RL029-1**; Rochester/Syracuse, NY-**RLC20-1**; San Diego, CA-**RL018-1**; Tampa/St. Petersburg, FL-**RL004-2**; Toledo, OH-**RL002-3**. New editions are being added monthly. For an area not shown above call Fox at 800-543-7892. In Ohio call 800-621-2513.

NEW! Regency® HX1500-GR

List price $369.95/CE **price $239.95**
11-Band, 55 Channel • Handheld/Portable
Search • Lockout • Priority • Bank Select
Sidelit liquid crystal display • EAROM Memory
Direct Channel Access Feature • Scan delay
Bands: 29-54, 118-136, 144-174, 406-420, 440-512 MHz.
The new handheld *Regency* HX1500 scanner is fully keyboard programmable for the ultimate in versatility. You can scan up to 55 channels at the same time including the AM aircraft band. The LCD display is even sidelit for night use. Includes belt clip, flexible antenna and earphone. Operates on 8 1.2 Volt rechargeable Ni-cad batteries (not included). Be sure to order batteries and battery charger from accessory list in this ad.

Bearcat® 100XL-GR

List price $349.95/CE **price $203.95/SPECIAL**
9-Band, 16 Channel • Priority • Scan Delay
Search • Limit • Hold • Lockout • AC/DC
Frequency range: 30-50, 118-174, 406-512 MHz.
The world's first no-crystal handheld scanner now has a LCD channel display with backlight for low light use and aircraft band coverage at the same low price. Size is 1⅜" x 7½" x 2⅞." The *Bearcat* 100XL has wide frequency coverage that includes all public service bands (Low, High, UHF and "T" bands), the AM aircraft band, the 2-meter and 70 cm. amateur bands, *plus* military and federal government frequencies. Wow...what a scanner!
Included in our low CE price is a sturdy carrying case, earphone, battery charger/AC adapter, six AA ni-cad batteries and flexible antenna. Order your scanner now.

Bearcat® 210XW-GR

List price $339.95/CE **price $209.95/SPECIAL**
8-Band, 20 Channel • No-crystal scanner
Automatic Weather • Search/Scan • AC/DC
Frequency range: 30-50, 136-174, 406-512 MHz.
The new Bearcat 210XW is an advanced third generation scanner with great performance at a low CE price.

NEW! Bearcat® 145XL-GR

List price $179.95/CE **price $102.95/SPECIAL**
10 Band, 16 channel • AC/DC • Instant Weather
Frequency range: 29-54, 136-174, 420-512 MHz.
The *Bearcat* 145XL makes a great first scanner. Its low cost and high performance lets you hear all the action with the touch of a key. Order your scanner from CE today.

TEST ANY SCANNER

Test any scanner purchased from **Communications Electronics™** for 31 days before you decide to keep it. If for any reason you are not completely satisfied, return it in original condition with all parts in 31 days, for a prompt refund (less shipping/handling charges and rebate credits).

NEW! Bearcat® 800XLT-GR

List price $499.95/CE **price $317.95**
12-Band, 40 Channel • No-crystal scanner
Priority control • Search/Scan • AC/DC
Bands: 29-54, 118-174, 406-512, 806-912 MHz.
The Uniden 800XLT receives 40 channels in two banks. Scans 15 channels per second. Size 9¼" x 4½" x 12½."

OTHER RADIOS AND ACCESSORIES

Panasonic RF-2600-GR Shortwave receiver..... $179.95
RD95-GR *Uniden* Remote mount Radar Detector... $128.95
RD55-GR *Uniden* Visor mount Radar Detector..... $98.95
RD9-GR *Uniden* "Passport" size Radar Detector... $199.95
BC-WA-GR *Bearcat* Weather Alert™ $49.95
DX1000-GR *Bearcat* shortwave receiver **SALE**... $349.95
PC22-GR *Uniden* remote mount CB transceiver ... $99.95
PC55-GR *Uniden* mobile mount CB transceiver.... $59.95
R1060-GR *Regency* 10 channel scanner **SALE**.... $92.95
MX3000-GR *Regency* 30 channel scanner $229.95
XL156-GR *Regency* 10 channel scanner $139.95
UC102-GR *Regency* VHF 2 ch. 1 Watt transceiver... $124.95
P1405-GR *Regency* 5 amp regulated power supply... $69.95
P1412-GR *Regency* 12 amp reg. power supply... $164.95
MA256-GR Drop-in charger for HX1200 & HX1500... $84.95
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MA516-GR Carrying case for HX1500 scanner.... $14.95
MA257-GR Cigarette lighter cord for HX12/1500 ... $19.95
MA917-GR Ni-Cad battery pack for HX1200....... $34.95
SMMX7000-GR Svc. man. for MX7000 & MX5000 ... $19.95
SMMX3000-GR Service man. for *Regency* MX3000 ... $19.95
B-4-GR 1.2 V AAA Ni-Cad batteries (set of four) $9.95
B-8-GR 1.2 V AA Ni-Cad batteries (set of eight) $17.95
FB-E-GR Frequency Directory for Eastern U.S.A. $14.95
FB-W-GR Frequency Directory for Western U.S.A.... $14.95
ASD-GR Air Scan Directory $14.95
SRF-GR Survival Radio Frequency Directory $14.95
TSG-GR "Top Secret" Registry of U.S. Govt. Freq. ... $14.95
TIC-GR Techniques for Intercepting Comm. $14.95
RRF-GR Railroad frequency directory............. $14.95
CIE-GR Covert Intelligenct, Elect. Eavesdropping ... $14.95
A60-GR Magnet mount mobile scanner antenna... $35.95
A70-GR Base station scanner antenna $35.95
USAMM-GR Mag mount VHF/UHF ant. w/ 12' cable... $39.95
USAK-GR ¾" hole mount VHF/UHF ant. w/ 17' cable ... $35.95
USATLM-GR Trunk lip mount VHF/UHF antenna.... $35.95
Add $3.00 shipping for all *accessories* ordered at the same time.
Add $12.00 shipping per shortwave receiver.
Add $7.00 shipping per scanner and $3.00 per antenna.

BUY WITH CONFIDENCE

To **get the fastest delivery from CE** of any scanner, send or phone your order directly to our Scanner Distribution Center.™ Michigan residents please add 4% sales tax or supply your tax I.D. number. Written purchase orders are accepted from approved government agencies and most well rated firms at a 10% surcharge for net 10 billing. All sales are subject to availability, acceptance and verification. All sales on accessories are final. Prices, terms and specifications are subject to change without notice. All prices are in U.S. dollars. Out of stock items will be placed on backorder automatically unless CE is instructed differently. A $5.00 additional handling fee will be charged for all orders with a merchandise total under $50.00. Shipments are F.O.B. Ann Arbor, Michigan. No COD's. Most products that we sell have a manufacturer's warranty. Free copies of warranties on these products are available prior to purchase by writing to CE. Non-certified checks require bank clearance. Not responsible for typographical errors.

Mail orders to: Communications Electronics,™ Box 1045, Ann Arbor, Michigan 48106 U.S.A. Add $7.00 per scanner for R.P.S./U.P.S. *ground* shipping and handling in the continental U.S.A. For Canada, Puerto Rico, Hawaii, Alaska, or APO/FPO delivery, shipping charges are three times continental U.S. rates. If you have a Discover, Visa or Master Card, you may call and place a credit card order. Order toll-free in the U.S. Dial 800-USA-SCAN. In Canada, order toll-free by calling 800-221-3475. WUI Telex anytime, dial 671-0155. If you are outside the U.S. or in Michigan dial 313-973-8888. Order today.

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For credit card orders call
1-800-USA-SCAN

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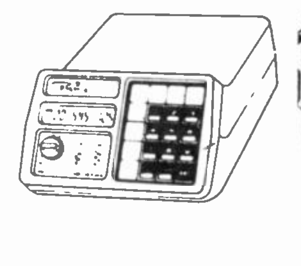
Regency MX7000



Regency HX1500

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CIRCLE 79 ON FREE INFORMATION CARD

EDITORIAL

I just received a letter insisting that the editorial content of **Radio-Electronics** is being bought by our advertisers. The letter mentioned Dick Smith Electronics specifically and said: "Isn't it funny that one month you get this new advertiser out of nowhere, and then feature their kits in numerous articles?"

That's a very easy question to answer, because **Radio-Electronics** has a strict policy that separates our Editorial and Advertising departments. Even if Dick Smith Electronics buys twenty pages of advertising per issue, we'll never give one of their kits any coverage if we don't think that kit deserves it. On the other hand, if they never bought one single page of advertising, our January 1986 issue would still have featured their $99 satellite-TV receiver, and it would still have been our cover story.

Take a look at the projects that we've featured over the last few months. Our July cover displayed a 1.2-GHz frequency counter that was designed and sold by a small company in Florida that has never (as far as I know) advertised with us. Our August cover featured a radar speed-gun calibrator that is available in kit form from another company that has never advertised in this magazine. Last month's cover shows a stun gun that is available as a kit from a company that usually runs a 1/6-page ad, and this month's cover story is available as a kit from a company that has run a one-inch classified ad a few times.

What has me a little confused is that I don't really understand what some readers are complaining about. Are they saying that we shouldn't cover a great construction project because it's commercially available as a kit? Just because a circuit is available as a kit doesn't mean we shouldn't cover it in **Radio-Electronics**. When we run a story based on a kit, we treat it as we do every other construction project—with complete schematics, circuit descriptions, and printed-circuit patterns. Remember: We're not just covering a kit; we're covering circuits and technology.

We do our best to ensure that you don't have to buy the kit or specific parts from a specific supplier. The circuit is there for you to build whether you buy parts or pull them out of your junkbox. But don't forget that, for many of our readers, having a supplier of parts and complete kits can make the difference between building or not building a project.

Now that I've re-affirmed our long-standing policy, it seems like a good time to offer an invitation to all individuals, companies, and corporations, whether or not you advertise in **Radio-Electronics**: If you have an electronics project that you think will interest our readers, let me know about it.

Brian C. Fenton
Managing Editor

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RAG ELECTRONICS, INC.

TEST EQUIPMENT BONANZA

POWER SUPPLIES

B&K		
1601	0-50V,2A	$345.00
1650	2@0-25V,5A,5V5A	350.00
TOPWARD		
2202	0-20v/2a	150.00
2203	0-20v/3a	165.00
2301	0-30v/1a	150.00
2302	0-30v/2a	165.00
2303	0-30v/3a	180.00
2306	0-30v/6a	270.00
2310	0-30v/10a	450.00
2601	0-60v/1a	165.00
2603	0-60v/3a	280.00
2606	0-60v/6a	490.00
TOPWARD TRIPLES		
4302	2@0-30v/2a,5v3a	270.00
4303	2@0-30v/3a,5v3a	325.00
TOWARD WITH DIGITAL MTR		
23020	0-30v/2a	195.00
23030	0-30v/3a	215.00
43020	2@0-30v/2a,5v3a	340.00
43030	2@0-30v/3a,5v3a	395.00
VIZ DIGITAL METERS		
WP-705A	0-50v/2a	330.00
WP-706A	0-25v/2a	327.00
WP-707A	2@0-25v/2a	419.00
WP-708A	2@20v/2a,5v4a	453.00
WP-709	5or13v,7.5a	329.00
WP-711A	0-40v/1a	254.00
WP-712A	0-20v/2a	266.00
WP-713A	2@0-20v/1a	349.00
WP-714A	2@0-20v/.75a,5v4a	372.00
WP-715A	0-36v/3a	319.00
WP-716A	2@0-24v/0.5a	369.00
	5v4a	349.00
WP-717A	0-20v/5a	349.00
GLOBAL		
1300	2@5-18v/.25a,5v1a	109.00
1301	2@5-18v/.5a,5v1a	199.00
1302	2@30v/1a,5v5a	299.00
POWER DESIGN 5YR WRNTY		
5015V	0-50v/1.5a	450.00
4050	0-40v/5a	595.00

COUNTERS/FREQUENCY ONLY

TOPWARD		
TFC-1201	100MHZ	195.00
TFC-1204	650MHZ	305.00
TFC-1207	1000MHZ	380.00
SIMPSON		
710	80MHZ	199.00
VIZ		
4WO-754	100MHZ	219.00
WO-756	1GHZ	399.00
B&K DYNASCAN		
1803	100MHZ	149.00

LEADER		
LDC-831	150MHZ	188.00
GLOBAL		
MAX-100A	100MHZ	99.00
6000	650MHZ	379.00

COUNTERS/UNIVERSAL

TOWARD		
TFC-1211	100MHZ	270.00
TFC-1214	650MHZ	395.00
TFC-1217	1GHZ	490.00
VIZ		
WO-755	125MHZ	255.00
WO-757	1GHZ	489.00
LEADER		
LDC-822	80MHZ	319.00
LDC-823S	250MHZ	424.00
LDC-824S	520MHZ	520.00
LDC-825	1GHZ	1,197.00
B&K DYNASCAN		
1805	80MHZ	259.00
1822	175MHZ	399.00
1851	520MHZ	509.00
FLUKE		
1900A	80MHZ	369.00
1910A	125MHZ	513.00
GLOBAL		
5001	10MHZ	359.00

FUNCTION GENERATORS

TOPWARD		
TFG-8101	2MHZ	185.00
TFG-8104	2MHZ	
AM/FM MOD		240.00
TFG-8111	2MHZ	
+6 DIG 100MHZ COUNTER		275.00
TFG-8114	5MHZ SWEEP	
+5 DIG 100MHZ COUNTER		495.00
SIMPSON		
420A	1MHZ	189.00
4200	1MHZ+BAT	219.00
B&K DYNASCAN		
3010	1MHZ	175.00
3011	2MHZ+COUNTER	175.00
3020	2MHZ+SWEEP	349.00
3025	5MHZ+SWEEP	420.00
GLOBAL		
2001	100KHZ	149.00
2002	2MHZ	199.00
LEADER		
LFG-1300S	2MHZ+SWEEP	439.00
LFG-1310	10MHZ+SWEEP	989.00

HANDHELD DIGITAL METERS

FLUKE			
73	7%	3½	71.00
75	5%	3½	89.00
8060A	04%	4½TRMS	319.00
8062A	05%	4½TRMS	265.00
8026B	1%	3½TRMS	179.00
8020B	1%	3½	179.00
HITACHI			
3525	25%	3½AUTO	64.00
QTY 3EA +	SPECIAL		54.00
3510	1	3½AUTO	79.00
QTY 3EA +	SPECIAL		67.00
B&K DYNASCAN			
2802	7%	3½PROBE	49.00
2820	4%	4½TRMS	297.00

SIMPSON			
470	15%	3½	123.00
474	03%	4½	197.00
KEITHLEY(TEGAM)			
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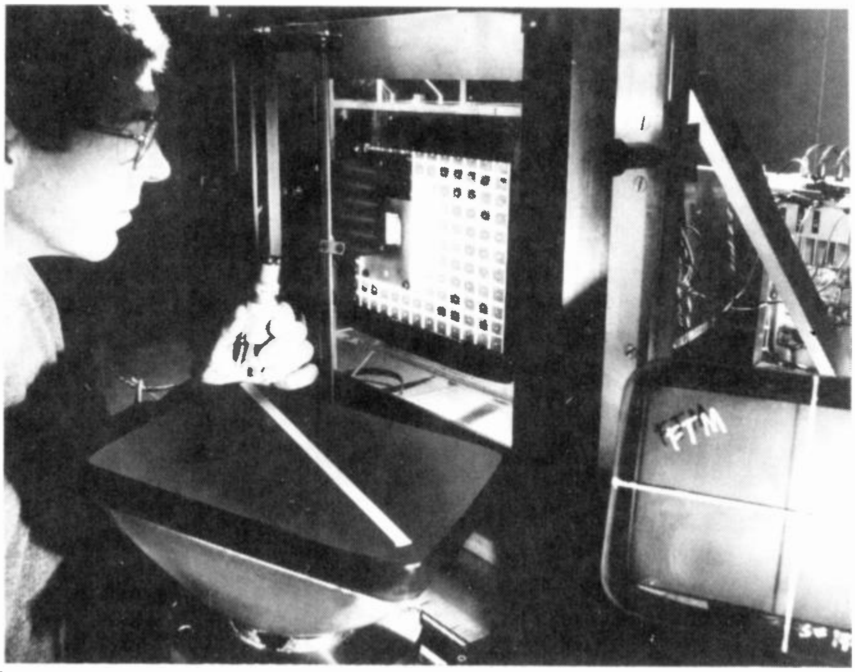
WHAT'S NEWS

New CR display tube has flat tension mask



ZENITH'S NEW FTM COLOR PICTURE TUBE has a perfectly flat face and truly square corners, so straight lines appear straight, rather than curved, as on a conventional picture tube.

A new cathode-ray display tube with a perfectly flat and almost reflection-free faceplate was announced by Zenith at the recent annual symposium of the Society for Information Display. The new *F*lat *T*ension *M*ask (FTM) tube is 80 percent brighter than a conventional tube at equivalent levels of resolution and contrast, and has a 70 percent increased contrast ratio, as well as greater resolution and color fidelity than conventional tubes. It is freer from glare and reflection because it does't reflect light like a convex tube, and because its flat surface can be economically treated with both anti-glare and anti-reflection coatings.

In a conventional color CRT, a curved shadow mask is supported by a frame and suspended by springs inside the tube. As electron beams strike the mask, it heats up and moves. In the new Zenith FTM, the shadow mask is held under tension directly behind the tube's flat glass faceplate. It does not move even at brightness levels that cause discolored images in conventional tubes.

The new mask is sealed to the tube with melted ground glass (frit-sealed). Heated by that process, the mask goes into tension upon cooling to room temperature. Stretched tight, the mask is virtually immune to the deformation that plagues conventional shadow masks.

The flatness of the tube also simplifies the problem of a protective faceplate. Ordinary flat glass can be used for the plate, resulting in lower cost and facilitating both anti-reflection and anti-glare surface treatments.

Electrical measurements may be made with light

The National Bureau of Standards is reviewing the economic and technical advantages that may result from using new optical technologies for measuring voltages and current. Those advantages may be particularly great in power systems, where such measurements are traditionally made with bulky but accurate transformer systems.

The advantages are: isolation from electrical circuits (important at some of the extremely high voltages used in power transmission); high speed (optical methods have been used to measure nanosecond pulses), and economy (optical fibers are much cheaper than transformers).

Optical measurements depend on three opto-electric phenomena: the Faraday effect, in which the application of a magnetic field to a suitable material produces a change in the material's index of refraction; the Pockels effect, in which the application of an electric field produces the same kind of change, and the Kerr effect, also one in which the index of refraction is changed by an electric field. In the Pockels effect, the change is proportional to the change in the field; in the Kerr effect it is proportional to the square of the change.

Various methods may be used to apply those effects to electrical measurement. For example, a number of turns of optical fiber may be coiled around a conductor. Light from a laser is beamed through the fiber. Changes in refraction due to the current result in changes in the intensity of the light transmitted by the fiber. The output of the optical fiber is focused on a photodiode that detects those changes in output and transforms them into changes in electrical current. R-E

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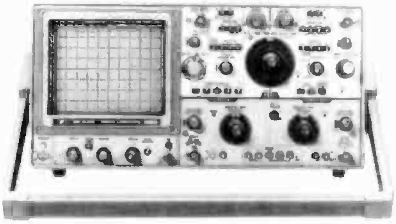

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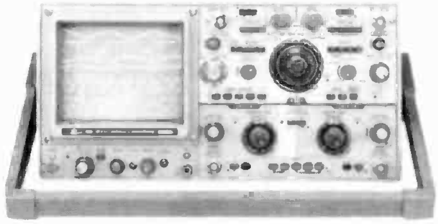

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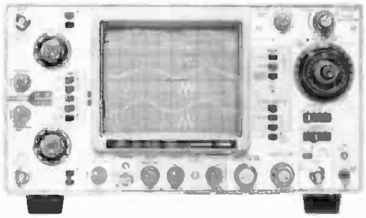

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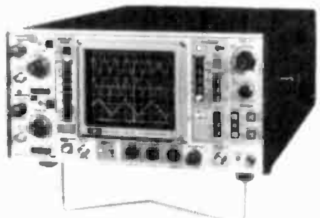

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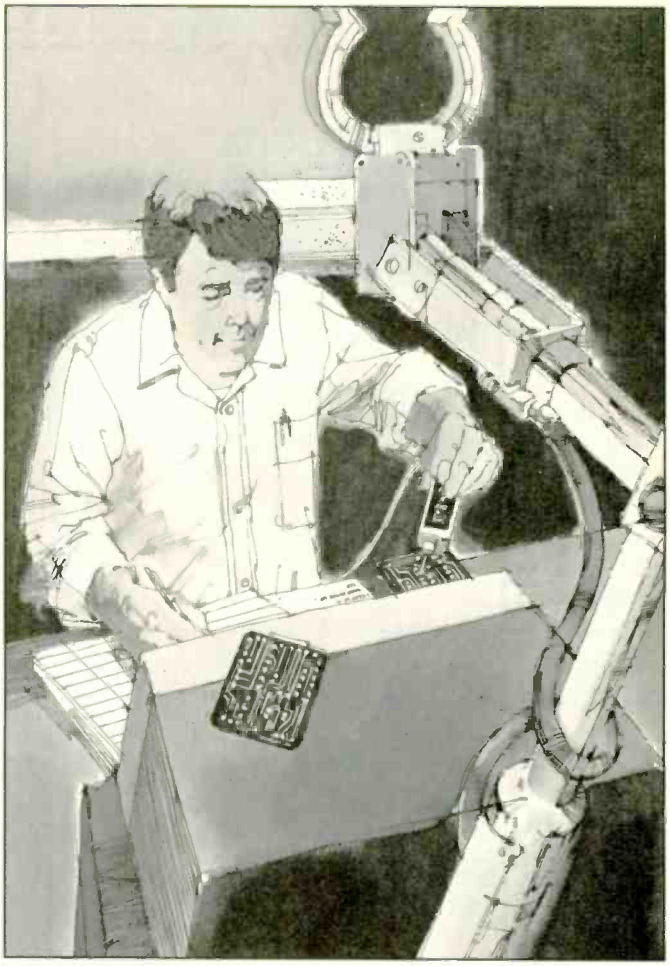

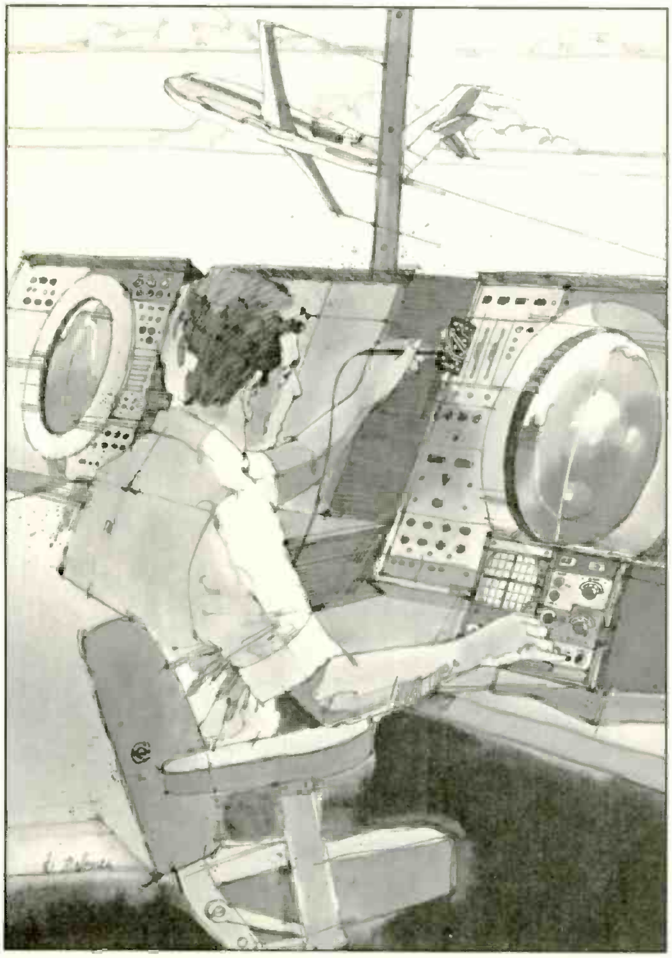

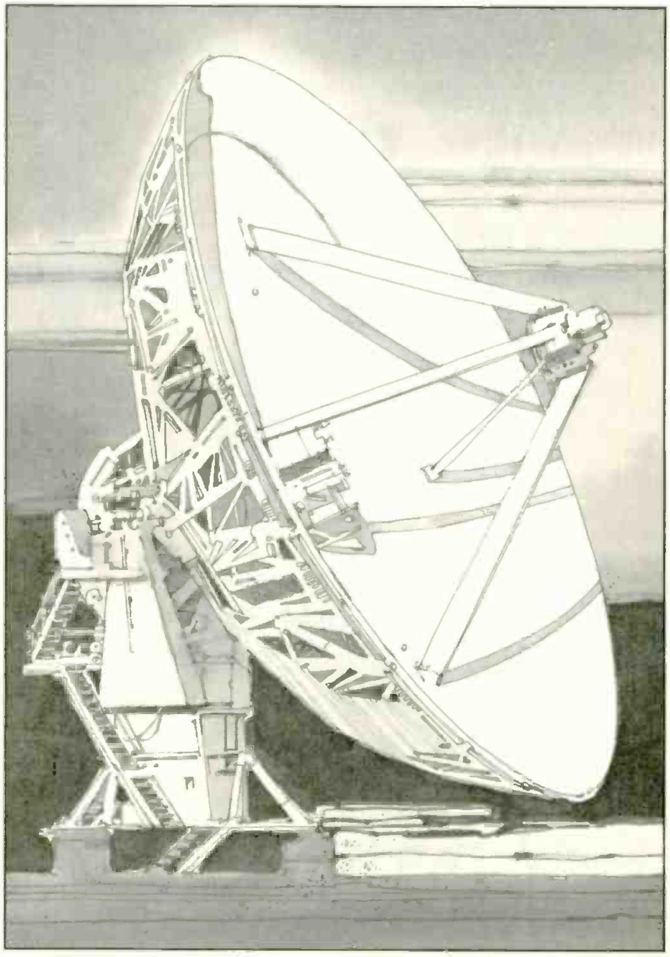

VIDEO NEWS

DAVID LACHENBRUCH
CONTRIBUTING EDITOR

• **Beta I returns.** In the beginning there was Beta I, which delivered excellent picture quality, but only about one hour of recording time. Then came VHS, which initially delivered two hours of recording time, but later could allow tapes as long as eight hours to be made. Of course, the longer tapes came at the expense of picture quality. The Beta camp responded with Beta II and later Beta III, which also offered longer recording times at the expense of video quality.

Much to the dismay of some Betaphiles, in the rush to offer longer playing time, the Beta group ceased to offer the Beta I recording speed, although some recorders that could playback Beta I tapes were still available. Those Betaphiles will be pleased to learn that Beta I has made a comeback. Sony's latest top-of-the-line SuperBeta VCR will record and play back in the Beta I speed as well as in all the others. In addition it has a wireless remote control containing a professional-type jog-and-shuttle dial, which can operate two VCR's and control editing functions previously possible ony with professional-type VCR's. The combination of the Beta I speed and the SuperBeta highband recording-technology provides what probably is the best picture available from a consumer VCR.

Tubeless TV. Trying to estimate the size of the market for TV-sets that use LCD's (*L*iquid *C*rystal *D*isplays) instead of picture tubes is an exercise in futility. There are now four major brands offering those pocket TV's—Casio, Citizen, Epson, and Seiko—and their estimates of sales this year vary from 350,000–400,000 (Casio) to more than 2,000,000 (Citizen). The fact remains that those little sets are coming into the U.S. in increasing numbers, in both color and monochrome models, and that their picture quality is constantly improving. Some proponents estimate that the LCD TV's—after large-screen versions are developed—will represent 40-50% of all TV sets sold by 1995. No matter what, one thing is certain—most major TV-set manufacturers are seriously considering moving into the LCD-TV field, now occupied almost exclusively by Japanese watch and calculator makers.

Swansong for Beta? Although the Beta VCR-format is still preferred by many videophiles—particularly those who pioneered in the field—it seems to be fading from the mass-market scene. In this space we've enumerated the defections from the Beta camp in the past, as major Beta manufacturers have added VHS units to their lines. More recently, NEC, which was an original member of the Beta group and later added VHS, said it was phasing out of Beta in the U.S. because of low demand. Toshiba, whose VHS sales now eclipse those of its Beta line, is adding no new Beta models for the U.S. and says it will continue to supply Beta units upon demand. The only home VCR manufacturers in the Beta camp that do not now offer VHS models are Beta's inventor, Sony, and its affiliate, Aiwa. Sony is now pushing 8mm for both camcorders and home decks, while continuing tc offer Beta in the SuperBeta models, which produce pictures demonstrably better than the original Beta units.

• **HDTV on UHF band?** High-definition TV may be coming down to earth. Many of the proposals for the new super service (more than 1,000 lines, widescreen aspect ratio) have centered on inaugurating it via direct satellite transmission, or possibly over special cable channels. An industrywide working group, Advanced Television Systems Committee (ATSC), has been looking into the entire subject. Now, for the first time, there are strong hints that HDTV could actually start on the standard broadcast frequencies—in the UHF band—as a compatible service. Here's how it would work: A UHF channel would transmit a standard 525-line picture, receivable by any conventional TV set. An adjacent channel would simultaneously transmit the additional information needed to provide a 1,050-line widescreen picture to special advanced HDTV receivers. (UHF probably would have to be used because there's no room in the VHF band for such adjacent-channel broadcasts.) CBS and others have already outlined basic parameters for such compatible systems, and there are indications that the FCC would look with favor on proposals for testing. **R-E**

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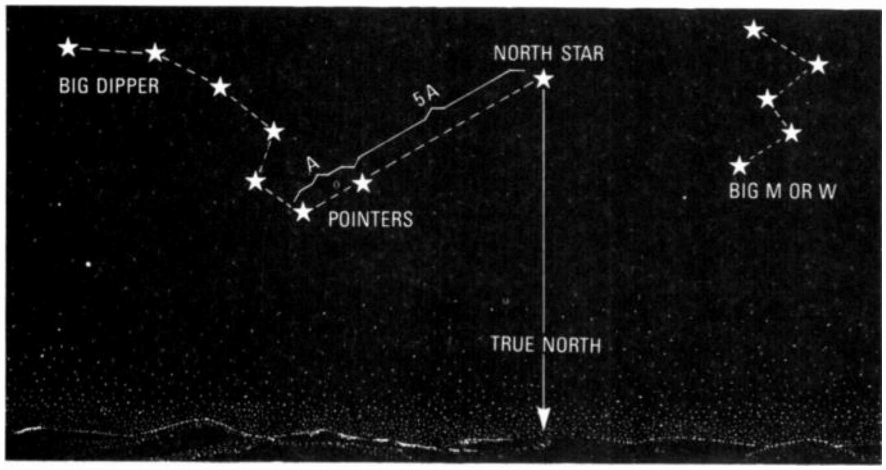

WHERE IS TRUE NORTH?

I have all the components for a TVRO system and I'm ready to install the dish. I plan to use my old magnetic army compass to orient the dish. But some "experts," including my son, say that I can't use the compass until I correct its readings for "True North," whatever that is. The compass seems to work OK and points north as far as I can tell. What are my friends talking about? How can I fix the compass?—H. W. McD., Orlando, FL.

Barring outside influences that might be exerted on the compass needle by large steel structures, nearby power lines, or magnetic ore deposits, a magnetic compass points to the *magnetic* North Pole, which is not located at exactly the same place as the Earth's *geographic* North Pole. It is some distance away in a location that is constantly and slowly changing with respect to the geographic or true North Pole.

From most points on the globe, there will be an angle between true north and the magnetic north indicated by the compass needle. The angle of separation between these two poles is called variation and is measured in degrees east or west of true north. Variation varies with locality and time. In some areas, magnetic north is west of true north; that is called variation west or westerly variation. On the other hand, when magnetic north is east of true north, we have easterly variation.

At a number of points through the southeastern and central United States there is no (zero degrees of) variation, and the directions for true north and magnetic north coincide. An imaginary line passing through the points of zero-variation is called the *agonic* line. As a rule, magnetic variation ranges from about 25 east in the Washington State/British Columbia area to about 15 west in the Maine/Nova Scotia area.

So, to correct your compass to get a heading for true north, you must first determine the amount and direction of variation. You can get this from marine or aviation navigation charts. Check with the operators of a local airport or marina. If there are none in your area, check with a local surveyor.

When variation is westerly add the amount of variation to the compass reading to get the true bearing. And, when variation is easterly, subtract the amount of variation from the compass reading. For example, suppose variation is 15 west in your area. True north will be 15° east of magnetic north.

If your are really out in the boondocks and can't get help, you can use the stars. The North Star, or Polaris, appears directly over the geographic North Pole and its position is accurate to within 1 degree. The Big Dipper can help you locate the North Star.

The two stars (called pointers) forming the side of the dipper farthest from the handle are in a line pointing directly to the North Star, as shown in Fig. 1. The distance (A) from the pointer star at the dipper's lip is about five times the distance (5A) between the two pointer stars. The Big Dipper constellation (among others) rotates around the North Star during the night and may not be aligned as shown in the drawing on your first attempt to locate the North Star. If you're not sure that you've identified the Big Dipper or located the North Star, look to the east for a five-star grouping that forms the letter "W" or "M," depending on how you view it. In any case, the bottom of the "M" or top of the "W" points to the North Star.

When you've pin-pointed the North Star, drive a stake at the point where you're standing and then, sight along the line toward True North and drive a second stake 100 yards or so from the starting point. With this line indicating

True North, use it to calibrate your compass. Take your compass and sight along the line. Record the angle of variation between the line and magnetic north, as indicated on the compass.

Remember that if variation is west, add the deviation to the compass reading, and subtract deviation when it is east. If you want to point the dish toward the west (270°) and variation is 12° west, simply aim the dish on a compass heading of 282 degrees (270 + 12). If variation is 8 degrees east then aim for 262 degrees.

BALUN FOR TV RHOMBIC WHERE'S THE FIGURE?

You answered a question in your August issue regarding a balun for a rhombic antenna. You referenced a figure, but I couldn't find any. Am I missing anything?—G.S.W., New York, NY.

No. Your weren't missing anything, but we certainly were missing something! The figures that we

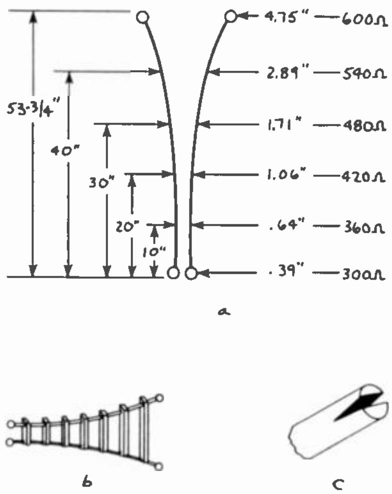

FIG. 2

referred to are shown here in Fig. 2. Please accept our apologies for that embarrassing omission.

ELECTRONIC TIME DELAY

Please show me how to build a time-delay circuit that can be adjusted for up to five minutes. Either an electromechanical or a solid-state relay will be OK.—C. C. S., Holiday, FL.

Figure 3 shows the circuit of an inexpensive general-purpose timer based on a 555 IC. The time delay T in seconds is:

$$T = 1.1 \cdot C1 \cdot (R1 + R2)$$

Resistances should be specified in

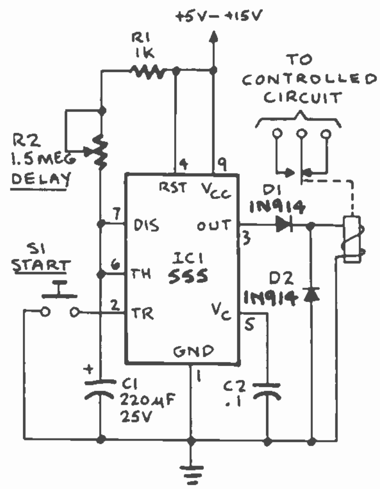

FIG. 3

megohms and capacitance in microfarads. The sum of R1 and R2 should not be less that 1000 ohms nor higher than 20 megohms. Pressing S1 starts the timing cycle. You could use a low-going pulse, instead of S1, to initiate the timing cycle.

Suppose that you have a good 5-megohm linear pot that you want to use as the adjustable control. Then C1 = 300 / (1.1·5) = 55 μF. Since that's not a standard value, use the next highest standard value, 75 μF. The actual value of a device with 20% tolerance can range from 60 to 90 μF. So the maximum time delay (with R2 at 5 megohms) will be 5 minutes and 30 seconds if the value of C1 is 60 μF, or 8 minutes and 15 seconds if C1 is 90 μF.

With the values shown in the diagram, and allowing for the tolerances of the 200-μF capacitor, the delay will range from 4 minutes and 50 seconds to 7 minutes and 26 seconds.

The output terminal, pin 3, of a 555 is normally low and switches high during the timing cycle. The output can either sink or source currents up to 200 mA. Therefore a load such as a relay coil can be connected between pin 3 and V_{CC} or between pin 3 and ground, depending on circuit requirements. When the relay is connected between pin 3 and ground, as in Fig. 3, it is normally de-energized, so it is energized only during the timing cycle. Connecting the relay to ground will save power and allow the IC to run cool. **R-E**

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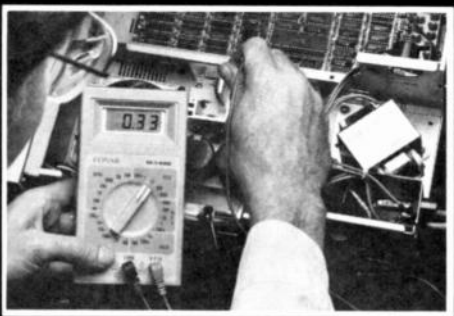
After you build this digital logic probe, you'll explore the operation of the Sanyo detached "intelligent" keyboard and its dedicated microprocessor.



The power supply is assembled in the main unit of the computer. You check out keyboard connections and circuits with the digital multimeter included for training and field use.

LETTERS

LASER TECHNOLOGY

Thanks for Josef Bernard's report on laser technology in the June 1986 **Radio-Electronics.** I agree with his view that the laser is one of the most significant inventions of this century.

Regarding the brief description of semiconductor lasers, I would like to add that such lasers can produce high-power outputs. For example, pulsed gallium arsenide and aluminum arsenide laser diodes can emit pulses having a peak power of 100 watts or more. If the light-emitting region of the front facet of one of those lasers could be enlarged to a square centimeter, the device would emit a million watts of optical power. That coincides nicely with the power available from crystal- and glass-host lasers. Large area, non-junction, electron-beam pumped semiconductor lasers have been developed by several laboratories, and at least one was made commercially available.

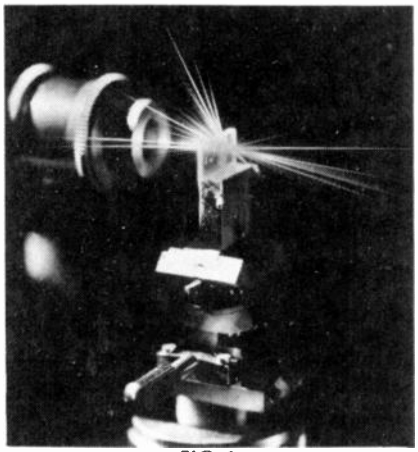


FIG. 1

The family of cw laser diodes used in compact-disc players, laser printers, and lightwave communications emit from 1 to 50 milliwatts continuously when driven by a forward current of from 25 to a few hundred milliamperes. Experimental laser diodes with lasing thresholds on only a few mA have been fabricated.

FORREST M. MIMS, III
Seguin, TX

KIRLIAN PHOTOGRAPHY

John Iovine's article on Kirlian Photography (**Radio-Electronics,** May 1986) is an extremely interesting project. I hope that many of you carry out some of his interesting experiments and add your own observations to the phenomena, while observing all of the safety precautions—particularly the one about not grounding a live subject!

If, however, any of you are encouraged to experiment with Kirlian Photography, please let me recommend an article that appeared in *The Skeptical Inquirer:* "A Study of the Kirlian Effect," by Arleen J. Watkins and William S. Bickel (Spring 1986). The article describes the numerous experimental parameters and controls that must be considered before any Kirlian photographs can be, considered as evidence of paranormal phenomena.

To receive a copy of the article, please send me a self-addressed, 22-cent stamped envelope. (Permission to copy the article has been obtained). I believe that it is extremely important to carry out your experiments with adequate controls and an understanding of the many parameters that are involved. If that is not done, erroneous conclusions will be drawn.

ERNEST L. LIPPERT, JR.
2228 Barrington Drive
Toledo, OH 43606-3149.

COMPLEX CONSTRUCTION PROJECTS

I was scanning the "Letters" column in the May 1986 issue, and noticed Troy Laminack's letter. I have been a **Radio-Electronics** reader for some time now (+25 years), and have watched your magazine's direction change with the times...from vacuum tubes, to transistors, to integrated circuits. I have also watched the demise of a few other electronics magazines at the same time.

Reader Laminack bemoans the inclusion of some of your more complex electronics construction projects in lieu of more simpler (and perhaps more practical) beginner's projects. To quote: "While the $2500 IBM look-alike (*PC Compatible Computer,* July, 1985) would be great to build, and was fun to read, and while a $200 see-in-the-dark-doo-hickey (*See-In-The-Dark Viewer,* August, 1985) would be fun for a few weeks, how practical is it really, and how many of your thousands of readers have hundreds of bucks to spend on that type of tinkering?"

I'd like to answer his question. To begin with, I don't have hundreds of bucks to spend on that type of tinkering. I almost never build the more complex construction projects featured in **Radio-Electronics,** or in any of the other magazines, either. What I do with those articles is to learn about how such devices work, and to extract any circuit ideas from them that may be useful to me at a later date. Many of the projects that I build result from fragments of circuits that I have seen elsewhere.

While I haven't built many of the projects, I have learned a great deal about how things work, circuitry in general, and various facets of electronics design. I owe a great deal to the knowledge that I have gained over the years from magazines such as **Radio-Electronics.**

In closing, please enter my vote to keep the content of the magazine substantially the same. The balance you now present is good as it stands. Anything else would narrow your focus.

RICK CHINN
Redmond, WA

OPPORTUNITIES FOR HANDICAPPED

We are a non-profit organization founded to help the handicapped and disabled to acquire job skills and jobs with the assistance of personal computers. Our staff helps coordinate the efforts of rehabilitation agencies and educational institutions; whenever possible, we supply the needed PC equipment at no cost, and provide training in use of the equipment.

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JAMES R. NICHOLS, Chairman
Personal Opportunities for the Handicapped,
P.O. Box 374
Spicer, MN 562888

PHOTON BUSTER

We read your review of the Melville Technologies Phot-On-Off CD Cleaner with great interest.

The argument that photons may collect underneath the clear plastic surface of a CD sheds some light on the subject of telecommunication via fiber-optics cables. A problem very similar to the one you described in the April, 1986 issue of **Radio-Electronics** exists with the fiber-optic telephone lines.

Everyone has, at one time or another, had the unfortunate experience of using a "bad link." That bad link is usually a fiber-optic cable which has a large photon accumulation. It manifests itself as a "static"-like sound or a reduced received-voice level.

The solution to the problem is gamma radiation, as in the case with CD's. We are in the process of developing such a device for a major long-distance carrier. It will be introduced next April (1987). It will be called "Photon-buster," and will allow the user to efficiently rid fiber-optic cable of excess photon buildup.

For further information, please telephone us at 1-800-PHO-TONS.

ART COPPER and HARRY STEEL, Engineers
Photon Technologies
6006 West John Street
Hicksville, NY 11802

MUSIC MAKERS

Congratulations on the greatest magazine ever! I look forward to every single issue; even if the constructional projects don't interest me, I always enjoy all the other sections—especially "Letters."

A new interest is developing at an incredible rate in projects devoted to music-makers. I'm one of those musicians who struggle to hunt down a high-quality music peripheral (i.e. sequencer). As you know, computers and synthesizers are all one and inseparable in these days of the MIDI link. Please consider running a series on dedicated music-assisting tools that are on par with the overpriced ready-built units.

I'd like to describe my setup briefly: KORG MS-20 Modular Mono Synthesizer, which I'd love to accompany with a sequencer. How about a micro-interfaceable DAC, which is run off the Timex/Sinclair *1000*, with 16K RAM (very fair, don't you think?) I'm sure you'd have no problem in starting the design. I'll leave the rest of the design up to you, as I'm sure that you know the necessary requirements of such a versatile musical instrument.

I'm hoping to spark an interest amongst your readers to support my request. Please consider it seriously; many of us just can't afford the commercial units, and using a cheap micro (such as a *ZX81*) as a dedicated controller is a rock-bottom start for many struggling music experimenters.

TONY KALOMIRIS
Quebec, Canada

VOICE-SWITCHED SPEAKERPHONE

I would like to thank you for mentioning Motorola's Voice-Switched Speakerphone IC, the *MC34018*, in your April issue (page 6). We have received almost two dozen inquiries from hobbyists around the country since that issue's distribution. In order to speed up our response to those who write to Motorola for data sheets and applications information, I would like to provide a more direct mailing address for the department responsible for the *MC34018*. Please send inquiries to: Dennis Morgan (PR340), Motorola Semiconductor Products, 7402 S. Price Rd., Tempe, AZ 85283. All inquiries will be answered with the latest available information.

DENNIS MORGAN
Applications Engineering, Motorola, Inc.

IC PACKAGING

I am writing in response to your article entitled "A Revolution in IC Packaging," **Radio-Electronics**, May 1986.

The author, T. J. Byers, gave an excellent overall picture of the various packages and the handling of them. There is one very important feature that I think was glossed over. The SMD's (Surface Mounted Device) offer a substantially lesser amount of parasitic impedance than the DIP packages. At higher frequencies, that is of extreme importance. Above 100 MHz, although that figure may be argued, lead inductance (in series) and stray capacitance (in parallel) must be taken into account, and compensated for, to ensure a "clean" signal. SOIC's, PLCC's and LCCC's have a 12 to 15% better rise/falltime than DIP packages. Also V_{CC} noise, pin-to-pin crosstalk, and noise-margin problems are less of a problem.

An excellent article on the subject appeared in the December 1985 issue of *Design Technology,* entitled "SMD's Make Bipolar Quick and Quiet." The authors are Charles Hefner and Rich Moore, from Texas Instruments.

DANA C. GLEN
San Leandro, CA

MORE ON IC PACKAGING

I would like to comment on the article, "A Revolution in IC Packaging," that appeared in the May 1986 issue of **Radio-Electronics.** It seems that our world is getting more complicated and changing at rapid pace, as well as being more "global" in nature.

For example: There was a time when you could say "TO-92, TO-3, or TO-5" and people would know what kind of package you were talking about. Now, some use a number—TO-236; some use a name—"super-mini type," and some another name—"small outline transistor." Isn't that confusing?

We at JEDEC recognize TO-236 because it's our standard; the Japanese recognize SC-59, and others recognize Philips's designation SOT-23. Your article uses TO-236/SOT-23, and then quickly drops the TO-236 part, saying that SOT-23 is popularly accepted. I don't see why we need to use three numbers if the parts are the same; and if they are different, we should not say that they are the same.

But there *are* differences. And for the popular SOT-23, we get disagreement on how you make it, even to the extent of putting j-bend leads on it.

What furthers the confusion is that people want to use the JEDEC 2N numbers on surface-mount parts. For example, the popular 2N3904 transistor is registered in a TO-92 (we know what it is) package. Now people want the 2N3904 in an SOT-23 package—but the package cannot handle the heat generated by the part. Is it still a 2N3904? It can't meet the JEDEC specification.

The SO-8 SOIC package that your article referred to is also a Philips design. JEDEC has a standard width on SOIC's both in the .150" width (MS-012) and the .300" width (MS-013). We prefer to use the JEDEC numbers because they have had the review of the entire semiconductor industry, and because JEDEC controls the drawing.

The PLCC's that your article refers to are also JEDEC standards. The square version is the MO-047, and the rectangular is the MO-052 with 50-mil leadspacing. If people would like to see the US-approved packaging standards, JEDEC sells Publication 95. Copies can be obtained from our address below.

KEN McGHEE
JEDEC Solid State Products Engineering Council,
2001 Eye Street NW
Washington, DC 20006

R-E

EQUIPMENT REPORTS

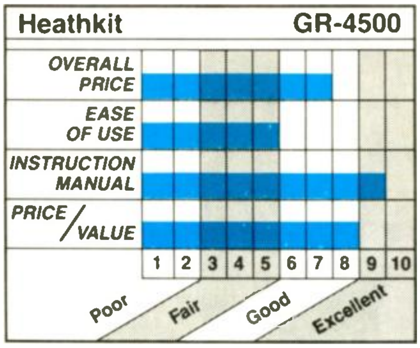
Heathkit Model GR-4500 Projection-TV Kit

The first build-it-yourself projection TV.

CIRCLE 9 ON FREE INFORMATION CARD

MANY YEARS BACK, HEATHKIT (THE Heath company, Benton Harbor, MI 49022) developed and marketed the first color TV-set in kit form that was sold to the general public. Easy to build, thanks to the meticulous instructions that accompanied the unit, that TV-set, as well as many of the ones that followed, became favorites among electronics enthusiasts.

Now, Heath has a new first: It's the *GR-4500*, the first projection TV-set to be offered in kit form. As you might expect from Heath, the projection TV is not a stripped-down, bare-bones model. Instead it offers an array of features that will satisfy even the most ardent videophile, and at a price of only $1695.00



Features

The *GR-4500* is a 45-inch (diagonal measure) rear-projection television receiver. It uses liquid-cooled, high-definition projection tubes, with optically-coupled projection optics, and a black matrix projection screen to yield a picture with superior contrast. Further, the screen acts to absorb ambient light, thus reducing glare and room reflections.

The top-notch optics are complimented by a stereo-audio system complete with MTS decoder for stereo-TV or SAP audio. The amplifier has an output of 5-watts-rms-per-channel into an 8-ohm load with less than 2% THD (*T*otal *H*armonic *D*istortion). The built-in speakers include 2 6½-inch woofers and 2 2½-inch tweeters. For maximum flexibility, audio I/O jacks are provided that allow you to feed the output of the amplifier to a pair of external speakers, feed a line-level signal to a separate stereo-audio system, or to feed a stereo-audio signal from an external source to the set's speakers.

The set has, of course, an infrared remote control. Among other things, that remote offers parental lockout, a quick view function for rapid switching between two stations, a volume control, and a stereo-sound select function. If you own a Zenith VCR, it is likely that the remote can also be used to operate that unit.

Other features that one would expect to find on a high-end piece of video equipment are all present. Those include PLL tuning, on-screen time and channel display, and a comb-filter for the highest possible resolution. The tuner is "cable-ready" and can receive 178-channels of programming if available. The set can be used with the newer HRC cable systems.

The set does not include a resolution control. Instead that function is handled by a preset filter. When switched out, resolution is at its greatest, but so is the video-noise level. If you live in a fringe area, or otherwise suffer from low signal levels, the filter can be used to remove some of the video noise (static, sparkles, etc.), but it will also reduce the set's resolution somewhat.

One item you won't find in any other projection TV is a built-in cross-hatch generator. That is used in aligning the set and eliminates the need to buy additional test equipment. Therefore it is possible to build the unit using just common tools.

Building the set

That brings us to building the unit. In the past, when we've reviewed other kits in this space we've used the "Heathkit" test: That is, how good are the instructions, etc., compared to those found in Heath products. The highest compliment we could pay a kit is to say that it is just as good as a Heathkit. This *is* a Heathkit.

Those of you that have dealt with that company's products in the past know what we are talking about. Illustrations are detailed and complete. Every step in the set-up, construction, and alignment process is painstakingly explained. As a result, if the instructions are carefully followed, the odds of obtaining a correctly working product the first time are high.

To top it off, in keeping with Heath's policy, all stages that are difficult to build or align are pre-assembled. In a kit of the complexity of a projection TV-set, that means that just about the entire unit is contained within a series of pre-assembled modules. The electronic construction is pretty much limited to a single small board. Even the wire harness comes pre-assembled. The result is that the kit can be built in just a few eve-

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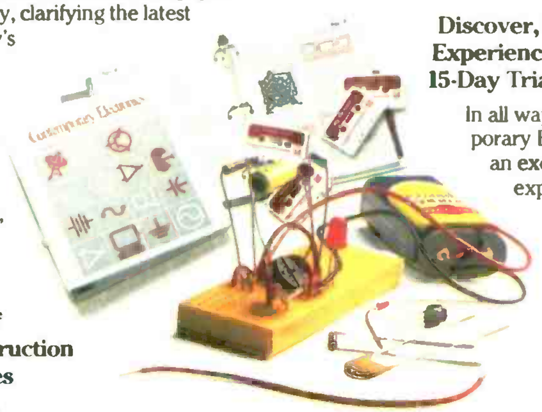

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nings Heath's estimate is 23 hours and we agree that it is accurate.

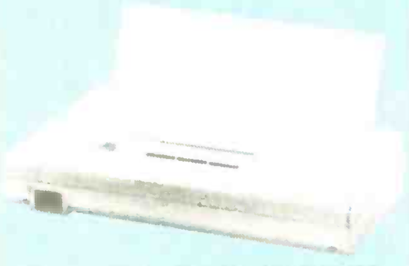
There was one probelm that bears mention. Those of you who are familiar with convergence adjustments know how tricky they are to make, even for someone who does those adjustments on a daily basis. The dynamic adjustments on our completed *GR-4500* seemed particularly difficult to perform, even with Heath's detailed manual.

We eventually were able to obtain acceptable convergence, but we are still not completely satisfied, so we plan to keep after it until it's perfect.

For those of you who run into that or other problems, Heath provides direct technical-assistance telephone numbers. By calling the appropriate number listed in the manual, you can reach directly a specialist in the type of product (computer, TV, ham, etc.) you are building. Even if you never need it, knowing that help is just a telephone call away can be very reassuring. **R-E**

Diconix 150 Portable Printer

This battery-powered printer is IBM and Epson compatible.



CIRCLE 10 ON FREE INFORMATION CARD

TAKE A CMOS MICROPROCESSOR IN AN SMT package, five Ni-Cd C cells, a couple of stepper motors, and a bladder of ink. What do you come up with? How about a versatile portable printer? Diconix, Inc., (3100 Research Blvd., Dayton, OH 45420), a division of Kodak, came up with their model *150*, an under-$500 printer that deserves attention from those needing a portable printer with Epson *FX* and IBM-*PC* compatibility.

The model *150* is an ink-jet printer. A disposable printhead contains a bladder of ink; the ink is forced electrostatically through a vertical series of 12 nozzles to form characters and graphic images. The printheads (which bear the Hewlett-Packard logo) cost about $10 apiece, and are good for about 500 standard sheets of double-spaced text.

The model *150* can print on just about any kind of paper, but best results are obtained on special ink-jet paper, which is available from the manufacturer. The maximum page width is 8-1/2 inches; both sprocket-fed paper and single sheet (such as letterhead stationery) can be accommodated.

In addition to the power switch, the model *150* has three pushbutton switches that control operation. Each has several functions, depending on whether the printer is on- or off-line when it is pushed. The ON LINE switch selects and deselects the printer. The FORM FEED switch advances the paper to the top of the next page if it is pressed when the printer is off-line; if it is

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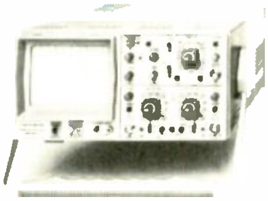

HM 203-6 DC to 20MHz **$489.00**

- Rectangular screen, internal graticule **8x10cm**.
- **Deflection:** 5mV/cm to 20V/cm
- **Timebase:** 0.5us/cm to 0.2s/cm X-Magnification x 10
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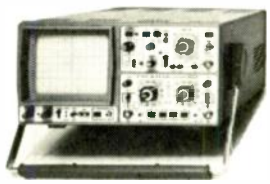
  Test voltage: max. 8.5Vrms (open circuit)
  Test current: max. 24mA rms (shorted)



HM 204-2 DC to 20MHz **$629.00**

- **Component Tester**
- **Deflection:** 5mV/cm to 20V/cm Y-Magnification x 5
- **Timebase:** 0.1 us/cm to 0.5s/cm X-Magnification x 10
- **Sweep delay:** 100 ns to 0.1 s.
- **Calibrator:** square-wave generator, ≈1 kHz/1MHz switchable, risetime<5ns, for probe compensation, output voltages: 0.2V and 2V ± 1%.

HM 605 DC to 60 MHz **$899.00**

- **Component Tester**
- **Deflection:** 5mV/cm to 20V/cm Y-Magnification x 5
- **Y-Output from Ch.I or Ch.II:** ≈45 mV/cm into 50Ω.
- **Timebase:** 50ns/cm to 1 s/cm X-Magnification x 10
- **Sweep delay:** 100ns to 0.1s.

HM 205 **$799.00**

Real-time - See 203-6 Specifications

Digital Storage

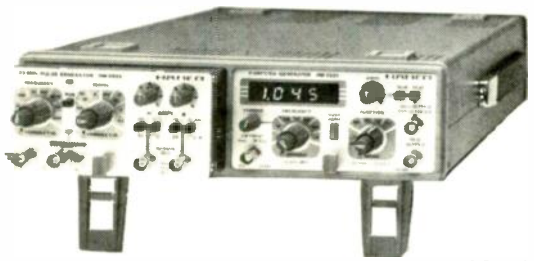
- **Operating modes:** Refresh and Single with Reset (incl. LED indication for Ready), Hold Ch.I, Hold Ch.II. 1024x8 bit for each chan. Sample rate: max. 100kHz. Resolution: vertical **28 pts/cm**, horiz. **100 pts/cm**.
- **Option:** Interface for plotter.
- **Component Tester**

HM 208 **$2,380.00**
HM 208-I **$2,860.00**
(with IEEE Interface)

Real-time - See 203-6 Specifications

Digital Storage

- **Operating modes: XY**, Roll, Refresh, Single (LED ind.), Hold Ch.I, Hold Ch.II, Plot I and Plot II with read-out check on screen, backing storage, **Dot Joining** button. **2 x 1024 x 8bit** for each ch. Sample rate: **max. 20MHz**. Resolution: vert. **28 pts/cm**, horiz. **200** or **100 pts/cm**.
- **Plotter output:** vertical 0.1V/cm, horizontal 0.1V/cm. Output imped.: 100Ω each. Penlift: TTL/CMOS compat. Output speed rate: 5-10-20/10-20-40 s/cm.
- **Option:** Lithium battery for memory backup.



Modular System 8000

ATTACHES TO ALL HAMEG SCOPES ON THIS PAGE!

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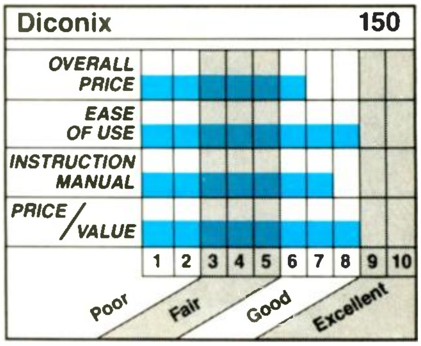
HITACHI Hitachi Denshi, Ltd · IWATSU · LEADER Instruments Corporation · Polaroid · POWER DESIGNS · Simpson pressed when the printer is on-line, the printer's correspondence mode (called Vintage-12 by Diconix) is selected. Similarly, the LINE FEED switch advances the paper one line or selects the draft quality mode. Print quality may also be chosen through software.

Several other options are available through the switches; some, but not all, are also available through software. One innovative and useful feature is the envelope mode. The printer enters the envelope mode when you press the LINE FEED key while powering the printer up. Then you insert a #10 business envelope into the model *150 sideways*. Last, you send the



data to be printed (as many as 20 lines of 100 characters each). Upon receipt of a form feed [CHR$(12)], the model *150* will then print the envelope with all characters rotated 90° clockwise. Multiple copies of an envelope can be printed without resending the same data.

Another special mode is enabled by pressing all three pushbutton switches simultaneously. At that point, the ON LINE and PAPER EMPTY LED's begin flashing alternately. The flashing indicates that the model *150* is recharging the five Ni-Cd cells. You cannot print while recharging.

To save space, Diconix has cleverly chosen to use the platen to store the Ni-Cd's. They must be purchased separately at extra cost. A fully-charged set of batteries will power the model *150* for about 50 minutes of continuous printing, in which time about 150 pages may be printed in draft mode.

The printer measures about 2 × 10½ × 6½ inches and weighs about four pounds—that's less than most portable computers! It comes with a parallel interface; a

unit with a serial interface should be available by the time you read this. No cable is included.

Our impressions

The model *150* is certainly compact enough to be stowed in a briefcase along with a portable computer such as the Radio Shack model *100*. And its ability to operate from batteries makes it very handy for field use.

The model *150*'s print quality is not bad. It's definitely not good enough for business correspondence, but it is good enough for program listings, student papers, and the like. And its Epson/IBM compatibility should make it compatible with 90% of the software on the market, for personal computers ranging from Apples to CP/M machines to IBM PC's.

Print quality is very dependent on the paper that you use. Rough bond paper that is highly absorbent gives smeared characters; polished tractor-fed paper we use for everyday printouts produced results almost indistinguishable from the special ink-jet paper.

One thing that we particularly like about the model *150* is that it is quiet—quiet enough to use with a sleeping baby in the next room. The printhead is easy to change, and configuring the single DIP switch for set-up is also easy.

There are several things we don't like about the model *150*. The paper feed mechanism is weak and poorly designed. It's hard to get single sheets aligned properly, and it's easy for printed sheets (either single or tractor-fed) to loop back into the feed mechanism and jam it.

Also, the plastic cover that allows access to the batteries in the platen is held by two weak clips that look as if they could break easily. If one (or both) did break, there would be no way of keeping the batteries in place. The manual is only so-so and lacks an index.

The $479 price of the Diconix *150* is a little steep; other battery-powered portable printers are available for as little as $100. But most of the very inexpensive units are thermal types that require special paper, and that have much poorer print quality, as well as much less flexibility. **R-E**

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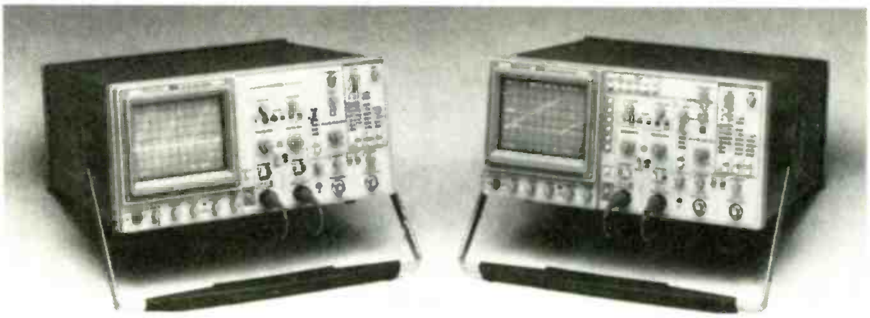

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nm sensor for the model *6810* and 850 nm sensor for the model *6800*, (2) FC-type connector adapters, wavelength-sensitivity response chart, 4 AA batteries, AC adapter, carrying case, and comprehensive instruction manual.

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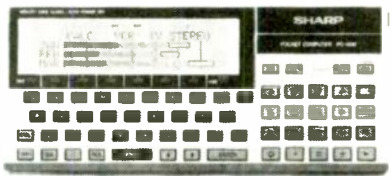

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faster than the *PC-1500A's*, making it a complement to the unit's increased memory capacity.

Measuring 3½ by 8 inches, and weighing less than a pound, the model *PC-1600* features an easy-to-read, four-line, 26-character display. The standard configuration includes 16K RAM, expandable to 80K. The unit also has an analog input and an RS-232C serial port.

Suggested retail prices for the model *PC-1600* and options are as follows: *PC-1600* pocket computer: $345.00; *CE-1600F* micro floppy drive: $210.00; *CE-1600; CE-1600P* 4-color pen plotter/cassette interface: $315.00; *CE-1600M* 32K RAM module: $155.00.—**Sharp Electronics Corporation**, Sharp Plaza, Mahwah, NJ 07430.

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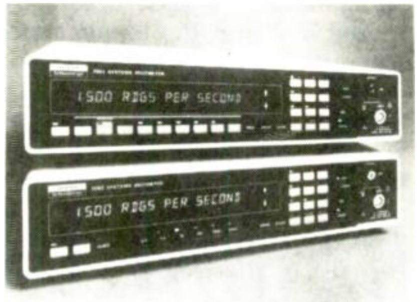

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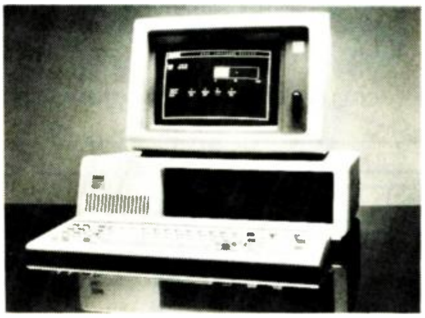

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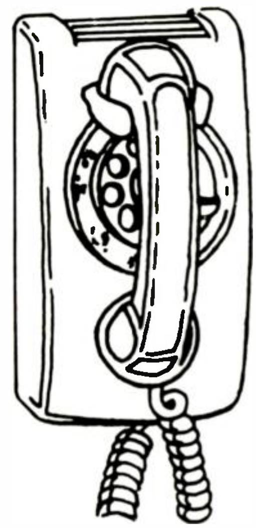

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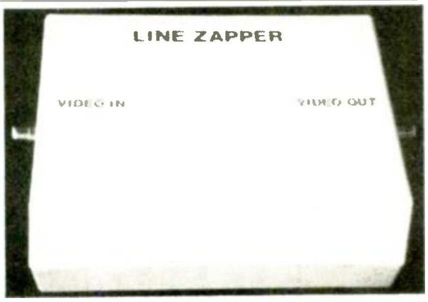

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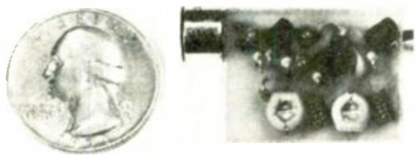

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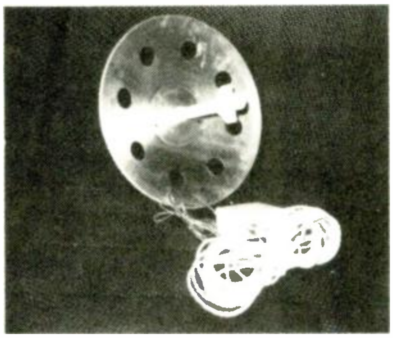

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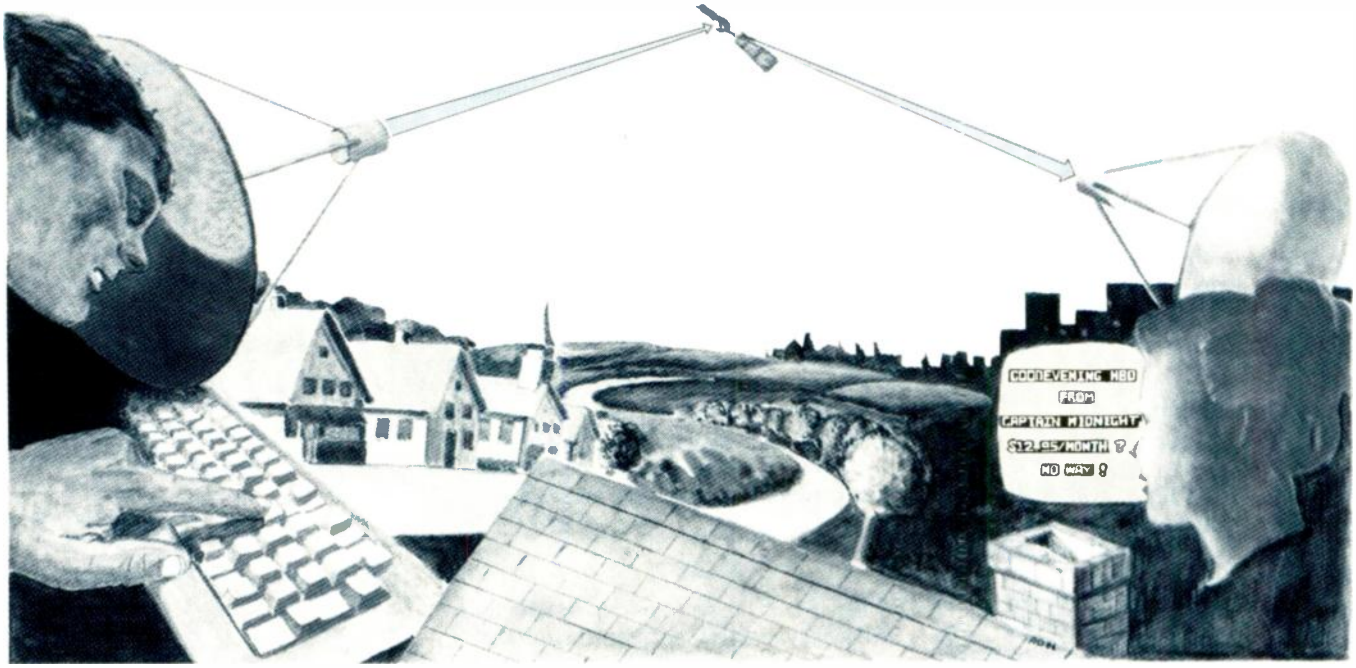

The Raid on HBO

Here's one way Captain Midnight might have engineered his daring raid on HBO.

WILLIAM SHEETS and RUDOLF GRAF

IN THE EARLY MORNING HOURS OF APRIL 27, 1986 the satellite-communications industry received a jolt that it's not likely to forget. For roughly four to five minutes, a satellite "pirate" commandeered HBO's east-coast feed, located on Galaxy 1, transponder 23. Viewers of a movie entitled "The Falcon and the Snowman" were suddenly treated to a color-bar display. Superimposed on the display was the following message:
"Goodevening HBO
From Captain Midnight
$12.95/month
No way!
(Showtime/Movie Channel beware)"

Public reaction to the incident ranged from joy to outrage. But no matter what the reaction to the event, almost everyone asked the same question: How did Captain Midnight engineer his stunning "heist?"

HBO and other satellite-industry sources were in no hurry to reveal all that they knew about the incident; as you read on you'll come to realize why. As a result there was much misinformation in the media. One report stated that the feat required a great deal of technical expertise and about $60,000 worth of equipment.

TVRO "hackers" must have had a few chuckles over that one. The truth of the matter is that taking over a private communications satellite is so terribly simple that the surprise is that no one had done it before.

And that fact, so clearly illustrated by Captain Midnight's escapade, has HBO and the rest of the satellite-communications industry scared silly.

A little background

In the beginning, satellite TV was the province of the professionals. The broadcast- or cable-network program producers used satellite to distribute their products to local TV stations or cable companies.

If you happened to live in a city or town serviced by one or more TV stations or cable companies, that arrangement sufficed because you had access to that programming either for free or for a monthly fee. But if you lived in one of the many areas of the country that had no such service, you were out of luck.

The early TVRO pioneers had no desire to "rip off" the cable companies. Their only aim was to obtain TV programming the only way possible—directly from satellites.

Early experimenters were faced with incomplete information and expensive equipment. Later on, savings were made possible by using salvaged radar gear and other surplus equipment. Eventually, the market grew large enough to encourage some companies to mass-produce TVRO gear.

All the while, a shadow of legality hung over the infant industry. The major producers all considered TVRO users a nuisance. Their position was that any unauthorized reception of their signals was against the law. But, partially due to pressure from their cable affiliates and partially due to the headache of having to track hundreds if not thousands of individual accounts, the cable networks refused to give authorization to TVRO owners, even if those owners offered to pay a fee.

Legislation passed in 1984 allowed everyone to receive satellite signals in their own homes as long as that reception was for personal use. The satellite industry took off. Prices fell as more and more manufacturers jumped into the TVRO field. For instance, the price of a good (85°K) LNA was once greater than $500; today it is less than $100.

By now, the original aims of the TVRO pioneers were largely forgotten. Many new TVRO buyers were mainly interested in "beating" the cable companies. Small hotels, motels, bars, and restaurants were racing each other to install dishes to attract customers. In some cases, the programming was even being sold by the dish owners; that was particularly prevalent with apartment-house systems. In most cases, those users paid nothing to the program suppliers.

A more serious problem was presented by the cable affiliates themselves. Many were habitually late in paying their bills. Others understated the numbers of their subscribers. Some didn't bother paying their bills at all.

Enter scrambling

The cable networks, led by HBO, answered back by scrambling their feeds. That one act achieved two goals: It enabled the programmers to control who could receive their signal, and it brought the cable affiliates into line.

Scrambling, though recognized by many as a necessary evil, did not come without bitterness. Used to receiving their programming for free, TVRO users were now required to shell out just under $400 for a decoder, providing one could be located. Further, most services charged a monthly fee for their programming.

No one realized how much bitterness there was until that fateful night in April.

The raid

It is generally assumed that the raid was carried out by using a remote uplink to overpower HBO's signal and commandeer its transponder on Galaxy 1. See Fig. 1. Let's spend some time and see what the technical requirements are to conduct such a raid. Particularly, we will see what dish sizes and power levels are needed. Note that the information provided is illustrative only. We will show what is theoretically possible, not what was actually done. The authors have not had any direct contact with Captain Midnight nor have they had a chance to examine that individual's facilities. *(See box—Editor)*

Let's see what the requirements are for a minimal satellite link. To do that we need to make a few assumptions and a few calculations. To calculate the range of a signal we need to know the transmitter power, transmitter-antenna gain, receiver-antenna gain, receiver bandwidth, and receiver noise-figure. The last three of those factors can be found by examining the technical details of the satellite we wish to transmit to. Determining the first two factors is the point of the following exercise.

Let's start off by determining the path loss between the transmitter and receiver. That is found from:

$$PL = 37 + 20\ LOG(f) + 20\ LOG(D)$$

where PL is the path loss in dB, f is the frequency in MHz, and D is the distance between two points in miles. Assuming an uplink frequency of 6000 MHz (6 GHz) and a distance of 22,500 miles, the resulting path loss is:

$$PL = 37 + 20\ LOG(6000) + 20\ LOG(22{,}500)$$

$$PL = 37 + 75.56 + 87.04$$

$$PL = 199.6$$

At a downlink frequency of 4 GHz it is slightly less. Sparing you the mathematics, it is about 196.1 dB.

Next, let's do the calculations for a typical satellite downlink. A typical *E*ffective *R*adiated *P*ower (ERP) level for a transponder is 36 dBw (dB's referenced to one watt). That means that the effective transmitter power is 3981 watts (or approximately 4000 watts). Actual transponder output levels are typically about 8 watts, or 9 dBw. Therefore, typical antenna gain is 36 − 9 = 27 dBw.

On earth, a typical TVRO will have a receiver bandwidth of 30 MHz, a noise figure of 1.5 dB, and a 10-foot dish. From Fig. 2 we see that a the gain of a 10-foot dish at 4000 MHz is about 40 dB. Now that we have all of the facts, we can calculate the power of a received signal.

$$P_R = ERP - PL + \text{antenna gain}$$

$$P_R = 36 - 196.1 + 40$$

$$P_R = -120.1\ dBw$$

or, converting to dBm (decibels referenced to a milliwatt), −90.1 dBm. Note that assuming a 50-ohm input, 0 dBm = 223 mV; we'll need that figure in a moment.

Continuing with our calculations, since:

$$dB = 10\ LOG(P2/P1) = 20\ LOG(V2/V1)$$

$$90.1 = 20\ LOG(0.223/V_R)$$

where V_R is the received signal. Continuing:

$$4.505 = LOG(0.223/V_R)$$

$$V_R = 6.97\ \mu V$$

Receiver sensitivity can be found from:

$$S_R = NP + LOG(BW) + NF$$

where S_R is the receiver sensitivity in in dBm, NP is the noise power in dBm per Hz at 25°C, BW is receiver bandwidth in Hz, and NF is the noise figure. A typical noise power value would be −174. Solving:

$$S_R = -174 + LOG(30 \times 10^6) + 1.5$$

$$S_R = -97.72\ dBm$$

The resulting S/N ratio can be found from:

$$S/N = P_R - S_R$$

Since our received signal is −90.1 dBm and our receiver sensitivity is −97.7 dBm, the resulting signal-to-noise ratio is 7.6 dB.

Incidently, that is a marginal signal. Generally a TVRO receiver requires an 8-dB or greater S/N ratio for good performance. To improve signal performance, a larger dish (say 12-feet) would be called for. Many transponders output signal levels higher than our illustration; those could be viewed with satisfactory results.

We are getting off the track here a bit, so let's push on. Our point thus far was to lay the groundwork so that we could supply the missing data. The parameters required for a successful downlink do not differ greatly from those required for a successful uplink. Let's assume that we want to supply to our satellite-borne receiver an S/N of at least 10 dB, and prefer-

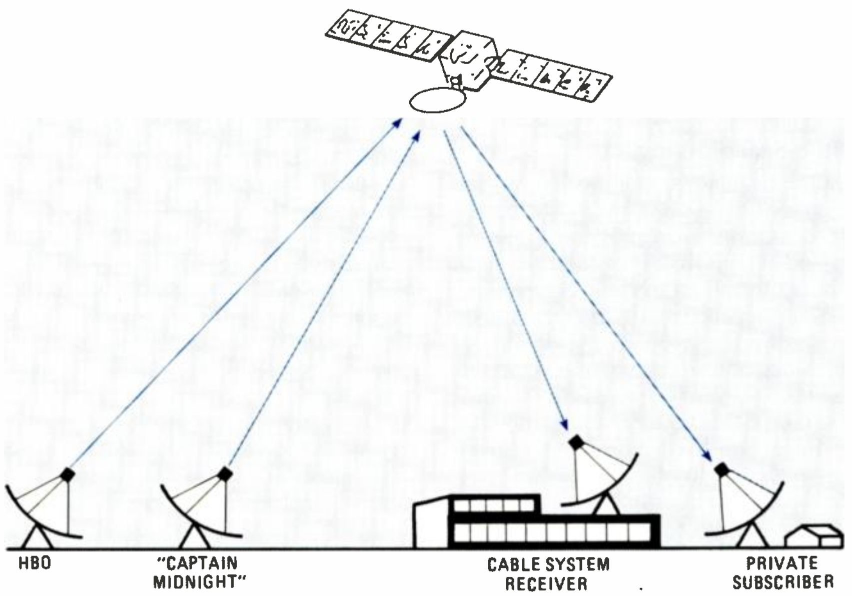

FIG. 1—IN THE MOST LIKELY SCENARIO, Captain Midnight commandeered HBO's transponder on Galaxy 1 by transmitting to the satellite from a secret uplink sight.

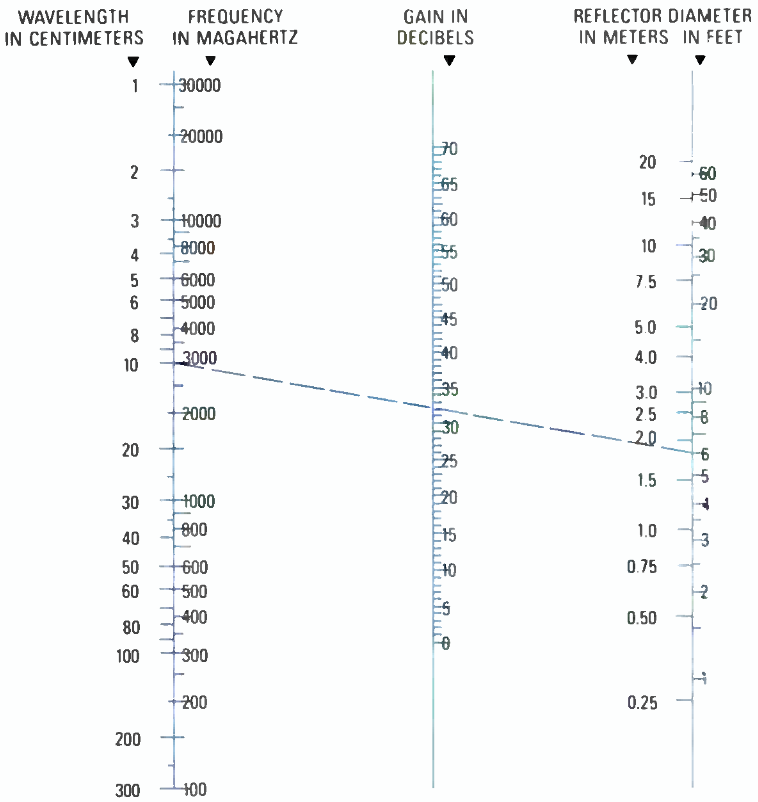

FIG. 2—IN THIS NOMOGRAPH, dish gain as a function of frequency and reflector diameter can be found.

Captain Midnight Unmasked!

On July 22, an Ocala Florida man surrendered to Federal authorities and admitted to being Captain Midnight.

As part of a plea-bargain agreement, John R. MacDougall was to be fined $5000 and sentenced to a year's probation in exchange for a guilty plea to one count of interfering with an FCC authorized transmission, a misdemeanor. That offense normally carries a maximum penalty of one year in jail and/or a $100,000 fine.

MacDougall, 25, owns a TVRO dealership and also worked part-time as an operator for Central Florida Teleport, a satellite-TV uplink facility. He used that facility's equipment when he interrupted HBO's Galaxy 1 uplink from Hauppauge, NY on April 27.

The FCC used information provided by HBO and Hughes Communications, owner of the Galaxy bird, as well as analysis of several videotape recordings of the interfering signal to track down MacDougall. Further, the investigators also learned that another transmission, consisting of a color-bar pattern only, had over-ridden HBO's signal nearly a week before the celebrated message from Captain Midnight.

Using the supplied data, the FCC was able to determine approximate dish size (seven meters) and the model of character generator used. Examining the nearly 2,000 professional uplink sites in this country, those factors, and others such as transmitter power, allowed the investigators to narrow their search to less than a dozen sites.

Further, the Central Florida Teleport was the only one of those facilities that was not otherwise in use at the time of the April, 27 incident. Sealing the case was the fact that both interfering transmissions occurred just after scheduled programming from the Florida facility had ended and the operator on duty both times was MacDougall.

Asked to speculate as to why the Captain turned himself in, investigators revealled that several of MacDougall's associates at the Central Florida Teleport had been questioned and that he himself had been subpoenaed. No other individuals or organizations have been implicated in the jamming incident. **R-E**

ably one of 16 dB. Also, assume that the receiving antenna on the satellite has the same gain as the transmitting one. Finally, assume a satellite receiver NF of 1.5 dB and a receiver bandwidth of 36 MHz. We can plug those values into our equation for signal-to-noise ratio and solve for the required power level:

$$S/N = P_R - S_R$$

$$S/N = P_R - 174 + LOG(BW) + NF$$

$$P_R = -174 + 75.56 + 1.5 + 16 = -80.94$$

Let's round that off to −81 dBm. With an antenna gain of +27 as previously calculated, the effective received-power-level required would be −81 − 27 = −108 dBm. We earlier saw that at 6 GHz, path loss is 199.6 dB. Therefore, the effective transmitted power required would be 199.6 − 108 = +91.6 dBm, or +61.6 dBw.

Assuming a modest 10-foot dish diameter with a gain of about 42 dB, the transmitted power would be 61.6 − 42 = 19.6 dBw. That translates to a transmitter power level of 91.2 watts.

In other words, all that is needed to uplink to a satellite is about 91 watts into a 10-foot dish. Smaller dish sizes could also be used. For instance, with a 6-foot dish the job could be done with 280 watts. With larger dish sizes, less power would be needed.

Granted it is not cheap to generate those types of power levels at 6 GHz, but it does not really pose much of a technical obstacle. It's even easier to generate pulse power at those levels. Intelligence could not be conveyed, but a prospective jammer could achieve his aim of knocking a transponder out of service. Further, an encoded signal presents even an easier target. All that a would-be pirate needs to do is to disrupt the signal enough that the system's decoders cannot do their jobs.

As you can now see, large dish sizes and high power levels are not needed to establish satellite communications. With a moderate-sized dish, a few tens of watts are all that are needed at microwave frequencies. It is feasible, in fact, to mount a satisfactory uplink system in a small truck or van.

Other considerations

So far we have seen what is needed to establish satellite communications. But what is needed to snatch control of a transponder that is already in use? A characteristic of FM systems is the so-called "capture effect," which allows the system to receive only the strongest of two or more competing signals. Usually the weaker signal is suppressed by between 20 and 30 dB. The difference between signal levels, called the capture ratio, need not be great for the capture effect to take place. In high-quality receivers, capture ratios of less than 2 dB are common.

Of course, FM is used for both video and audio satellite communications. That means that to take over a transponder, a pirate need only have a signal that is a few dB stronger than that of the legitimate user.

Repelling the raiders

Now that we have a little insight into how a pirate might take over a transponder, what can the programmers do to stop or catch him? Unfortunately, the answer is not much. Let's see why.

HBO has stated that it will simply increase power to override any future would-be pirate. But that approach presents its own problems. Some satellite-

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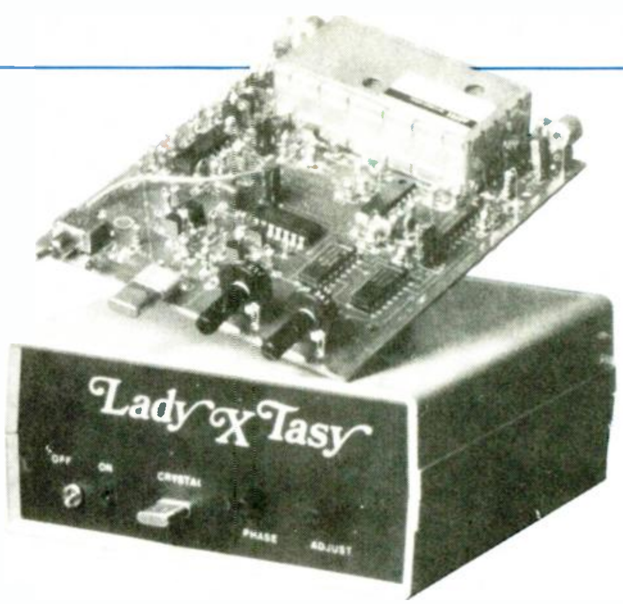
Satellite-TV Descrambler



VICTOR J. TERRIO, JR. and JAMES PERODI

Learn about one of the more popular satellite-TV scrambling systems, and how it can be decoded.

IF YOU HAVE BEEN WAITING FOR AN EASY-to-build satellite decoder, your wait is over. Here is a relatively simple unit that can be built in just a few evenings. In the process, it can teach you about some of the technology behind satellite-TV scrambling

Before you get too excited, we should tell you that the unit will *not* decode HBO, Showtime, or any of the other services that use the *VideoCipher II* system. Instead, it decodes the *Telease-Maast* system. That medium-security system is used by two adult-oriented direct-broadcast systems, as well as by a few sports-programming services.

Next, heed this important warning: **The use of an unauthorized descrambler may constitute a violation of federal or local laws. It is up to the user to determine what the requirements for use are, and to meet them fully before using the unit.** The details presented in this article are for informational purposes only.

Design philosophy

The decoder represents the latest version of a series of decoders that have been developed over the last five years. We took the best features of previous designs and combined them with the latest technical advancements to achieve the unit described here. The unit offers a number of convenience features, including front-panel-mount phase-control adjustments and crystal socket.

The unit is designed to accept baseband audio and video inputs; outputs of that type are available from just about any satellite-TV receiver. The unit as described in this article features an RF modulator. It is an easy matter to eliminate that modulator and bring out baseband audio and video outputs for connection to a VCR, etc. If applicable, that modification is recommended. It will be fully described later on.

The *Telease-Maast* system

The *Telease-Maast*, or Telease system is a medium security system that uses analog audio and video scrambling. By contrast, to the high-security *Videocipher II* system uses analog video scrambling and *digital* audio scrambling.

That's not to say that a *Telease*-encoded signal is simple to descramble. In the *Telease* system the video is inverted, its level is reduced to one half of normal, and it is modulated by a 94-kHz sinewave. The audio is modulated by a 15.67 kHz sinewave before being placed on the usual 6.8-MHz subcarrier. To further complicate matters, no attempt is made to precisely control the frequency of the scrambling oscillator at the uplink and no reference signal is transmitted with the scrambled signal. Finally, 94 kHz is nearly 6 times the TV horizontal-scan frequency (15.734 kHz), but not exactly. If the scrambling sinewave is not completely cancelled, the 6th harmonic of the horizontal frequency (94.4 kHz) can beat with the sinewave to generate an annoying 400-Hz interference signal.

Descrambling *Telease*

A block diagram of the descrambler circuit is shown in Fig. 1. Circuit details for that unit are shown in the schematic of Fig. 2. Refer to both of those figures as we describe the operation of the circuit.

Transistors Q1 through Q4 form a balanced differential video amplifier. The baseband video input jack, J1, is connected to the inputs of Q1 and Q2. The signals at the collector of Q3 and the emitter of Q4 are inverted with respect to each other, and are also 180° out of phase. Those signals are fed to the inputs (pins 1 and 4) of IC3, an MC1496 balanced demodulator. That IC removes the 94-kHz carrier from the video signal. The outputs of IC3 appear at pins 6 and 12; the outputs differ in phase by 180°.

The outputs of IC3 are fed to IC1-a, ¼ of a TL084CN quad biFET op-amp. That amp takes the outputs of the balanced demodulator and uses them to develop an error voltage that in turn is used to control operation of the Voltage Controlled Oscillator (VCO).

The VCO, which consists of XTAL1, varactor diode D2, and Q9, is part of a *Phase-Locked Loop* (PLL). The other stages of the PLL consist of a divide-by-16 counter, a divide-by-4 counter, and a 94-kHz bandpass filter. The PLL accurately tracks the scrambling sinewave frequency and allows the decoder to generate the reference signal needed for descrambling. The output of the VCO, taken from Q9, is fed to Q8 and then Q7 for amplification and buffering. It is then fed to pin 1 of IC5, a 4024 7-stage binary ripple counter that is set up as a divide-by-16 counter. The output of that stage (pin 6) is then fed to IC4, a 4027 dual J-K flip-flop that is set up as a divide-by-4 counter. Three outputs are taken from IC4. One, taken from pins 6 and 15 and labeled CLOCK1 in Fig. 1, is fed to a 94-kHz bandpass filter built around IC1-b. The output of that filter serves as a reference signal for IC3.

The second output, taken from pins 1 and 11 and labeled CLOCK2, is fed to another 94-kHz bandpass filter, which is built around IC1-c. The output of that filter is the correction signal used to remove the scrambling sinewave. It is fed to the cancel- and phase-adjust stage, which consists of R70, R65, R39, R47, R49, C10, and C11. That stage is used to adjust the phase of the correction signal for proper cancellation of the scrambling signal.

The actual cancellation of the scrambling signal takes place in the clamper-amp and adder stage. In that stage, which consists of transistors Q5 and Q6 the scrambled video, which is taken from the output of the differential amp, is summed with the correcting sinewave to yield an unscrambled video signal.

The third output of IC4, taken from

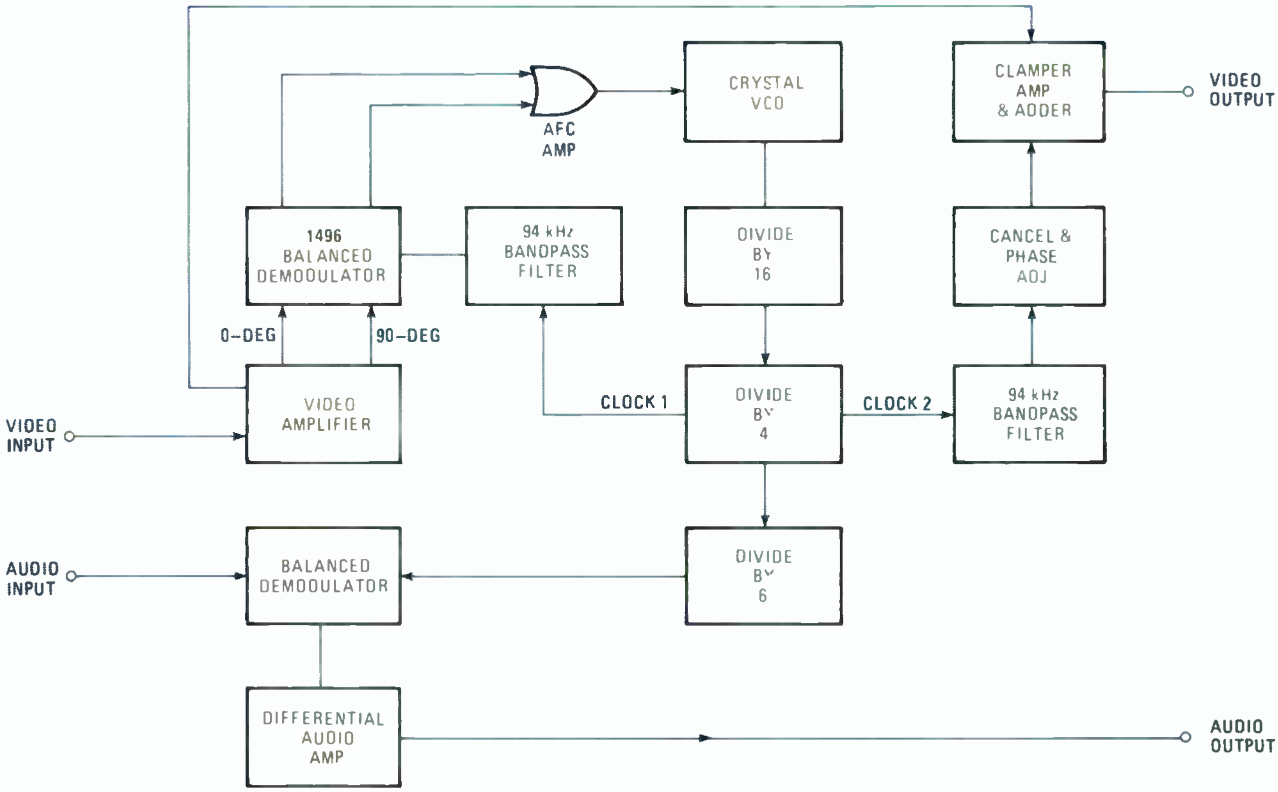


FIG. 1—DESCRAMBLING TELEASE. This block diagram shows the steps that a descrambler must take to decode that medium-security system.

pins 2 and 10, is fed to IC6, a divide-by-2-through-10 synchronous counter configured as a divide-by-6 counter. The output of that IC is used as a reference signal by IC2, a second MC1496 balanced demodulator. That demodulator removes the 15.67-kHz scrambling sinewave from the audio and passes the audio to a differential audio amplifier, which is the last of the four op-amps of IC1-d. The output of that amp is fed either to an audio output or to the RF modulator, if it is used.

Building the unit

The first step in building the descrambler is to obtain the board. An appropriate double-sided PC pattern is shown in PC Service, found elsewhere in this issue. Otherwise, a board can be purchased from the supplier mentioned in the Parts List.

A parts-placement diagram for the board is shown in Fig. 3. Note that the version shown includes an RF modulator. If you have a VCR, TV, etc. that can accept direct audio and video inputs, the RF modulator and its associated components (D1, C1, and R46) can be deleted. If that is done, the audio and video inputs to the modulator can be brought out to the rear panel of the case and terminated with standard phono plugs. If your TV, VCR, or other equipment can accept direct audio and video inputs that is the recommended approach as it will yield superior picture and sound.

Building the unit is a fairly straightforward procedure, although a few things bear special mention. Before mounting S1, trim the lead nearest the outer edge of the board so that it does not make contact with the board when the switch is mounted. Connect the lead stub to the appropriate pad in the center of the PC board with a jumper as indicated in Fig. 3. The unused pad beneath the switch becomes the ground connection for the external power supply (more on that in a moment).

The crystal socket should be accessible from the front panel so that you can switch between services easily. There are a number of ways to accomplish that. One is to use a panel-mounted socket and to make the connections to the PC board with short jumpers. Another is to mount a PC-mounted socket on Y-shaped PC-mount tie points, creating a 90° crystal socket.

As mentioned, the PC board is double-sided. If you buy the board from the supplier mentioned in the Parts List, it will be provided with plated-through holes. Otherwise, you should solder all component leads on both sides of the board and you must also install feedthroughs at all unused pads. Use short, uninsulated pieces of wire for that and be sure to solder them on both sides of the board. Clipped resistor, capacitor, etc. leads are ideal for use as feedthroughs.

Three components, C17, R74, and R75, are installed on the solder side of the board. One end of R74 shares a mounting hole with the base of Q5; one end of R75 shares a mounting hole with Q6. The other end of both resistors is tack-soldered to the ground plane. One end of C17 connects to the junction of C8/R43; it shares its mounting hole with either of those components. The other end of the capacitor is connected to the ground plane. You likely will need to extend the lead length of the capacitor with a jumper to make that connection.

The unit requires ±5 volts, and +12 volts if the optional RF modulator is used. Most aftermarket computer power supplies are capable of supplying the needed voltages and current levels.

Note that the components are tightly spaced in some regions of the board. Because of that, some of the resistors must be mounted vertically.

For easiest construction, if used, mount the RF modulator last. Otherwise you might run into difficulty when mounting the surrounding components. Note that the output channel is selected by the

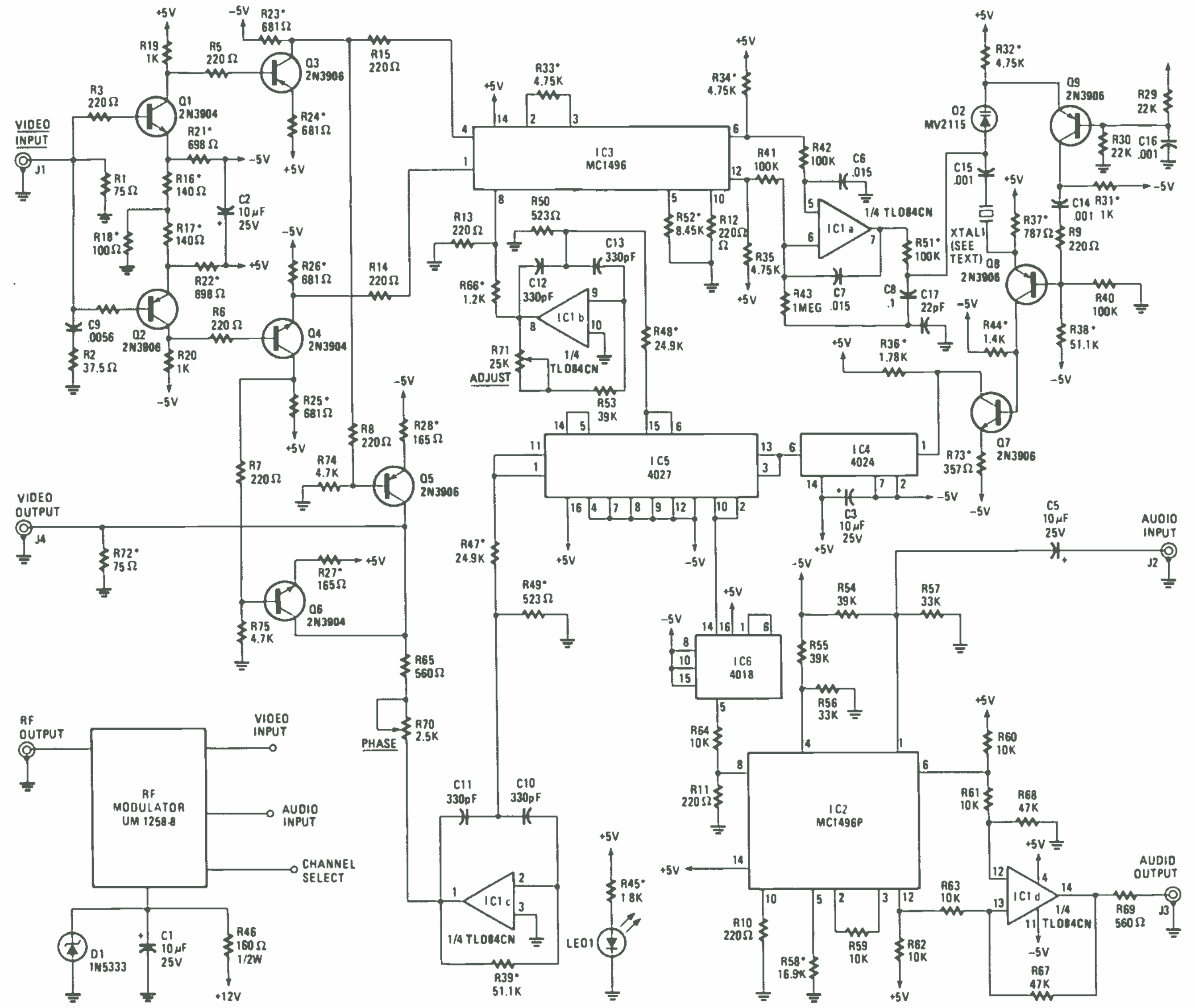


FIG. 2—THE DESCRAMBLER CIRCUIT uses just a handful of IC's and transistors to restore a Telease-encoded signal to normal.

CHANNEL SELECT lead. For a Channel 3 output, that lead should be grounded; otherwise, clip the lead. Finally, be sure to solder all four of the modulator's mounting lugs to the ground plane.

Note that many of the resistors are 1% precision types. Do not substitute 5% units for them.

Checkout

Before you test or use the unit, read the following notice:

It may be unlawful to operate a descrambler to decode certain satellite transmissions without authorization. It is up to the user to determine what the requirements are for legal use of the decoder and to meet them.

Once you have obtained the needed authorizations, if any, you may proceed with the testing.

Plug in the power pack and switch S1 to the on position. LED1 should light up. Check the power-supply voltages at the following locations: B, +5; Y, −5; R, +12, and cathode side of D3 (if RF modulator is used), +6. All voltages should be within 5% of the given values. Assuming that all voltages are correct, plug an appropriate crystal into the socket and monitor the unit for signs of overheating. If none of the transistors or IC's become hot, you can proceed.

Actually, we've gotten a little ahead of ourselves. Let's backtrack and say a few words about selecting and obtaining the crystal.

Table 1 lists the required crystal frequencies to decode some of the satellite services that use the Telease system. Note that the crystal's resonant frequency must be within 150 Hz of the listed center frequency for acceptable picture locking.

Crystals can be obtained from several sources. Among those are JAN Crystals (2400 Crystal, Fort Myers, FL 06017) and B&D Crystal Company (1727 West Galbraith Rd., Cincinnati, OH 45239). Further, crystals are available from a source mentioned in the Parts List. However, due to Federal law, it is illegal to supply a descrambler in assembled or kit form with a crystal. Thus, the kit supplier will not honor orders for crystals.

Once you have selected and obtained the proper crystal, and obtained any required authorization, it is time to do the final checkout.

Connect the baseband-video and the audio outputs of your satellite receiver to the appropriate inputs on the descrambler. If using the RF modulator, connect the modulator's output to the VHF terminals on your TV set. Be sure to use only the highest grade shielded cable and to terminate that cable with a 75-ohm-to-300-ohm matching transformer. If using direct video outputs, connect the video and audio outputs of the descrambler to the ap-

PARTS LIST

All resistors ¼ watt, 5% unless otherwise noted
R1—75 ohms
R2—37.5 ohms
R3–R15—220 ohms
R16, R17—140 ohms, 1%
R18—100 ohms, 1%
R19, R20—1000 ohms
R21, R22—698 ohms, 1%
R23–26—681 ohms, 1%
R27, R28—165 ohms, 1%
R29, R30—22,000 ohms
R31—1000 ohms 1%
R32–R35—4750 ohms, 1%
R36—1780 ohms, 1%
R37—787 ohms, 1%
R38, R39—51,100 ohms, 1%
R40–R42—100,000 ohms
R43—1 megohm
R44—1400 ohms, 1%
R45—1800 ohms, 1%
R46—160 ohms, ½ watt
R47, R48—24,900 ohms, 1%
R49, R50—523 ohms, 1%
R51—100,000 ohms, 1%
R52—8450 ohms, 1%
R53–R55—39,000 ohms
R56, R57—33,000 ohms
R58—16,900 ohms, 1%
R59–R64—10,000 ohms
R65, R69—560 ohms
R66—1200 ohms, 1%
R67, R68—47,000 ohms
R70—2500 ohms, potentiometer, PC mount
R71—25,000 ohms, potentiometer, PC mount
R72—75 ohms, 1%
R73—357 ohms, 1%
R74, R75—4700 ohms

Capacitors
C1–C5—10 µF, 25 volts
C6, C7—.015 µF
C8—0.1 µF
C9—.0056 µF
C10–C13—330 pF
C14–C16—.001 µF
C17—22pF

Semiconductors
IC1—TL084CN quad BiFET op-amp (Texas Instruments)
IC2, IC3—MC1496P balanced modulator (Motorola)
IC4—4024B CMOS 7-stage binary ripple counter
IC5—4027B CMOS dual J-K flip-flop
IC6—4018B CMOS divide-by-2-through-10 counter
Q1, Q4, Q6, Q7—2N3904 NPN transistor
Q2, Q3, Q5, Q8, Q9—2N3906 PNP transistor
D1—1N5333 6-volt Zener diode
D2—MV2115 Varactor diode
LED1—green LED

Other components
S1—SPDT toggle switch
J1, J2—phono jacks, PC mount

Miscellaneous: PC board, regulated power supply (+5 volts, 0.9 amps, −5 volts, 0.1 amps, +12 volts, 0.3 amps), RF modulator (optional, Astec UM-1285-8 or equivalent), crystal socket (see text), additional phono jacks (optional, for direct video/audio version), cabinet, wire, solder, hardware, etc.

Note: The following are available from Pilgrim Video Products, 33 Grasshopper La, Marshfeld MA 02050: Complete kit including PC board, RF modulator, case, power supply, and all parts except the crystal, $109.95; basic kit, including PC board, power supply, and all components except the crystal, but minus the modulator and case, $69.95; PC board alone, $24.95; Assembled and tested unit, minus the crystal, $189.95. Other components and kit configurations are available; contact the supplier for more information. Please add $2.50 for postage and handling. All MA residents must add 5% for sales tax.

Crystals are available from Blackbeard, P.O. Box 737, Prudential Center Station, Boston, MA 02199 for $22.00 each. Be sure to specify frequencies desired. All MA residents must add 5% for sales tax.

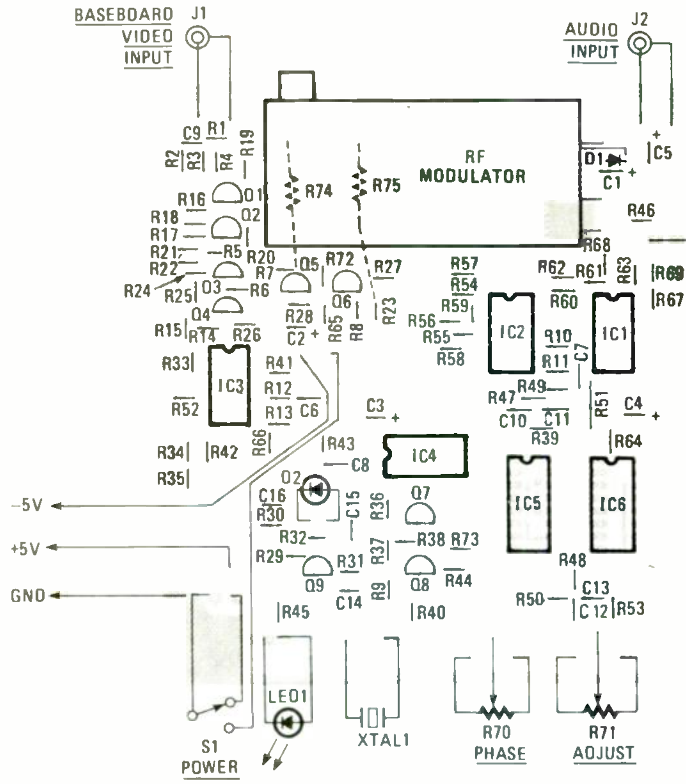
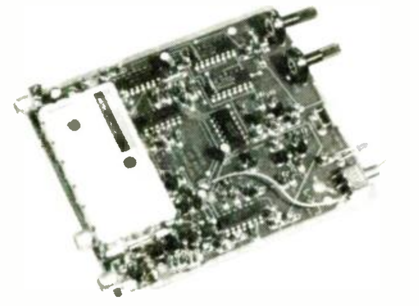


FIG. 3—FOLLOW THIS PARTS-PLACEMENT DIAGRAM when building the decoder. The patterns for the double-sided PC board are provided in PC Service.



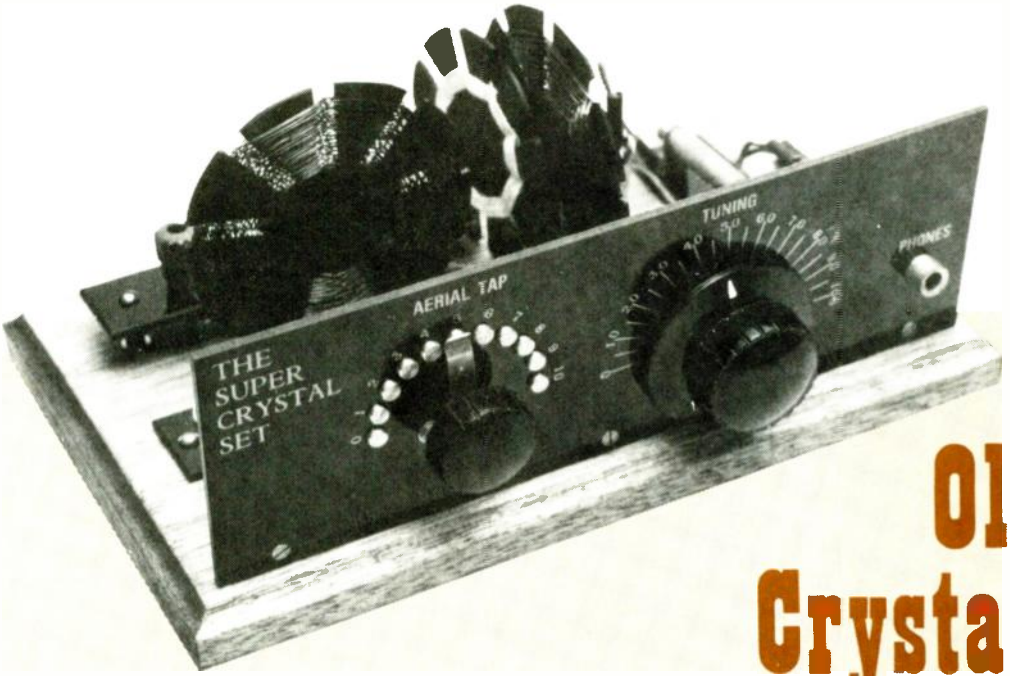
THE COMPLETED DESCRAMBLER board is shown here.

TABLE 1—CRYSTAL FREQUENCIES

Service	Frequency (MHz)
Italian Soccer	6.052167
Portuguese Soccer	6.056800
Fantasy Channel	6.020412
American Triple Ecstasy	6.028440
Wrestle/Mania	6.025140

propriate inputs on your TV-set, monitor, or VCR.

Turn the unit on, using S1. You should now be receiving clear audio. Adjust potentiometers R70 and R71 until the picture locks in. That's all there is to it. If you run into trouble, go back over your work looking for things like cold solder joints, solder bridges, or out-of-place components. If you've satisfied yourself that all is as it should be, your crystal may be off frequency. Remember, one that is off by as little as 150 Hz will cause the unit to fail to function. Obtain a different one and try again. **R-E**



Old-Time Crystal Radio

Here's how to build a vintage-style crystal radio receiver with performance that might surprise you.

PAT O'BRIAN

EVERY ELECTRONICS HOBBYIST HAS BUILT a crystal set. What? *You* haven't? Then this vintage-style crystal radio is the one to build! It's a high-performance receiver that tries its best to remain true to its era.

Crystal radios capture the imagination because they need no power source and they bring back the days when radio was "magic." There is, of course, nothing magic about a crystal set that works well. But careful design can make a receiver something special. This design uses the signals captured by the antenna very efficiently. Of course, the attractive polished wood base helps make the receiver special, too—even to those who aren't usually fascinated by the "magic" of crystal radios.

A high-performance circuit

The schematic of the receiver is shown in Fig. 1. One of the features of the design is that the antenna-tuning circuit is separate from the main frequency-selection circuit. The antenna-tuning circuit is made up of an 80-turn, 10-tap coil (L1), a coupling coil (L2), and an optional fixed capacitor (C1). It acts as a pre-selector for the main tuning circuit. In other words, it maximizes the strength of the signals received by the antenna at a particular frequency or frequency band.

The inductance of L1 is varied by selecting one of the coil's taps. The energy from the antenna-tuning circuit is inductively coupled to the main tuning circuit via L2 and L3. The degree of coupling is variable. As shown in the photo in Fig. 2, L2 can pivot about its mounting point. The variable coupling results in a more selective receiver.

The main tuning circuit is made up of L3 and C2. RF energy from that tank circuit is tapped off by S2 and detected by D1. Switch S2 isn't a conventional switch. Instead, it is an alligator clip that is moved from tap to tap. The detected audio signals are fed to jack J1, and then to a pair of high-impedance (4000 ohm) headphones. Capacitor C3 acts to bypass RF past the headphones, which must be a high-impedance type.

Building the receiver

How you build your receiver is, of course, a personal choice. But we'll show you what we think is the right way to do it. If you lack the skills or the materials that are needed to put together an authentic-looking crystal radio, then you might be better off buying the kit that's available from the source mentioned in the Parts

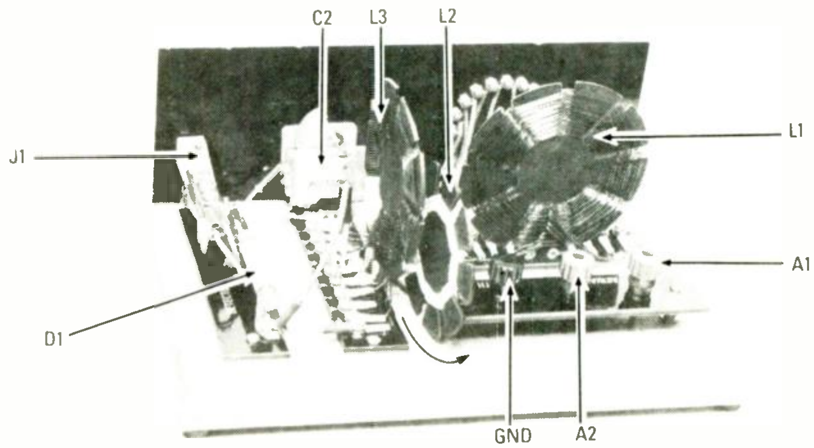


FIG. 1—THE CRYSTAL RADIO SCHEMATIC. The coils are hand-wound. Their starting points are indicated by bold dots. Note that switch S2 is not a standard switch—it is an alligator clip at the end of a "flying lead."

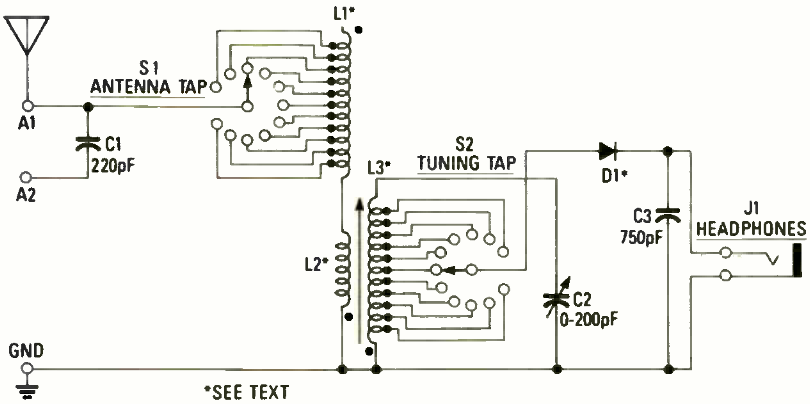


FIG 2—REAR VIEW of the crystal set shows how the components are mounted on bakelite panels, which are in turn mounted to the hardwood base. Note that the coupling coil, L2, pivots around its mounting point so that its degree of coupling to L3 can be adjusted. Also note the case in which D1, the crystal detector, is mounted.

PARTS LIST

D1—1N34A germanium. See text
C1—220 pF, mica
C2—0–200 pF, variable
C3—750 pF, mica
L1, L3—80 turns of 26-gauge wire on spider-web form. See text.
L2—16 turns of 26-gauge wire on spider-web form. See text.
J1—phone jack, ¼ inch
Miscellaneous: Hardwood base, coil forms, 26-gauge wire, binding posts, rubber mounting feet, high-impedance headphones, etc.

NOTE: A complete kit for the crystal receiver (order No. K-9002) is available from Dick Smith Electronics, Inc., P.O. Box 8021 , Redwood City, CA 94063, 800-332-5373 (orders) 415-368-8844 (inquiries) for $79.95 plus $5.50 handling. High-impedance vintage (1940) headphones (order No. C-4001) are available for $19.95 plus $2.50 shipping. California residents must add 6.5% sales tax.

List. (The receiver shown in the photos was built from a kit.) If you choose to put yours together from scratch, don't hesitate to change our layout to suit the components you find. Just try to keep the flavor of the past by following our prototype and by using using things like brass screws, DCC (*D*ouble *C*otton *C*oated) wire, bakelite mounting panels, etc.

Before we can build the receiver, we have to get all the components together. It will take some scrounging but it can be done. The best place to start is with the components you'll have to make yourself: the three "spider-web" coils.

Winding the spiderweb coils is perhaps the most difficult part of building the receiver. It's actually not that difficult if you follow our directions carefully. Two of the coils, L1 and L3, are wound identically. They consist of 80 turns of 26-gauge enamel-coated wire wound on a 9-spoke spiderweb coil form with a diameter of 4¼ inches.

The coil is wound as ten separate 8-turn coils. After they are wound, they are connected together—the connections become the taps. Figure 3 shows what your coil form should look like, and indicates some of the winding specifics.

The coils are wound from the "front" of the coil forms, which is the side where the "L" mounting brackets are attached. Start at the inside of the coil and work outward. To start each 8-turn coil, feed about 10 inches of wire through the appropriate hole from the front of the form, taking it around the right side of the mounting spoke (which we'll call the anchor spoke), and feeding it again through the same hole and pulling it tight. That anchors the start of each coil in place. Now wind the wire around the coil form, under the first spoke, over the second, under the third, and so on.

The "finish" end of the coil is pushed through the next hole toward the outside of the form, and it is anchored to the spoke by bringing the wire around the the *left* side of the mounting spoke and through the hole and pulling it tight.

The start of the next coil is anchored at the hole where the preceding coil ended. Be sure to wind the coils tightly so that a total of 80 turns will fit on the coil form, and so that you don't cover holes on the anchor spoke.

When all ten 8-turn coils are wound correctly on the coil form, you should be left with 9 pairs of wire, and two single wires (the start and end). Twist each pair together tightly, and cut to an appropriate length. Solder the 9 pairs together, and tin the start and finish leads. You'll have to apply a good amount of heat from the soldering iron because you need to melt the enamel coating. If you do it right, you won't have to scrape the leads bare. You can check your work by measuring con-

continued on page 101

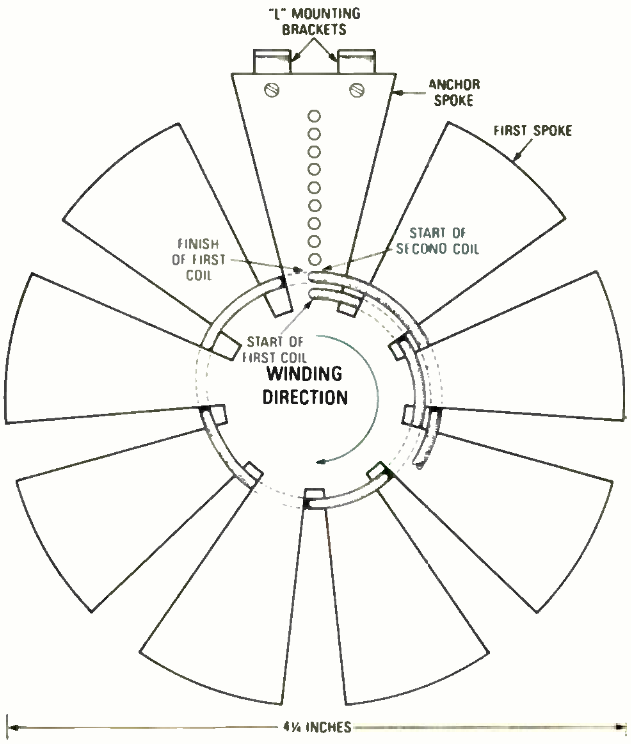


FIG. 3—THE SPIDER-WEB COILS must be hand wound. Here, shown half size, is the coil form for L1 and L3. Each coil consists of 80 turns of 26-gauge enamel-coated wire, tapped every 8 turns. However, as explained in the text, they are wound as ten separate 8-turn coils. Coil L2 is wound as 16 turns of 26-gauge cotton-coated wire on a 3¾-inch form. Use stiff, black cardboard to make the forms.

DEFINED BY WEBSTER AS AN INSTRUMENT FOR CONVERTING sound into electrical impulses for transmission by wire, the telephone has become much more than that in the over 100 years since its invention. The modern telephone is among the more sophisticated appliances in your home or office. Despite that, it is often taken for granted, even by those that are technically inclined. Let's correct that by taking a look inside that electronic marvel.

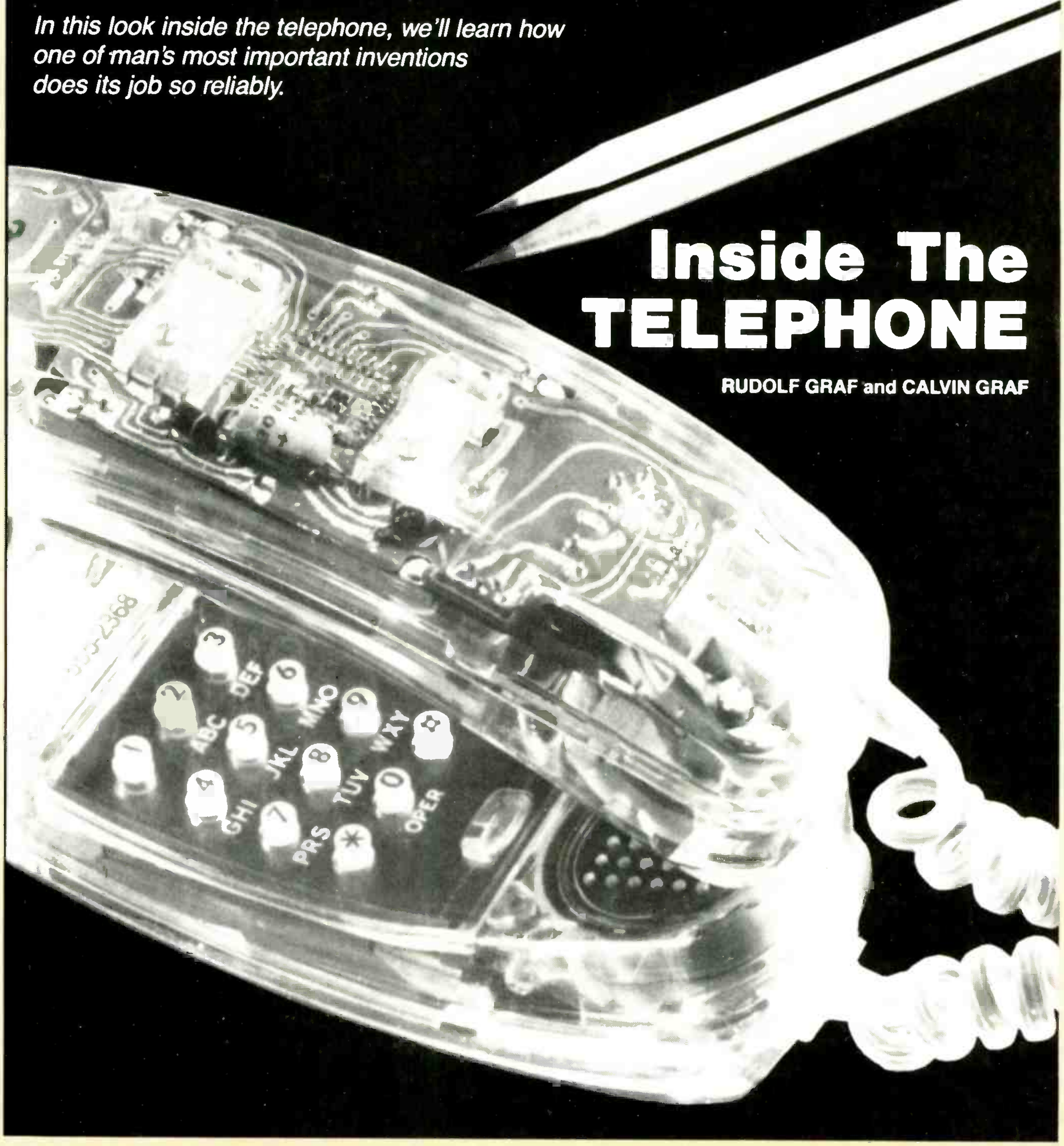
Inside the telephone

In any communications system, the basic goal is to transmit intelligence from one point to another with a minimum of distortion. To transmit intelligence using the telephone system we must convert sound into an electrical signal, send the electrical signals over the wires to a distant point, and then convert the electrical signals back into sound energy.

It is important that all of that occur with a minimum of distortion. In face-to-face communications much information is exchanged by facial expression, gestures, etc. With a telephone, all of that information must be exchanged by sound only. Feelings, emphasis, and the like are therefore conveyed by voice tones and, as a result, the recreated voice at the receiving side of the link must be as accurate as possible.

Because of that, the key link in the telephone system is the

In this look inside the telephone, we'll learn how one of man's most important inventions does its job so reliably.



Inside The TELEPHONE

RUDOLF GRAF and CALVIN GRAF

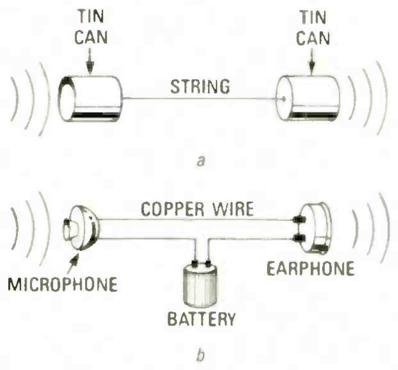


FIG. 1—TWO COMMUNICATIONS SYSTEMS. A mechanical system that is often experimented with by children is shown in *a*. The electrical system shown in *b* is the basis of our modern telephone system.

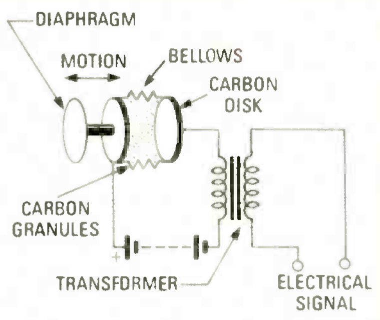


FIG. 2—IN A CARBON MICROPHONE, the vibration of a disc causes the compression of carbon granules inside a bellows to vary. That in turn varies the load across a battery.

transducer, a device for converting one type of signal into another type. The telephone "system" shown in Fig. 1-*a* uses a transducer that converts sound into mechanical energy. When you speak into one of the cans, sound waves cause the end of the can to vibrate. The vibrations from the can are carried to the receiver can a tightly stretched string. The end of the receiving can follows the in-and-out motions of the transmitting can and causes the air around it to vibrate to reproduce, albeit poorly, the transmitted sound.

A far superior system is shown in Fig. 1-*b*. There we see a circuit consisting of a microphone, earphone, battery, and wires. The microphone is a transducer that converts sound energy to electrical energy. The earphone is its compliment: it converts electrical energy into sound energy. Power for the system is supplied by the battery. If two such circuits were combined, a simple telephone system would be formed.

Let's take a closer look at the transducers. In Fig. 2 we see a diagram of a simple carbon microphone. Such microphones have been used in telephones almost since the beginning.

The microphone contains a flat, round, metal diaphragm. When sound strikes that diaphragm it vibrates. The diaphragm is connected by a rod to a bellows that is filled with carbon granules. The vibration of the diaphragm causes the bellows to expand and contract, varying the compression of the carbon granules. That varying compression presents a varying load to the battery, causing a time-varying current to be created. That current is passed through a coupling transformer and sent down the telephone line to the earphone.

The earphone converts the varying current back into sound. A diagram of an earphone is shown in Fig. 3. The current passes through the coupling transformer and then through a coil that is wound on a permanent magnet. That generates a time-varying magnetic field. That field causes a rigid metal diaphragm to vibrate, re-

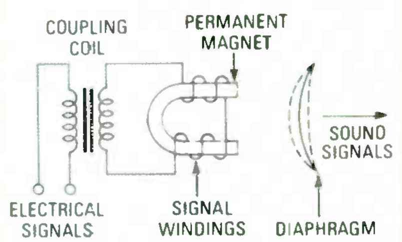


FIG. 3—IN A TELEPHONE EARPHONE, current passing through coils wound on a permanent magnet causes variations in the field of that magnet. That causes a metal diaphragm to vibrate, which generates sound.

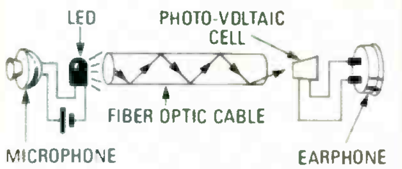


FIG. 4—COMMUNICATING WITH LIGHT. A basic fiber-optic communications system is shown here.

producing the original sound.

The principles behind the communications loop we have described have remained essentially unchanged since the invention of the telephone. However, technology does evolve. Currently, the telephone system is in the midst of one of its most significant changes. It is changing from a system based on wires and electric current to one that is based on optical fibers and light.

Figure 4 shows how a light-based communications loop works. At the transmitter end, a microphone is used to modulate the output of an LED. The light from the LED is conducted to the receiver by an optical fiber. At the receiver, the varying light levels are translated to a varying current by a photocell and fed to an earphone. The earphone turns the current into sound as previously described.

A modern telephone

As we've seen, the telephone started out as a relatively simple instrument. But it evolved quickly into a complex piece of electronic equipment as shown in Fig. 5. In addition to performing its basic task of communications, a telephone is required to perform a number of functions that help the telephone switching system make the proper connections. It also performs some basic signal-processing functions. For instance, it automatically compensates for variations in speech amplitude.

The simple telephone system that we've described thus far is of limited usefulness. That's because it can only be used to communicate between two established points. If an individual wanted to communicate with a number of people, he would need a separate telephone "system" for each of those. To overcome that limitation, we need a way to connect one telephone to a number of other telephones. That capability is provided by a system of local, exchange-area, and long-distance switching networks.

On the local level, switching functions are handled by a *central office*. That facility contains the switching and signaling equipment for a local area or *exchange*, as well as the batteries for the local system.

Each *subscriber telephone*, or individual telephone number (extension telephones are merely extensions of the subscriber telephone) is connected to the central office via a *local loop*. The loop consists of a color-coded wire pair. The positive wire is always green, while the negative wire is always red. Those wires are also designated as *ring* (negative) and *tip* (positive). That corresponds to the tip and ring connections of the plugs used in manual switchboards.

The central office and all of the local loops that it serves make up the *local exchange* or *local network*. A block diagram of a typical local exchange is shown in Fig. 6. The geographical area served by a local exchange can vary greatly. In urban areas, it might cover less than 12 square miles, while in rural areas a local exchange might serve a region as large as 130 square miles.

Central offices in a region are linked together into what is known as an *exchange-area* network. An exchange-area network might cover several cities and towns over a wide geographical area or just a single city or part of a city. Its coverage area is of course determined by the number of subscribers it must serve. Figure 7 shows a simplified diagram of an exchange-area network.

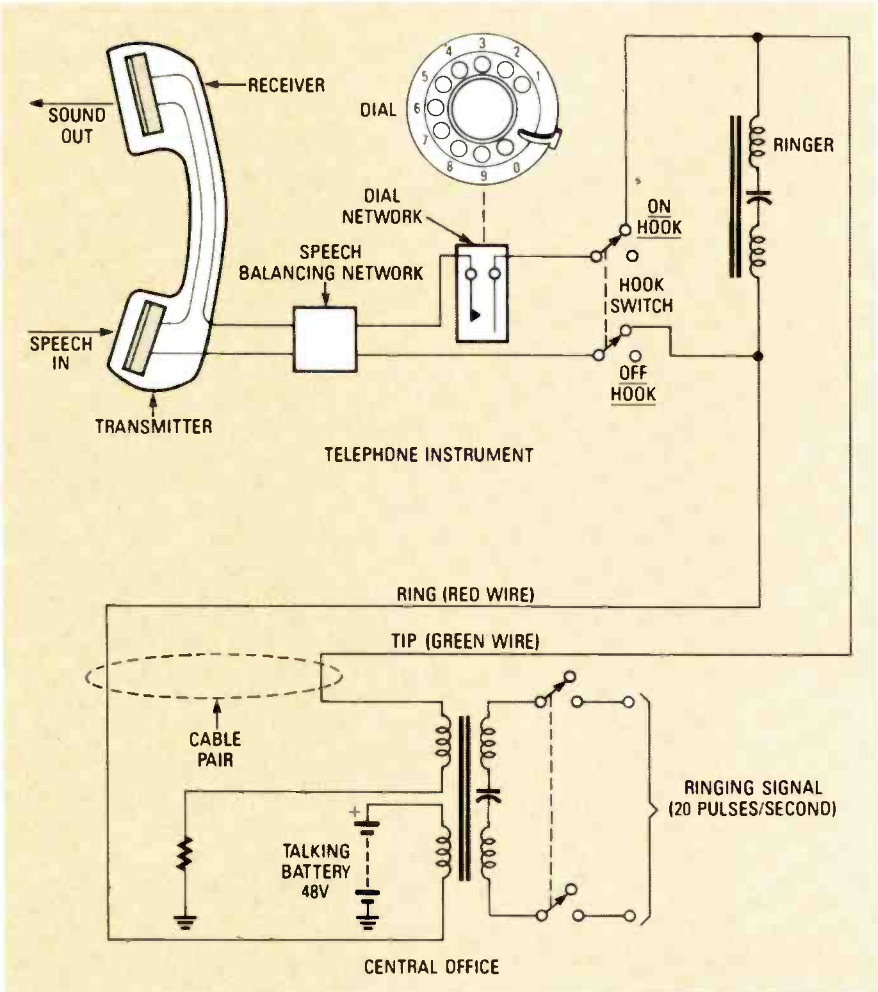


FIG. 5—A TELEPHONE is connected via the local loop to a central office. The central office supplies power for the phone and handles switching functions.

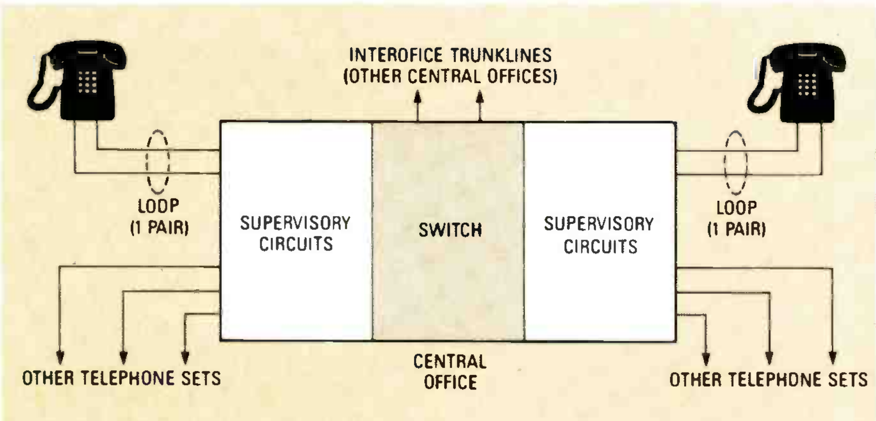


FIG. 6—CENTRAL OFFICE block diagram. Such an office is responsible for thousands of telephone subscribers.

Calls to points outside of your exchange area require use of the long-distance or *long-haul* network. In that network, exchange-area networks are interconnected. Figure 8 shows a portion of the long-haul network. That portion covers the busy West Coast of the United States.

Because of the high amount of volume it must carry, the links in that network have become highly sophisticated. Overhead cable has largely been abandoned in favor of microwave, satellite, and fiber-optic technologies.

Making connections

As we previously stated, a telephone would be of limited use if it could not be used to communicate with a number of different parties. In the early days, all switching was done manually. That is, a user would signal the operator, perhaps by turning a crank, that he wished to place a call. The operator would come on the line and request the identity of the party that the caller wished to reach. The operator would then complete the call by physically connecting the local loops of calling and desired with a patch cord.

While manual switching adds a pleasant touch to the process of making a telephone call, it is not terribly efficient. That led to the development of the rotary-dial telephone and its associated automatic switching system by Almon B. Strowger in 1892. That type of equipment is still in widespread use, so let's spend a few moments and examine its characteristics.

The signaling mechanism in a rotary-dial phone is spring loaded and designed to produce pulses at a rate of 10-per-second. Therefore, it takes 1 second to output a 0 (10 pulses) and 1/10 second to output a 1. A governor in the dial mechanism prevents any changes in that rate, no matter how the dial is manipulated. The reason that the constant rate must be maintained is that the line switches at the central office are designed to act only at that rate. Any disparity will result in inaccurate switching.

Since the dialing pulses are all of the same duration, and the spacing between pulses is identical for all digits, some small time interval is required between digits. That interval is called the *interdigit time*.

The *switching time* or pulse duty cycle is also constant. It is specified as 39%; that is, the pulse waveform is high 39% of the time for each digit. That low duty cycle is used to conserve battery power.

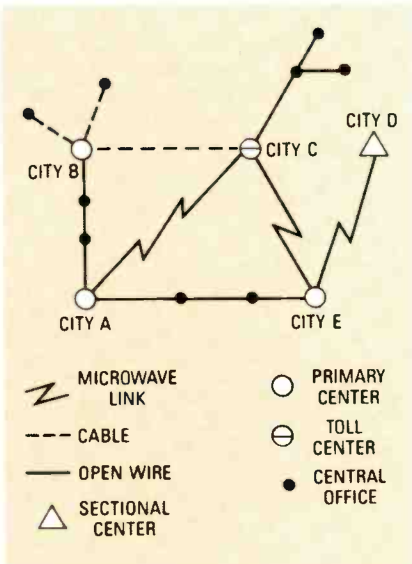


FIG. 7—A SIMPLIFIED EXCHANGE AREA network. Links between the various central offices and centers are handled by buried cable, overhead wire, and occasionally by microwave.

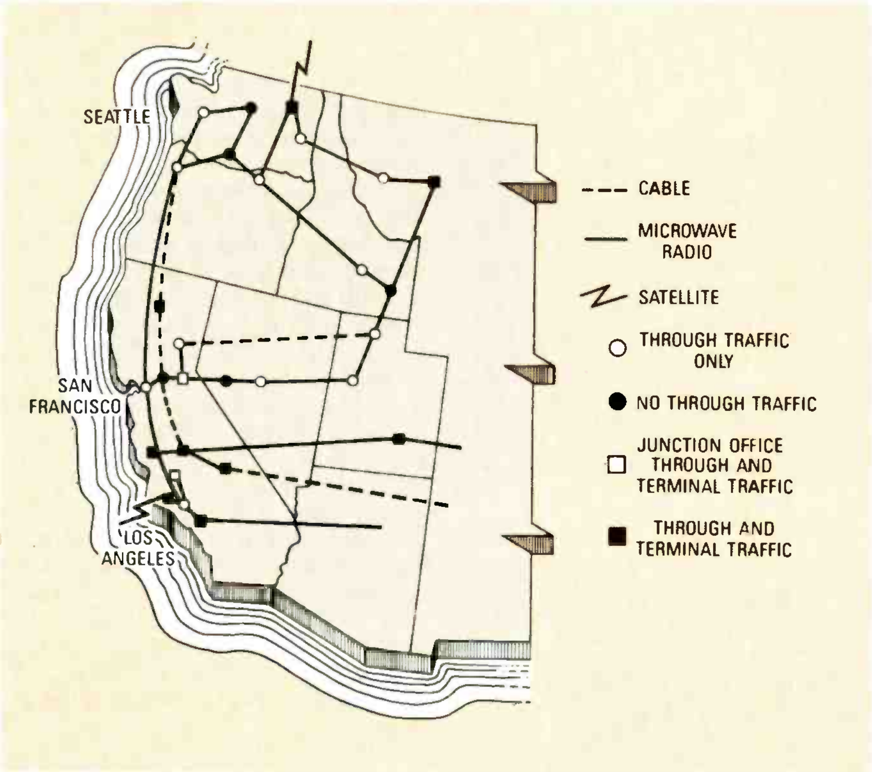


FIG. 8—THE LONG-HAUL NETWORK handles telephone calls to points beyond an exchange area. Here, a simplified diagram of the west-coast portion of that network is shown.

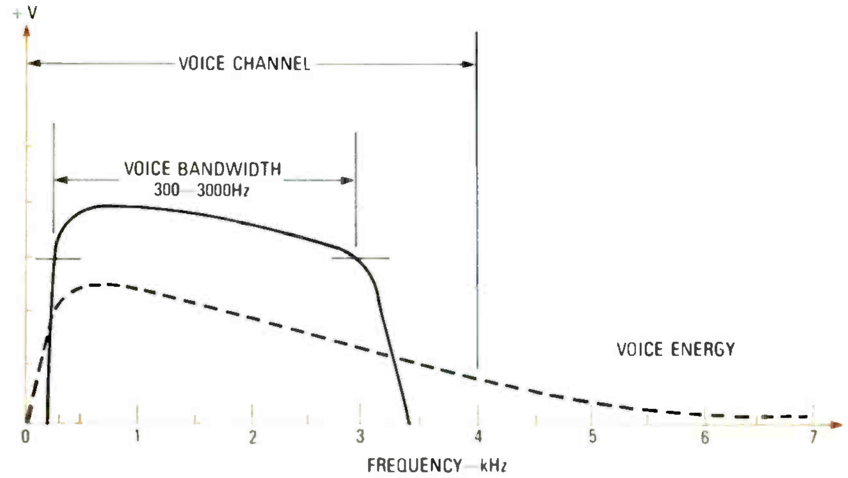


FIG. 9—ELECTRONIC TELEPHONE block diagram. Such a phone uses tone dialing. All circuitry is contained on just a few IC's.

The first tone-dialed telephones appeared in 1964. Those units were extremely sophisticated for their time but still relied on electromechanical bells, a carbon microphone, and a pushbutton pad that consisted of 120 separate components. In modern versions of that device, the circuitry is contained in IC's, the bells have given way to piezoelectric ringers, and the carbon mike has been replaced by a dynamic unit. A block diagram of a tone-dial phone is shown in Fig. 9.

While tone dialing is a relatively recent development, tones have been used for various system-signaling functions for a very long time. Among the tones that should be familiar to you are the dial tone, ringback tones (normal and busy), receiver off-hook tone, and circuits-busy or congestion tone. Most of the signals are actually made up of tone pairs, though some use a single tone while others use multiple tones. A summary of the most common tones, their frequencies, and their duty cycles (on time vs. off time) is provided in Table 1.

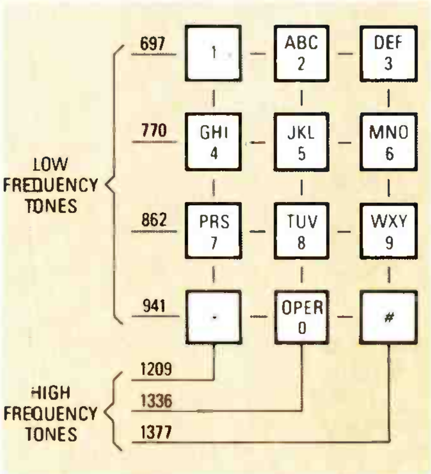


FIG. 10—IN TONE DIALING, each digit is represented by a frequency pair as shown here.

In tone or *Dual Tone MultiFrequency* (DTMF) dialing, each press of a key generates a duplex tone. (That type of dialing is also called *Touch-Tone*, which is a trademark of AT&T.) Figure 10 shows the frequencies for each digit. Note that the frequencies can be classified as low or high. There are four frequencies in the low range (697-, 770-, 862-, and 941-Hz) and three frequencies in the high range (1209-, 1336-, and 1377-Hz). Also note that none of the frequencies are harmonically related. That ensures that a signal harmonic will not confuse the telephone company's switching equipment.

The presence of a keypad does not in itself indicate whether a telephone uses tone or pulse dialing. Many keypad-equipped telephones have pulse-dial capability that allows them to be used with any telephone system. Remember that not

TABLE 1—CALL PROGRESS TONES

Tone Type	Frequency (Hz)	On Time	Off Time
Dial	350 and 440	continuous	
Ringback, normal	440 and 480	2 sec	4 sec
Ringback, PBX	440 and 480	1	3
Busy	480 and 620	0.5	0.5
Congestion (toll)	480 and 620	0.2	0.3
Reorder (local)	480 and 620	0.3	0.2
Receiver off-hook	1400, 2060, 2450, 2600	0.1	0.1
No such number	200 to 400	continuous (Frequency modulated at 1 pulse per second rate.)	

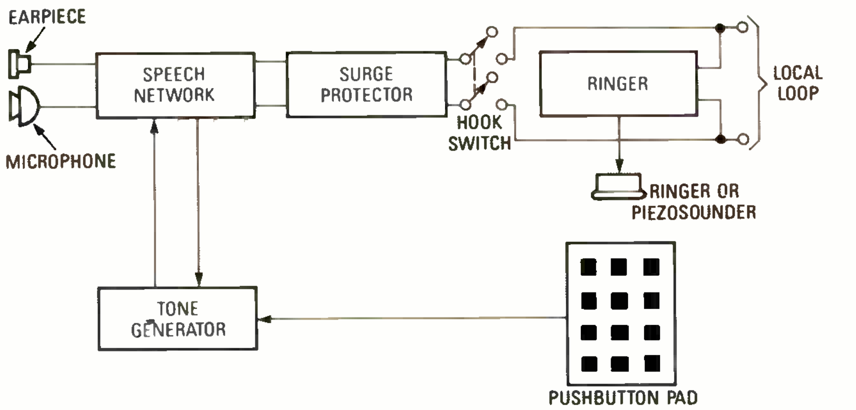


FIG. 11—ALTHOUGH THE HUMAN voice spans a wide frequency range, in the telephone system voice bandwidth is limited to just 300 Hz to 3 kHz.

TABLE 2—OPERATING PARAMETERS

Parameter	Typical U.S. values	Limits	Typical European values
Common battery voltage	−48-volts DC (on-hook)	−47 to −105 volts DC	Same
Common battery voltage	−6-volts DC (off-hook)		
Operating current	20 to 80 mA	20 to 120 mA	Same
Resistance of telephone set	300 ohms	100–400 ohms	
Subscriber loop resistance	0 to 1,300 ohms	0 to 3,600 ohms	
Loop loss	8 dB	17 dB	Same
Distortion	−50 dB total	not applicable	
Ringing signal	20 pps, 90-volts rms	16 to 60 pps 40 to 130 volts rms	15 to 50 pps 40 to 130 volts rms

every exchange can handle tone dialing, although the number with that limitation is shrinking rapidly.

Incidently, keypad pulse-dialed telephones require some type of memory device. That's because you generally can key in a number faster than the telephone can output its pulses. The pulse-duration requirements that we mentioned earlier hold whether the phone is equipped with a rotary dial or a keypad.

Odds and ends

Figure 11 shows the frequency response of the telephone system. While the human voice can generate sounds over the range of 100 Hz to 6 kHz and beyond, that entire range is not needed for communications. In the telephone system, a voice "channel" of 4 kHz is used. Within that channel, frequencies between 300 Hz and 3 kHz are passed. While the conversations such a system allows are not "Hi-Fi," they are certainly intelligible enough for satisfactory communications.

That voice channel and voice bandwidth are just two of the operating standards adopted many years ago. Others cover such things as handset dimensions, sound-pressure levels, and ringing voltage and frequency. Some of those parameters are summarized in Table 2.

One parameter not listed in that table is the *R*inger *E*quivalence *N*umber (REN). When your phone is on-hook, only the ringer bell is connected across the line. No current flows in your local loop because of a capacitor connected in series with the ringer circuit and no power is consumed from the central office battery. As we know, there are thousands of telephones to be rung from each central office, but since we are dealing with battery power, only a finite amount of power is available to ring all of those telephones. As a result, the telephone company only guarantees to supply enough power to each subscriber to sound five standard electromagnetic ringers. That amount of power is referred to as 5 REN.

The importance of that to a subscriber is that it limits the number of devices that can be connected to a line. For instance, if five standard telephones are connected to a line, each must have an REN no greater than one. Otherwise, there's no guarantee that any of the ringers will sound for an incoming call.

These days, the REN has taken on greater importance because a number of telephones and telephone accessories draw power for their features from the ringing voltage. Those include telephone-answering machines, extension bells, telephone-hold circuits, etc. On the other hand, many new telephones have electronic sounders that draw very little power. Some may be rated at as little as 0.1 REN. It's important to remember that you must notify your local phone company whenever you hook up a new device to your line and supply them with its REN.

All telephones that have been registered with the FCC by their manufacturer have an REN. It is usually stamped on the bottom of the unit along with the serial number and similar data. Sometimes, the REN may be followed by a letter (A, B, etc.). That letter refers to the ringing frequency. Table 3 lists the various ringing frequencies and their letter designations. The telephone company automatically provides a type A frequency to all single-party subscribers. As a result, most telephones are designed to respond to a type A frequency. If no letter is specified, it is safe to assume your telephone is one of those.

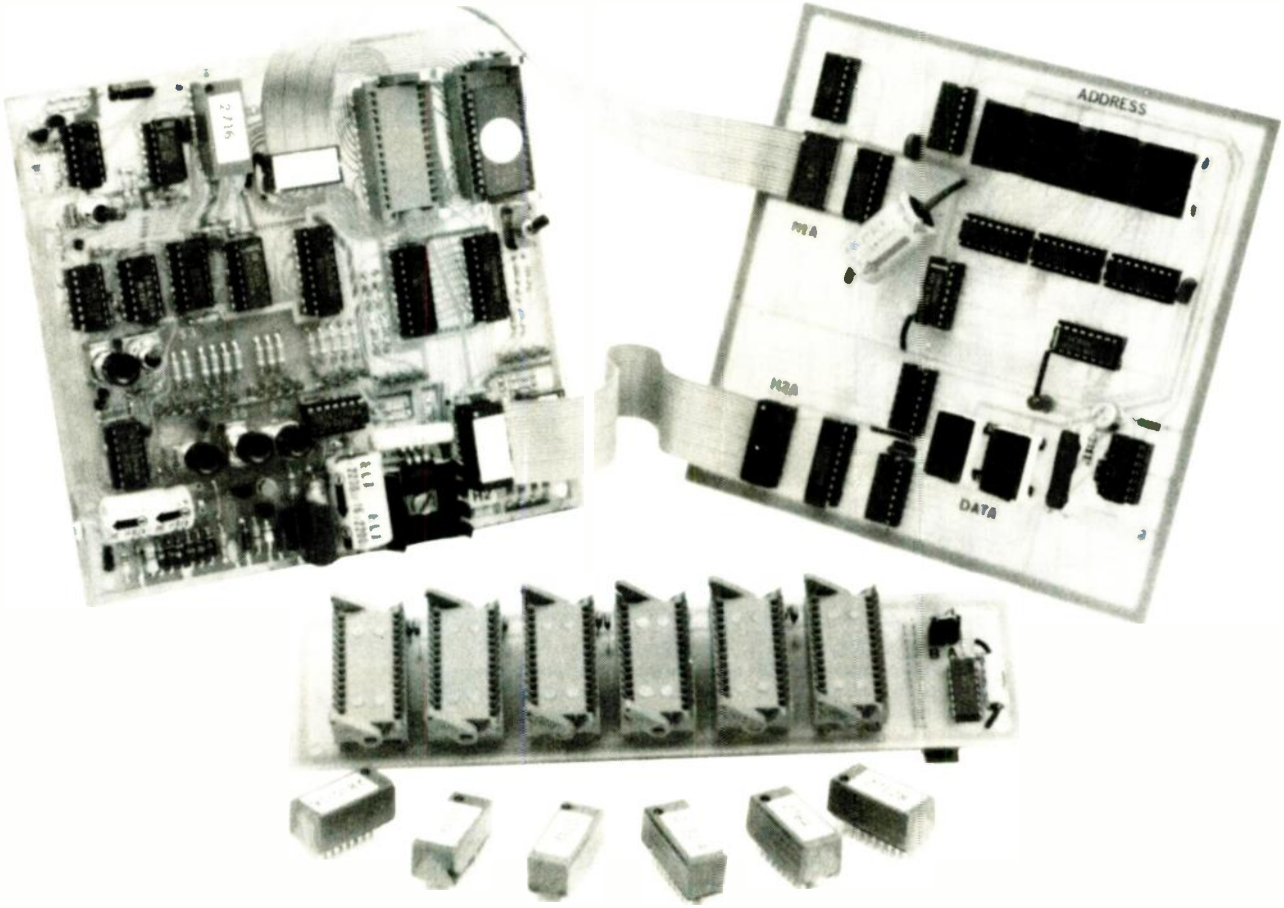
TABLE 3—RINGING FREQUENCIES

Ringing Type	Ringing Frequencies (Hz)
A	20 ±3 and 30±3
B	15.3 to 68.0
C	15.3 to 17.4
D	19.3 to 20.7*
E	24.3 to 25.7
F	29.3 to 30.7*
G	32.6 to 34.0
H	39.2 to 40.9
J	41.0 to 43.0
K	49.0 to 51.0
L	52.9 to 55.1
M	53.8 to 61.2
N	65.4 to 68.0
P	15.3 to 34.0

*Frequency-selective ringing (party line use)

Next time

In the past, customers were prohibited from tampering with their telephone equipment in any way. If you wanted a telephone installed or moved, telephone company personnel did the job, for a fee. That all has changed since the break-up of AT&T. Now, you pretty much can do what you want—as long as you know what you are doing! A service call to correct an error, or for any work for that matter, can be extremely expensive. Next time, we will provide you with a crash course in telephone installation that can help you save time, money, and aggravation. **R-E**



EPROM PROGRAMMER

Our low-cost EPROM programmer can burn all the popular types, including EEPROM's!

LUBOMIR B. SAWKIW

THE MICROPROCESSOR IS TURNING UP IN some very unlikely places these days. You might find one in a TV remote control, an automotive ignition and timing circuit, a video game, or even a microwave oven. But a microprocessor can't do the work all by itself: It requires permanent memory that stores the data and instructions that allows it to do its job. And that's where the EPROM comes in. It can provide a low-cost way of developing, testing, and even distributing data and programs for many types of computer systems.

EPROM's aren't used solely with computers, of course. Often a complex logic problem that would require numerous individual gates can be solved with a small EPROM.

So, sooner or later, whatever your involvement with digital electronics, you'll find it necessary to burn (program) an EPROM. And we've got an inexpensive way of doing so. Our EPROM programmer can be built for about $60 (less PC board) in its basic form, and it can burn all of the popular five-volt EPROM's in both 24- and 28-pin packages, as well as several popular types of EEPROM's. The unit allows you to burn single locations one by one, burn one value into a number of consecutive locations, or copy one entire EPROM to another. An optional multi-EPROM board allows you to program up to six EPROM's simultaneously.

Features

The programmer is a stand-alone unit; no computer or ASCII display terminal is required to operate it. But it has input/output lines (labeled A–G in Fig. 1) that you can use to automate control of all functions.

In the basic programmer, data input is provided by an eight-position DIP switch (S8), and addresses are selected by means of FAST (S5) and STEP (S6) switches. Address and data lines are displayed in binary by 22 discrete LED's (LED1–LED22). An optional display board allows you to view the address and data lines in hexadecimal.

The programmer has a verification feature that allows you to view the contents of each EPROM location after that location has been programmed.

Personality modules are used to accommodate a variety of EPROM's. The personality module matches the operating requirements and pin assignments of each EPROM to the address, data, programming and timing signals developed on the programmer board. By using the appropriate personality module, you can program the 2716, 2732, 2732A, 2764,

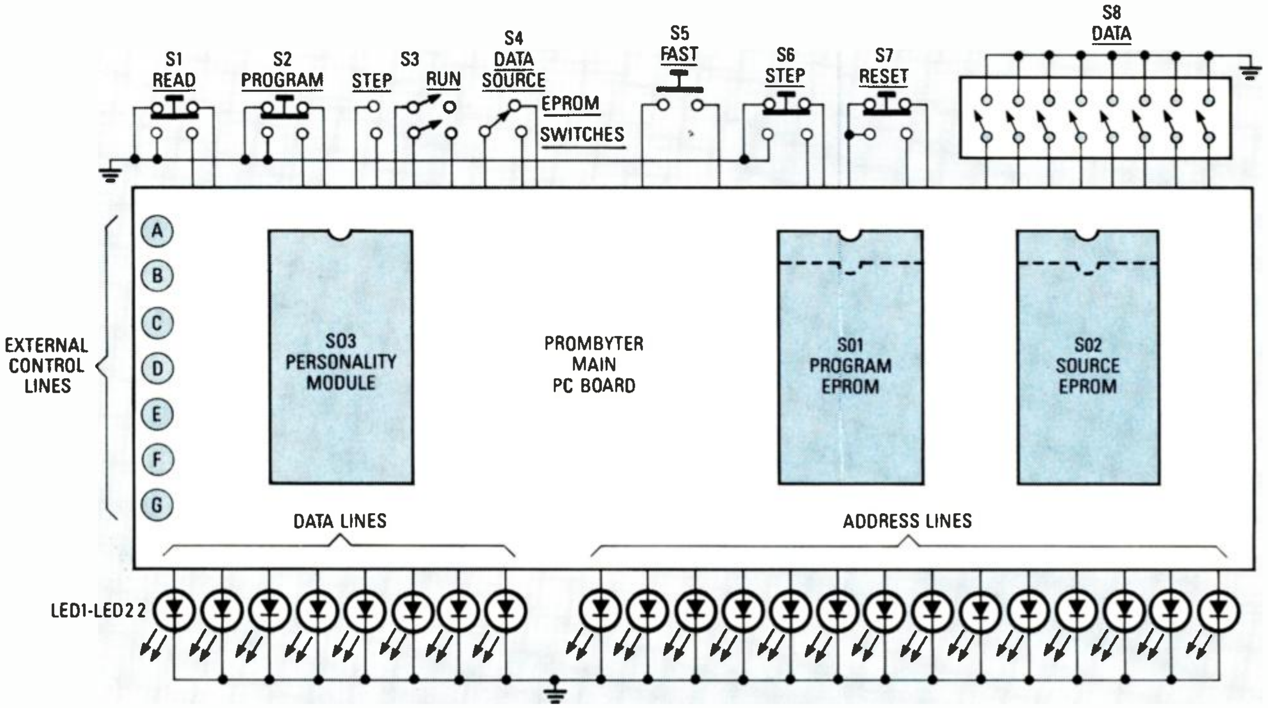


FIG. 1—THE EPROM PROGRAMMER can copy an entire EPROM or single locations; single locations can also be programmed manually. Separate sockets are provided for source and program EPROM's, and for plug-in personality modules that feed each type of EPROM the proper signals.

27128, 2758, 2516, and 2532 EPROM's; the CMOS versions of those devices; and the 2815/2816 EEPROM's.

Manual operation is simple. You set the DIP switches to the desired data, then set the FAST and STEP switches to the desired address, and last press the PROGRAM switch (S2). When that location has been programmed, the programmer automatically moves to the next location.

Circuit description

Except for the AC transformer, the entire power supply is contained on the main PC board. As you can see in Fig. 2, the regulated five-volt supply is derived from an eight-volt AC input. That AC is rectified by bridge BR1, filtered by capacitor C7, and then regulated by IC14, a 7805 regulator. Output capacitor C6 and bypass capacitors C10 through C17 further filter the +5-volt line. Optional resistor R57 provides extra power for the optional display board.

The 25-volt AC input is rectified and filtered for two purposes: to provide the +35-volt programming voltage (V_{PP}), and to provide the 120-Hz clock signal that is the core of the circuit's timing chain. Diodes D4 and D9 isolate the clock circuit from the V_{PP} output. Zener diode D10 clips the positive half-cycles of the unfiltered output at about 9 volts. Then IC7-b and IC7-c square up those pulses.

The programming voltage, V_{PP}, is what "burns" each bit into an erased EPROM. Digital control of V_{PP} is provided by IC7-f and IC7-a. When a high level signal is fed through the personality module (SO3) to pin 13 of IC7-f, the output of IC7-a goes high, Q1 turns on, Q2 turns off, and that allows D2 to bring the base of Q3 up to +25 volts.

At that point Q4 turns on and allows approximately +25 volts to appear at its emitter. That voltage is fed back to pin 8 of SO3. Capacitors C2 and C3 prevent a transient overshoot of the +25-volt line during switching. An overshoot of more than one volt could ruin the EPROM you are programming. Components in some personality modules reduce the +25- to +21-volts, for EPROM's that need +21 volts.

Transistor Q5 is used to prevent V_{PP} pulses from damaging an EPROM when power is removed from or applied to the circuit. As stated previously, Q2 normally conducts and shorts out Zener diode D2. However, Q2 is biased from the +5-volt supply line. If for any reason during power up the +35-volt line receives power an instant before the +5-volt line, Q3's base would shoot up to about +26-volts, and a +25-volt program pulse would appear on the V_{PP} line.

To prevent that surge, Q5's emitter is connected to the +5-volt supply, and its base is biased at +4.7 volts from the voltage at Q3's base by means of Zener diode D3. So, if the base of Q3 were trying to go up to +26-volts, and the +5-volt supply were not quite up yet, Q5 would be forward biased, so it would conduct through R52, and thereby reduce the voltage at the base of Q3.

Address circuit

Overall operation of the circuit is governed by the FUNCTION switch, S3. When that switch is in the RUN position, the 120-Hz clock signal causes operations to occur sequentially every 1/120th of a second. When S3 is in the STEP position, addresses must be set manually, and PROGRAM switch S2 must be pressed for each location that is to be programmed by the EPROM programmer.

Addresses are selected by pressing switches S5 and S6. When switch S6 is pressed, it is debounced by IC5-a, which delivers one pulse through IC6-b and IC6-d to IC8, a 4040 12-stage binary counter. That pulse increments the address held in IC8 by one. On the other hand, when switch S5 is pressed, it connects the 120-Hz clock signal to IC6-b and IC6-d, and then to IC8, which then increments at a rate of 120 Hz.

Since larger EPROM's have as many as 14 address lines, and the 4040 has only 12 outputs, IC3-b is also used as an address counter. When pin 1 of IC8 goes low, IC3-b increments. Its A, B, and C outputs provide the A12, A13, and A14 address lines. Two IC's buffer the current address for display on LED1-LED14: IC9 and IC10.

Reset

Switch S7 forces the system to reset. When that switch is pressed, a reset pulse is fed to all counters and flip-flops. Also, a reset pulse occurs at power up by means of C1's charging up through R8.

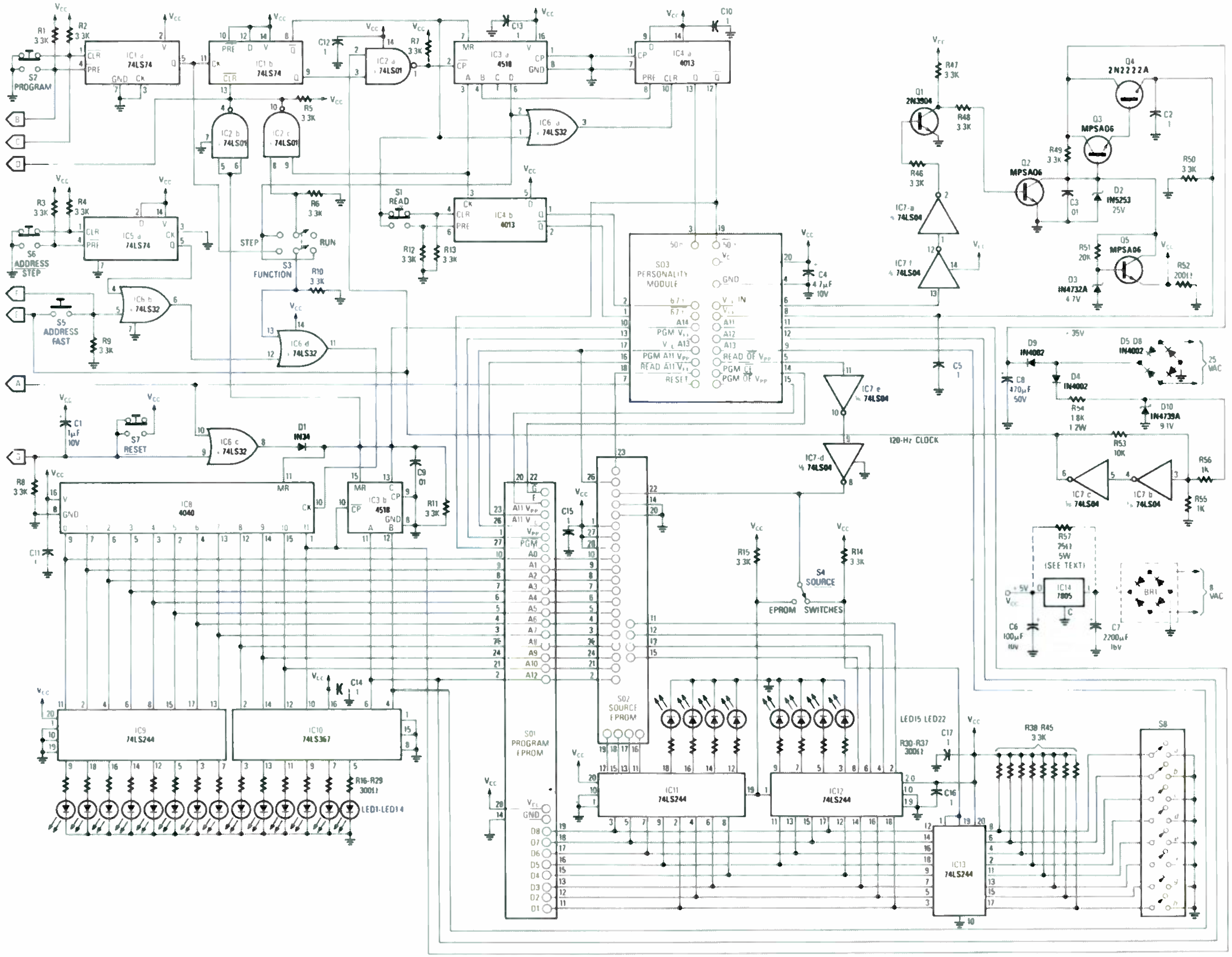


FIG. 2—THE EPROM PROGRAMMER IS DRIVEN BY A 120-Hz clock circuit that is generated by IC7-c and IC7-d; LED's indicate addresses and data in binary.

Programming circuitry

Assume that S3 is in the STEP position. Then, when S2 is pressed, a program cycle begins. That switch is debounced by IC1-a, which clocks IC1-b. The Q output of of IC1-b allows the 120-Hz clock (at pin 2 of IC2-a) to be fed to IC3-a. The first count to reach IC3-a is fed to IC4-b, which provides the 67-ms data gating pulse. The second pulse presets IC4-a and begins the 50-ms program pulse. Both signals stay high until count 8, which clears IC4-a and ends the 50-ms pulse.

When count 9 arrives NAND gate IC2-c clears IC1-b, which prevents the 120-Hz signal from passing through IC2-a and counter IC3-a. At that time $\overline{Q}$ of IC1-b also goes high, resets IC3-a, and clears IC4-b. That ends both the 50-ms program-pulse and the 67-ms gating pulse.

If S3 is toggled to the RUN position, NAND gate IC2-c never receives the ninth count, so IC1-b is not cleared, and IC3-a continues to count until the tenth pulse, at which time it internally resets to zero. Since there is no reset signal from $\overline{Q}$ of IC1-b, IC3-a continues to count, so IC4-b is not cleared, and the 67-ms pulse line remains high. Also, count eight (available at pin 6 of IC3-a) is used to increment the address counter (IC8) in this mode. If S3 is toggled to STEP, the next count of nine will reset the programming cycle.

Data verification

When S3 is in the STEP position, the 4040 address counter is not incremented until S2 is released and Q of IC1-a goes low. That low-going transition passes through S3 and IC6-d to the clock input of the 4040 and increments the address by one. So, if you hold S2 down after a location is programmed, you can see whether that location has the correct data by examining LED15–LED22. When you're ready to go to the next location, release S2. There is no way to "back up" by one location (or more than one). You'll just have to reset the prom burner, or cycle all the way around through 0000.

Data section

The programmer has an eight-bit data bus. The logic levels of all bits are displayed by LED15–LED22, which are driven by IC11 and IC12. The data displayed by those LED's (and used to program an EPROM) is chosen via switch S4, SOURCE. When S4 is in the EPROM position, the EPROM in SO2 provides data; when S4 is in the SWITCHES position, DIP switches S8-a through S8-h provide data.

Pushbutton switch S1 can be used to view the contents of the source EPROM in SO2. When that switch is pressed, IC4-b is preset, and that activates the 67-ms data gating line, which places the program EPROM in a standby mode. In addition, that signal places the source EPROM in a read mode, and connects its data input pins to the data bus. That allows you to view the contents of the source EPROM before programming.

Component selection

With that basic understanding of the circuit in mind, let's build a programmer now.

Our PC board was designed for miniature, PC-mountable switches like those sold by Alco, C & K, and other companies. But you can use any switches that are functionally equivalent. If you use the PC-mountable switches, you can, with careful planning, secure the PC board directly to the front panel of your enclosure. To do so, just drill holes in the appropriate locations on the panel, and secure the PC board to the panel with the switch-mounting hardware. If you don't want direct-panel mounting, simply run wires from the pads on the PC board to the appropriate terminals on the switches.

In addition, for panel mounting, two 28-pin wirewrap sockets should be mounted at the correct height above the board in the holes provided for SO1 and SO2; then plug the ZIF sockets into those sockets. The same applies to SO3, the socket for the personality modules, and S8, the data input DIP switch. A 20-pin socket is required for SO3, and a 16-pin socket for S8.

Pay attention to the circuit's power requirements. If you are going to use the two option boards, you'll will need 8-volts AC at 1.2 amps and 25-volts AC at 280 mA. The two AC supplies must be separate; they cannot be taps on one winding or in any other way be connected to each other. Two separate windings on one transformer will suffice. Don't apply more than 10 volts to the 8-volt input pads on the board, nor more than 30 volts to the 25-volt pads. In addition, the circuit works only with a power-line frequency of 60 Hz, because the timing circuitry is locked to that frequency. Also, it's not a bad idea to fuse the primary of the transformer. A ¼-amp, 250-volt fuse will do.

Don't use bargain transistors; they can be destroyed at power up. For example, Q4 is a 2N2222A. Make sure your transistor has the A suffix, because a plain 2N2222 is rated for operation at lower voltages. Nor should you use a PN2222, which has limited power dissipation.

The personality modules are built on 20-pin headers which may be hard to find. If you have trouble locating them, you can substitute 20-pin machined-contact, solder-tail IC sockets instead. Those sockets have pins that are sturdy but thin enough to fit into an IC socket.

Although 74LS series IC's were used in our prototype, you may want to experiment with 74HC and 74HCT devices. They are CMOS versions of the 74LS series, and they feature speed and drive capacity comparable to those of the 74LS series, but with the advantage of CMOS's low power consumption.

Last, use good quality LED's. We have found that LED's vary greatly in quality and light output. Some hobbyist-grade LED's require a great deal of current to produce much light, and the 7805 can't provide a great deal of current and drive all the other circuitry. So stay with prime LED's or get high-brightness LED's.

Construction

Due to the complexity of the project, we recommend that you use a PC board to build the programmer. Foil patterns for one side of double-sided board are presented in PC Service; the other side will appear in next month's issue. A pre-etched and drilled board is also available from the source in the Parts List.

If you etch your own board, it likely will not have plated-through holes. In that case use wirewrap IC sockets mounted a little above the board so that you can solder each pin to both sides of the board. Make sure that you also solder all other components on both sides of the board.

Referring to Fig. 3, mount all components on the board as follows. First solder the two jumpers to the board using insulated wire for each. One is located to the left of Q3 in the lower left corner of the board; the other is located to the left of IC8 in the upper center of the board.

Begin soldering parts to the board, starting with the lower-profile components (resistors and diodes) and working up to the larger components (C8, SO1, SO2, and all switches). All the discrete LED's should be mounted so that their cathodes (usually the flat side) face IC14, the 7805. Be careful to mount all polarized components correctly.

Personality modules

Shown in Fig. 4 are the modules for each of the EPROM types mentioned above. Some of the modules are very simple; others require several components. We'll give construction hints only for the more complicated modules. After you verify that each module works correctly, pot it with epoxy, mark pin 1, and label it with the type of EPROM it is used with.

The 2532, 2732, and 2372A modules, shown in Fig. 4-c–Fig. 4-e, are the only ones that are hard to build. When building them, wire the jumpers and the discrete components first, and then install the 4001 CMOS IC. Break off pins 4, 10, and 11 of the IC. Then bend pin 3 under the IC and solder an insulated jumper to it; that jumper will connect later to pin 15 (for the 2532) or pin 14 (for the 2732 and the 2732A) of the module.

Short the unused input pins (5, 6, 8, 9, 12, and 13) to pin 7, and connect that pin to pin 4 (ground) of the module. Finally, bend IC pins 1, 2, and 14 so that they can

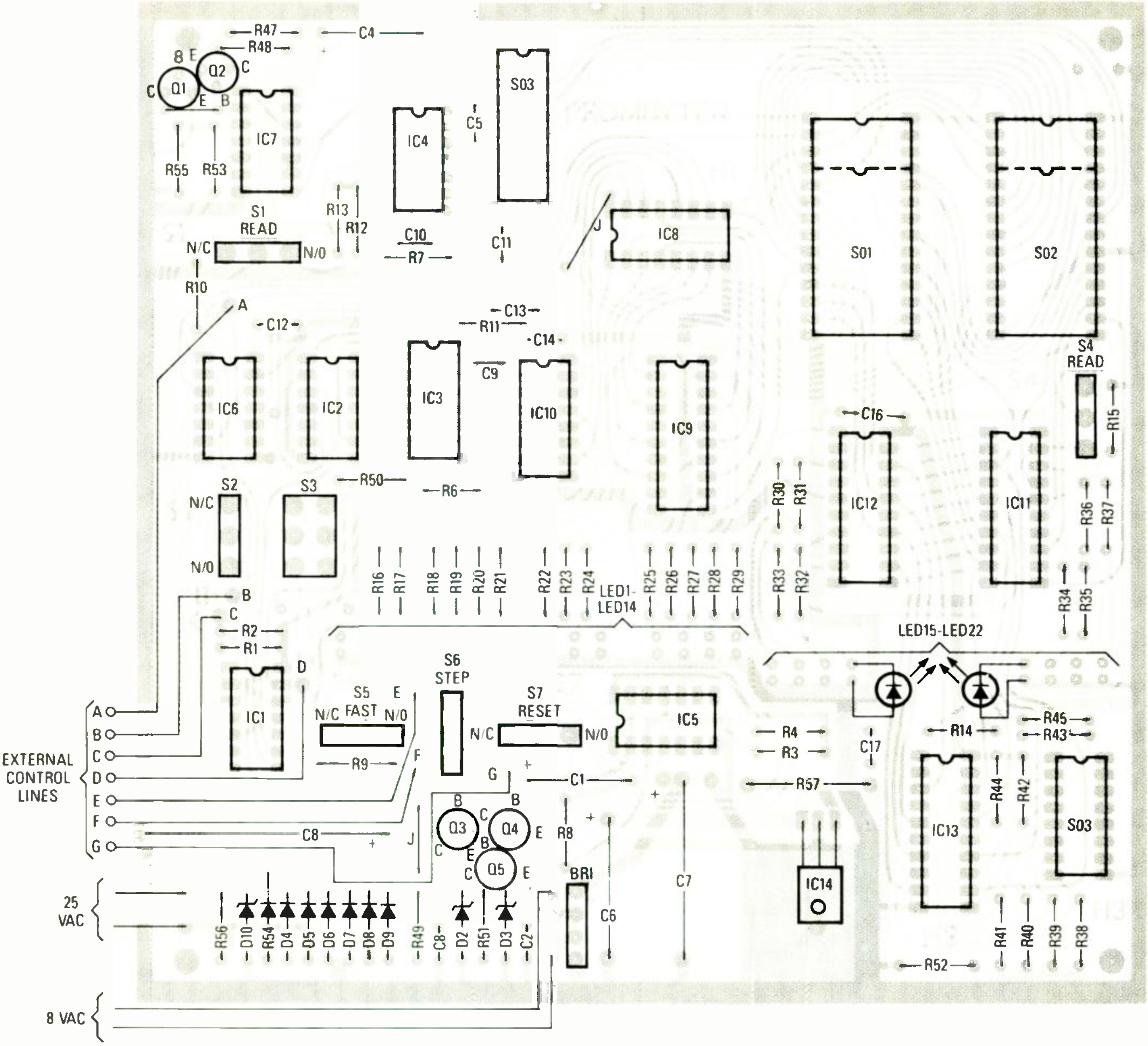


FIG. 3—THE EPROM PROGRAMMER'S PC BOARD is double-sided; all components mount as shown here. Since a home-made board's holes are not plated through, the IC sockets must be mounted slightly above the board so that the socket pins can be soldered to the top side of the board.

PARTS LIST

All resistors are ¼-watt, 5% unless otherwise noted.

R1–R15, R38–R50—3300 ohms
R16–R37—300 ohms
R51—20,000 ohms
R52—200 ohms
R53—10,000 ohms
R54—1800 ohms, ½ watt
R55, R56—1000 ohms
R57—25 ohms, 5 watts (see text)

Capacitors

C1—1 µF, 10 volts, electrolytic
C2, C5, C10–C17—0.1 µF, disk
C3, C9—0.01 µF, disk
C4—4.7 µF, 10 volts, electrolytic
C6—100 µF, 10 volts, electrolytic
C7—2200 µF, 16 volts, electrolytic
C8—470 µF, 50 volts, electrolytic

Semiconductors

IC1, IC5—74LS74 dual flip-flop
IC2—74LS01 quad 2-input NAND gate
IC3—4518 CMOS dual BCD counter
IC4—4013 CMOS dual flip-flop
IC6—74LS32 quad 2-input OR gate
IC7—74LS04 hex inverter
IC8—4040 12-stage binary counter
IC9, IC11–IC13—74LS244 octal 3-state buffer
IC10—74LS367 hex 3-state buffer
IC15—7805 5-volt regulator
BR1—1-amp 50-PIV bridge rectifier
D1—1N34A germanium signal diode
D2—1N5253 25 volts, 1 watt, Zener diode
D3—1N4732A 4.7 volts, 1 watt, Zener
D4–D9—1N4002 rectifier
D10—1N4739A 9.1 volts, 1 watt, Zener diode
LED1–LED22—miniature, high-brightness LED
Q1—2N3904 NPN transistor
Q2, Q3, Q5—MPSA06 NPN transistor
Q4—2N2222A NPN transistor

Other components

S1—SPDT, toggle, momentary
S2, S6—SPDT, pushbutton, momentary
S3—DPDT, toggle
S4—SPDT, toggle
S5, S7—SPST, pushbutton, momentary
S8—8-position DIP switch

Miscellaneous: Dual-secondary transformer: 8-volts at 1.2 amps, and 25-volts at 280 mA; heatsink for IC14; two 28-pin ZIF sockets; IC sockets, wire solder, case, etc.

Note: The following are available from Lubomir Sawkiw, P.O. Box 555, Rensselaer, NY 12144: A transformer with 25 and 10 volt AC secondaries, $8.00 plus $3.00 shipping and handling; 9368 Fairchild IC's, $4.25 each postpaid. New York residents must add 7% sales tax.

The following are available from E²VSI, P.O. Box 72100, Roselle, IL 60172: main circuit board, $25.00; hex display board: $15.00; gang board, $10.00; set of three boards, $45.00.

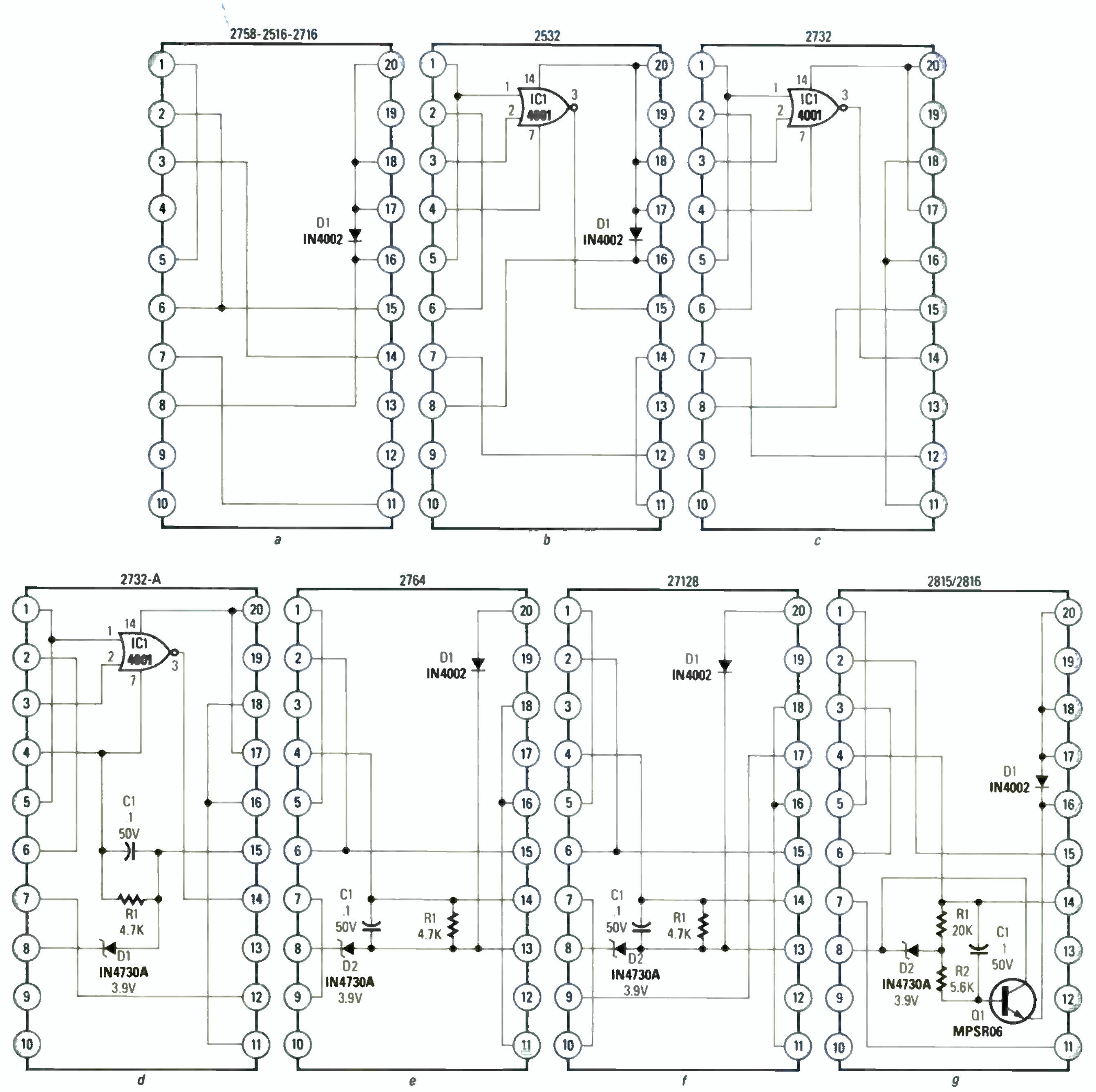


FIG. 4—EACH PERSONALITY MODULE is built on a 20-pin header; see the text for information on building the 2532, 2732, and 2732A modules.

attach directly to module pins 1, 3, and 20, respectively. When soldered in place correctly, the IC should sit firmly above the carrier wiring and components.

Initial check-out

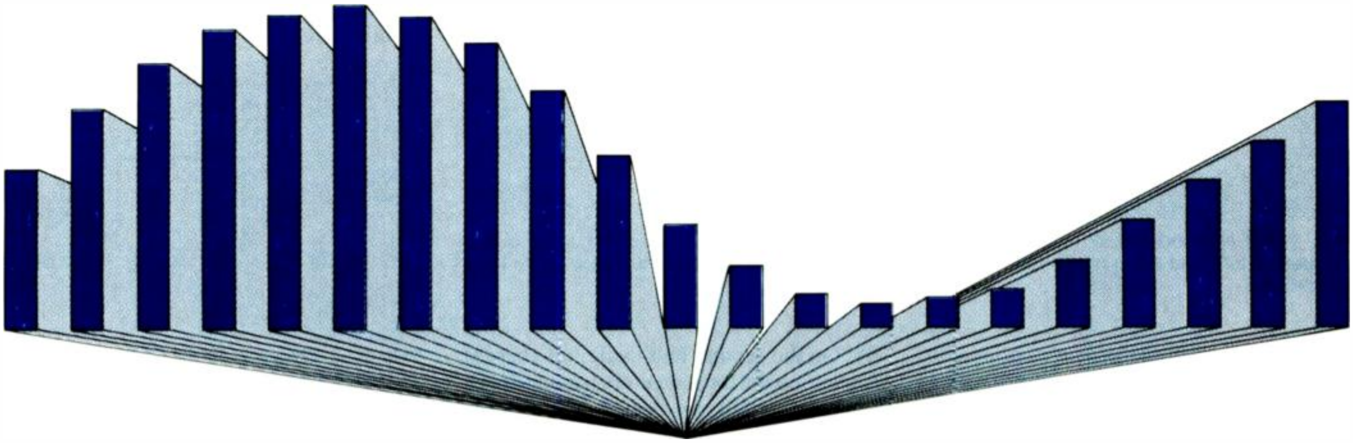
Install all IC's and a personality module in the proper sockets, but don't install an EPROM yet. Measure the +5-volt DC output of the regulator IC as you power the board. To measure that (or any other) voltage on the board, do not clip the negative lead of your meter to the edge of the board; you would short out the power supply. Rather, connect your negative test lead to the negative side of C6, C7, or C8.

After checking the +5-volt supply, measure V_{PP} across C8. The voltage there shouldn't exceed 40 volts. You need only about 27 volts to do the job; a higher voltage could destroy one of the transistors.

Now remove power and install an erased EPROM into SO1. Whether you use a 24-pin device (such as a 2716) or a 28-pin device (such as a 2764), the EPROM should be "bottom justified." In other words, pin 12 of a 24-pin device, or pin 14 of a 28-pin device should be plugged into pin 14 of the socket. After the EPROM is oriented properly, move the socket's locking lever to the closed position.

With power still off, insert the eight-position DIP switch in its socket. Mount it so that switch 1 is closest to the EPROM sockets. That places data bit 0, on switch one and data bit 7 on switch 8. A closed DIP switch puts a low (logic 0) on that line. An open switch puts a high (logic 1) on that line. At this point you should have an erased EPROM, the corresponding personality module, and the DIP switch inserted in the correct sockets. Place S3 in the STEP position, apply power, and press RESET (S7).

Next time we'll present more testing details, as well as plans for the optional display and gang-programming boards. **R-E**



Analog Delay Lines

You can use analog delay lines to produce special audio effects such as echo, reverb, room expansion, and many others. Find out how here.

RAY MARSTON

SOLID-STATE DELAY LINES ARE WIDELY used in modern music and audio systems. They can be used to produce effects such as echo, reverb, chorus, phasing, and flanging (sweepable filtering) for performing artists. In addition, delay lines can produce ambience synthesis and room expansion for home hi-fi systems. Further, a delay line can be used as the heart of a click/scratch filter for a record player, and as a sound-activated switch.

There are two basic types of solid-state delay systems: analog and digital. Digital delay systems tend to be more expensive and more complex than analog types, except when delay times exceed 250 ms, so we'll confine this discussion to analog systems only. But before we get into the hardware, let's talk about psycho-acoustics. In that way we'll learn why the effects produced by delay lines work.

Psycho-acoustics

Many of the special effects obtainable with delay lines depend heavily on how the human brain interprets sounds. The brain does not always perceive sounds as they truly are, but it interprets those sounds so that they conform to a preconceived pattern. Therefore, sometimes the brain can be tricked into misinterpreting those sounds. Scientists have discovered several psycho-acoustic laws that explain how the brain interprets various sounds.

1. If the ears perceive two sounds that are identical in form (waveshape and amplitude) and time-displaced by less than 10 ms, the brain integrates them and perceives them as a single sound.

2. If the ears perceive two sounds that are identical in form but time-displaced by 10–50 ms, the brain perceives them as two independent sounds, but integrates their information content into a single easily recognizable pattern, with no loss of information fidelity.

3. If the ears perceive two sounds that are identical in form but time-displaced by more than 50 ms, the brain perceives them as two independent sounds, but may be unable to integrate them into a recognizable pattern.

4. If the ears perceive two sounds that are identical in shape but not in magnitude, and which are time-displaced by more than 10 ms, the brain interprets them as two sound sources (primary and secondary), and draws conclusions concerning both the location of the primary sound source and the distance between the two sources.

Regarding location identification, the brain identifies the first perceived signal as the primary sound source, even if its magnitude is substantially lower than that of the second perceived signal. That is known as the Hass effect. So a delay line can be used to trick the brain into wrongly identifying the location of a sound source.

Regarding distance identification, the brain correlates distance and time-delay at roughly 0.3 meters (about 13 inches) per millisecond of delay. So a delay line can be used to trick the brain about how far apart two sound sources are.

5. The brain uses echo and reverberation (repeating echoes of diminishing amplitude) information to construct an image of environmental conditions. For example, if a sound reverberates for a total of two seconds, and an echo occurs every 50 ms, the brain may interpret its environment as being a 50-foot cave or a similar hard-faced structure. But if the reverberation time is only 150 ms, the brain may interpret the environment as being a softly-furnished 50-foot room. Those sorts of facts can be used to trick the brain into drawing false conclusions concerning its environment; in fact, it is those tricks that are used in ambience synthesizers and room expanders.

6. The brain is highly sensitive to sudden increases in sound intensity, such as clicks and scratches on record albums, but it is insensitive to sudden decreases in intensity. We're speaking now of transients that last only a few milliseconds. Those facts are what make click/scratch filters possible. We'll discuss how to do that later, but first let's discuss some of the basics of how delay lines work.

Delay-line basics

Modern analog delay lines come in integrated-circuit form and are commonly known as CTD (*C*harge *T*ransfer *D*evice) or bucket-brigade delay lines. Those devices contain a number of analog memory cells (buckets). Each cell is actually a sample-and-hold circuit and, usually, 512, 1024, or 4096 cells are wired in series. Analog input signals are applied at the first cell and the delayed output is taken from the last cell.

Figure 1-*a* illustrates the basic components of an analog delay line. Each bucket

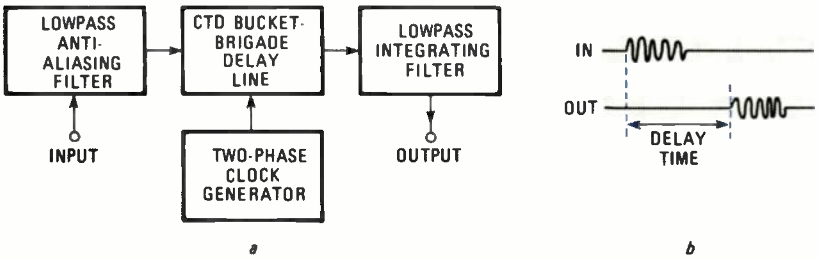


FIG. 1—AN ANALOG DELAY LINE is composed of a bucket-brigade delay line, input and output lowpass filters, and a two-phase clock (*a*). The circuit produces a time-delayed replica of the input signal (*b*).

consists of a small-valued capacitor and a MOSFET which function together as a sample-and-hold stage. As shown in Fig. 1-*b*, a signal fed to the input of a delay line will appear at the output at a later time; as we'll see below, that time depends on both the clock frequency and the number of buckets.

The input signal is applied to the delay line via a lowpass filter that has a cutoff frequency one third (or less) of the clock frequency. The lowpass filter is used to overcome aliasing (intermodulation) problems. The output of the delay line is passed through a second lowpass filter, which also has a cutoff frequency one third (or less) of that of the clock. That filter also rejects clock-breakthrough signals and integrates the output of the delay line into a faithful (but time-delayed) replica of the original input signal.

As shown in Fig. 2, an electronic switch is placed at the input of the delay line; that switch is externally biased to a pre-set voltage. Charges can then be shifted from cell to cell, one cell at a time, at a rate determined by an external two-phase clock. One phase of the clock controls shifting, and the other phase drives the input-sampling switch. The operating sequence is as follows.

On the first half of the clock cycle, the contents of each bucket are shifted to the next bucket in line and a sample of the input signal is fed to the first bucket via S1. On the second half-cycle, all charges (including the most recently sampled one) are shifted to the next bucket, but the input is not sampled. That double-shifting process repeats on each clock cycle, and input samples are repeatedly taken and then shifted.

Near the end of the delay line two sections of buckets are wired in parallel. Those sections differ in that one section has an extra bucket. There is also a phase difference between the clock signals applied to the parallel sections. So the circuit has two outputs which, when added together, effectively fill in the "gaps" in the main delay line. The outputs can be summed either by shorting them together or, preferably, by connecting them to a BALANCE potentiometer, as shown in Fig. 2. The final output of the delay line is thus a time-delayed replica of the original input signal.

Figure 3 shows the essential components of an analog delay circuit. The delay-line MOSFET's have a tetrode structure, so the IC needs two supply voltages (V_{DD} and V_B), plus a ground connection. The input terminal must be biased into the linear mode by resistors R1 and R2. The two outputs of the device are added together, as discussed earlier. Last, the IC must be provided with a two-phase clock signal; usually that signal is a pair of out-of-phase squarewaves that switch fully between V_{DD} and ground. Some analog delay lines have clock dividers so that only a single-phase clock input is needed. We'll discuss specific IC's later in this article.

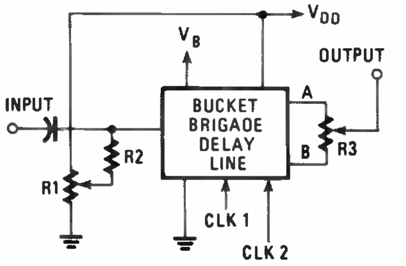


FIG. 3—A TWO-PHASE CLOCK and several biasing resistors are required to drive a bucket-brigade delay line.

How much delay?

The cells of an analog delay line are alternately empty and charged. Each complete clock cycle shifts a charge two stages along the delay line. Therefore the maximum number of samples that a line can take is equal to half the number of stages. For example, a 1024-stage line can take only 512 samples. The actual time delay available from a line is given by $t = ST/2$, where t is the time in seconds, S is the number of stages, and T is the period of the clock. In terms of clock frequency, that equation is $t = S/2f$.

For example, a 1024-stage delay line using a 10-kHz (100 µs) clock gives a delay of $1024 / (2 \cdot 10{,}000) = 51.2$ ms. A 4096-stage line gives a 204.8-ms delay at the same clock frequency.

It's worth pointing out that the bandwidth of an analog delay line is limited to about one third of the clock frequency. Hence a delay line clocked at 10 kHz has a useful bandwidth of only about 3.3 kHz.

Simple effects

Figures 4–15 illustrate a variety of applications for analog delay lines. In these block diagrams we will, for the sake of simplicity, not show the usual input and output lowpass filters. An actual circuit

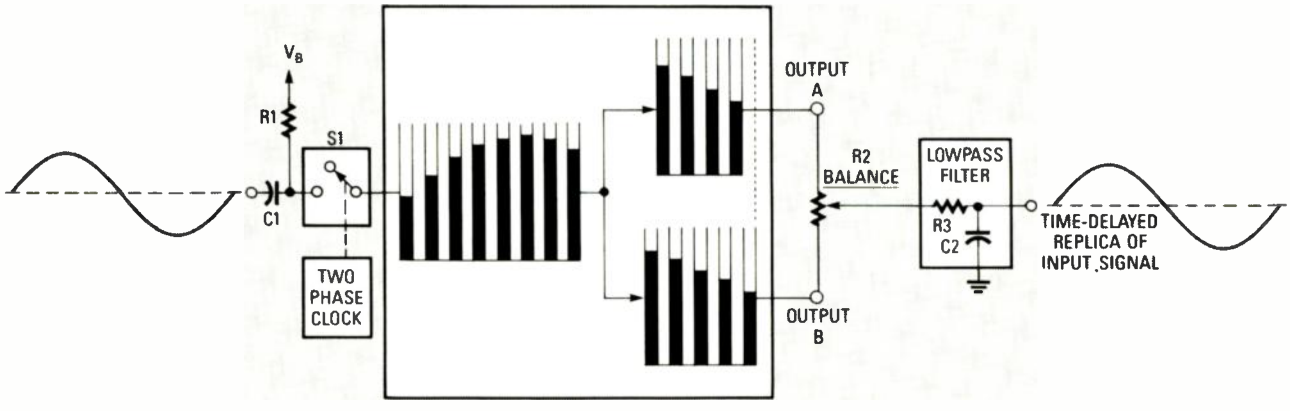


FIG. 2—THE BUCKET-BRIGADE DELAY LINE operates by sequentially shifting charges through alternate cells. The two outputs are summed and filtered for further processing.

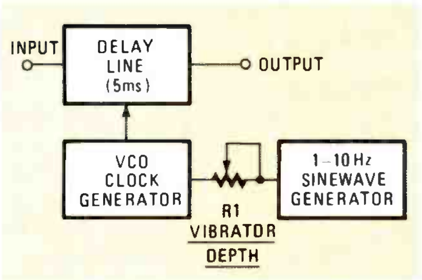


FIG. 4—THE VIBRATO CIRCUIT frequency modulates the input signal with a low-frequency oscillator.

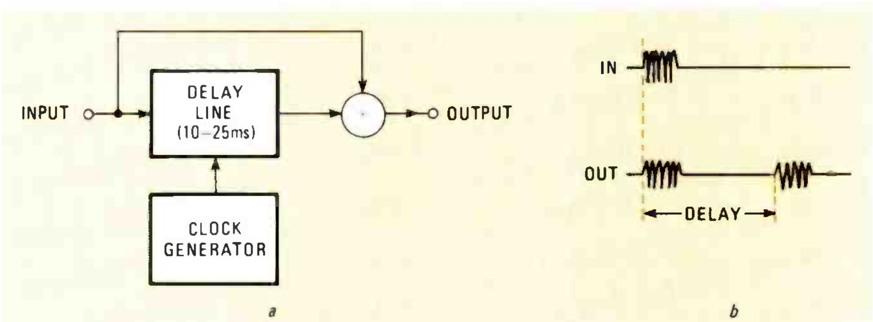


FIG. 5—THE DOUBLE-TRACKING CIRCUIT, or micro chorus, mixes the input signal with a delayed replica of the input signal (*a*). Input and output waveforms are shown in *b*.

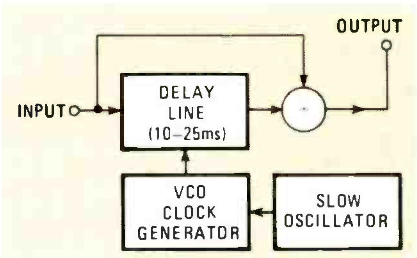


FIG. 6—THE AUTOMATIC DOUBLE-TRACKING, or mini-chorus, frequency modulates the delayed signal.

would have to include filters with the appropriate cutoff frequencies.

Figure 4 shows how the delay line can be used to apply *vibrato* (frequency modulation) to a signal. The low-frequency sinewave generator modulates the clock generator's signal and thereby causes the output signal of the delay line to be time-delay modulated.

Figure 5-*a* shows a delay line used to give a double-tracking effect. The delay is in the perceptible range (10–25 ms), and the delayed and direct signals are added in an audio mixer to give the composite output. Figure 5-*b* illustrates the circuit's input and output signals. One use for a double-tracking circuit is to feed a solo singer's voice through the unit. The output sounds as if two performers were singing in very close harmony. The double-tracking circuit is also called a mini-echo and a micro-chorus.

Figure 6 shows how the circuit shown in Fig. 5 can be modified to act as an Auto Double Tracking (ADT) circuit. Such a circuit is also called a mini-chorus. Clock signals are derived from a VCO that is modulated by a slow oscillator, so that the delay times slowly vary. The effect that results is that a solo singer's voice sounds like a pair of singers in loose or natural harmony.

Figure 7 shows how three ADT circuits can be wired together to form a "chorus" machine. Each delay line has a slightly different delay time. The original input and the three delay signals are summed; the net effect is that a solo singer sounds like a quartet, or a duet sounds like an octet, etc.

Comb filters

Figure 8 shows a delay line configured as a comb filter. In that circuit, the direct and the delayed signals are added together. In-phase components of both signals increase output amplitude, and those that are out of phase cancel each other and reduce output level. Consequently, as shown in Fig. 8-*b*, the frequency response shows a series of notches; the spacing between notches is the reciprocal of the delay-line time. In the example circuit, the 1-ms delay gives a 1-kHz (1/0.001) notch spacing. Those phase-induced notches are typically about 20–30 dB deep.

The two most popular musical applications of the comb filter are in phasers and flangers. In the phaser (shown in Fig. 9) the notches are swept slowly up and down the audio band via a slow-scan oscillator. Selected components of the input signal are then effectively deleted from the output signal.

The flanger circuit (shown in Fig. 10) differs from the phaser in that the mixer is placed ahead of the delay line, and part of the delayed signal is fed back to one input of the mixer, so that the in-phase signals

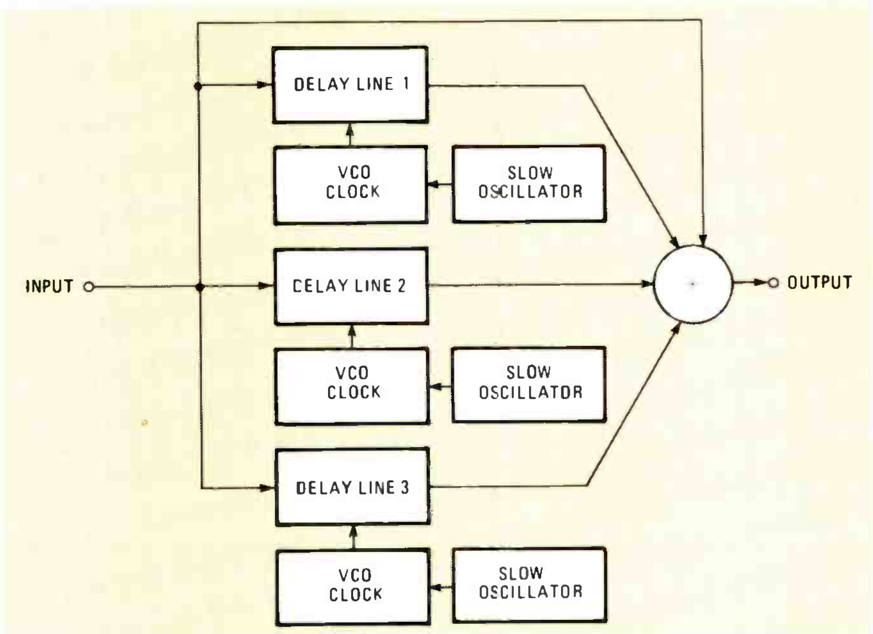


FIG. 7—A CHORUS GENERATOR is composed of several double-tracking circuits.

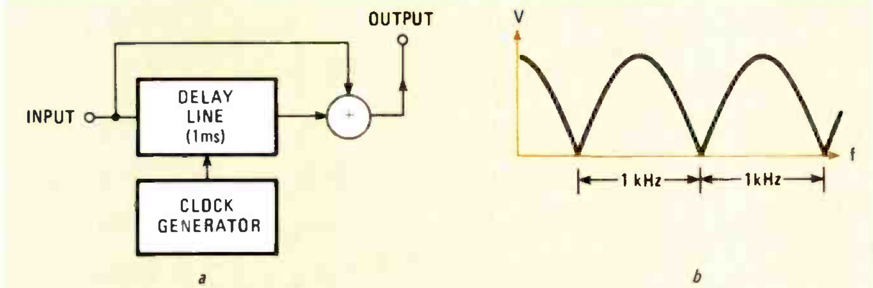


FIG. 8—A COMB FILTER can be built from a delay line, a clock, and a mixer (*a*). With a 1-ms delay, the notches are about 20–30 dB deep, and 1 kHz apart (*b*).

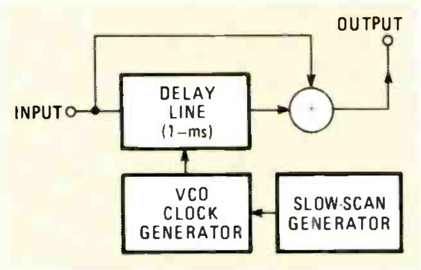


FIG. 9—THE PHASER is a variable comb filter in which the notches are slowly swept up and down the audio band.

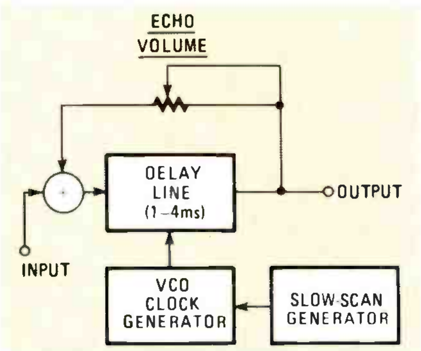


FIG. 10—THE FLANGER is a phaser with accentuated and variable notch depth.

add together regeneratively. Peak amplitudes depend on the amount of feedback, and they can be made very steep. Those phase-induced peaks introduce very powerful acoustic effets as they are swept up and down the audio band.

Echo and reverb circuits

Figure 11 shows how to build an echo circuit with a delay line. The delay (echo) may vary from 10 to 250 ms, and it is adjustable, as is the amplitude of the echo. Note that this circuit produces only a single echo, as shown in Fig. 11-*b*.

The echo/reverb circuit of Fig 12 produces multiple echoes, or reverberation. It uses two mixers, one before the delay line and one after it. Part of the delayed output is fed back to the input mixer, and that is what allows the circuit to give echoes of echoes, echoes of echoes of echoes, and so on. As shown in Fig. 12-*b*, the amplitude of each echo is less than that of its predecessor.

Reverb time is defined as the time it takes for the repeating echo to fall by 60 dB relative to the original input signal; reverb time depends on the delay time and the overall attenuation of the feedback signals. Echo delay time, echo volume, and reverb time are all independently variable.

Hi-fi effects

Figure 13 shows a block diagram of an ambience synthesizer or room expander. The outputs of a stereo system are summed to provide a mono image; the resulting signal is then passed to a pair of semi-independent reverb units (which produce repeating echoes, but not the original signal). The reverb outputs are then summed and passed to a mono amplifier and speaker; the latter is usually placed behind the listener. The system effectively synthesizes the echo and reverb characteristics of a chamber of any desired size, depending on control settings, so the listener can be given the impression that he is sitting in a cathedral, a concert hall, a small club, etc., although in fact he is sitting in his own living room.

There are many possible variations on that circuit. For example, the mono signal may be derived by taking the difference between (rather than the sum of) the stereo signals. Doing that cancels center-stage signals and overcomes a rather disconcerting "announcer-in-a-cave" effect that occurs in "summing" systems.

Predictive switching circuits

Delay lines are particularly useful in solving "predictive" or "anticipatory" switching problems, in which a switching action is required to occur slightly *before* a random event occurs.

Suppose, for example, that you need to record random or intermittent sounds (thunder, speech, etc.). It would be inefficient and expensive to run a tape recorder continuously, but it would be impractical to try to activate the recorder via a sound switch, because part of the sound will already have passed by the time the recorder's motors get up to speed.

Figure 14 shows a delay-line solution to that problem. The sound input activates a switch that (because of mechanical inertia) turns the recorder's motor on in about 20 ms. In the meantime, the sound travels through the 50-ms delay line towards the recorder's audio input. When the sound arrives, the motors have already been turning for 30 ms, so no sound is lost. When the original sound ceases, the sound switch turns off, but the switch extender keeps the motor running for another 100 ms or so, and that enables the entire delayed signal to be recorded.

Click/scratch filter

To conclude our discussion of applications, Fig. 15 shows how predictive switching can be used to help eliminate the sounds of clicks and scratches from an audio system. Sounds of that sort can be detected easily by using stereo phase-comparison techniques.

In Fig. 15, signals from a record album

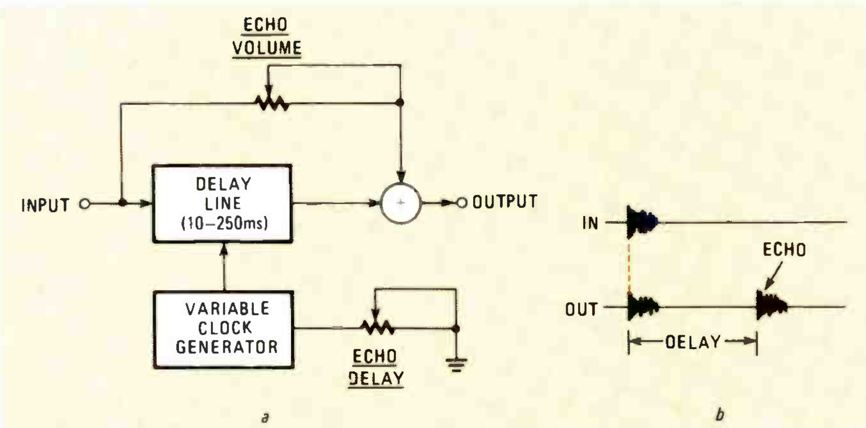


FIG. 11—A VARIABLE ECHO circuit can be built from a delay line, a clock and a mixer (*a*). The echo is actually a time-delayed replica of the input signal (*b*).

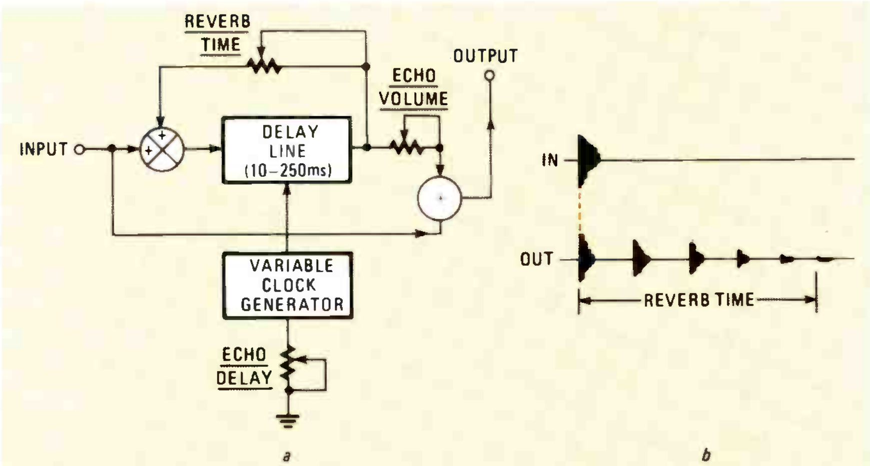


FIG. 12—ADDING REVERB to the echo circuit requires an additional mixer (*a*) to provide progressively diminishing echoes (*b*).

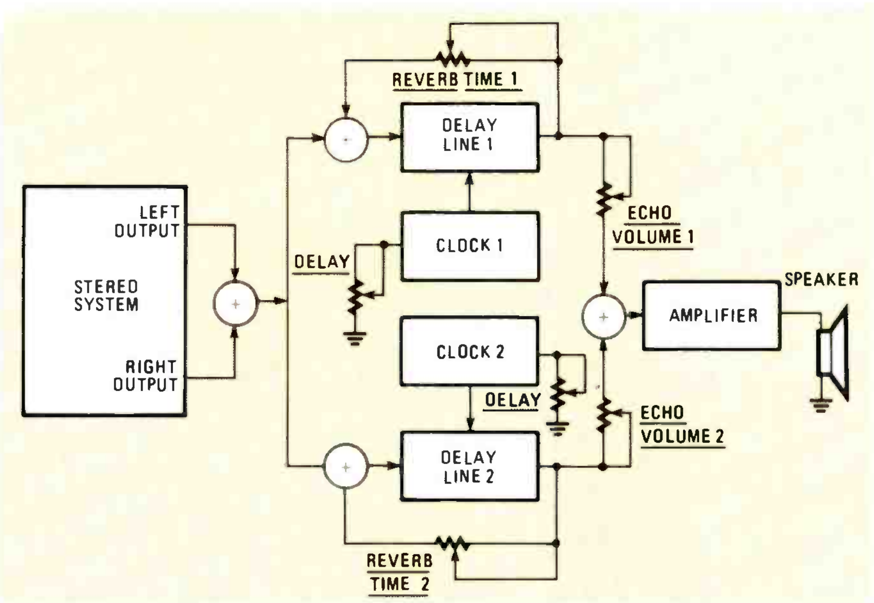


FIG. 13—THE ROOM EXPANDER produces a monophonic delayed output of the sum of the stereo outputs.

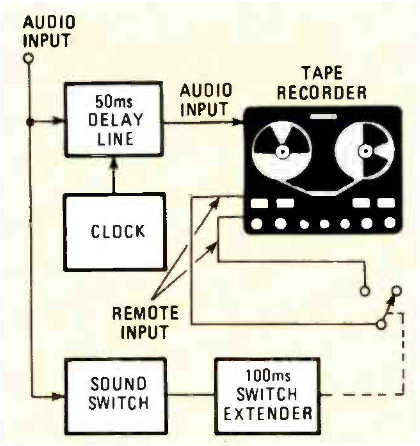


FIG. 14—A SOUND-ACTIVATED RECORDER that does not miss sound input can be built using an analog delay line.

are fed to the audio amplifier via a 3-ms delay line, an analog switch, and a sample-and-hold circuit. Normally the switch is closed, so the signal reaching the audio amplifier is a delayed but otherwise unmodified replica of the input signal. However, when a click or a scratch occurs, the detector/extender circuit opens the switch for 3 ms, and that momentarily blanks the audio signal. Since the ear is relatively insensitive to dropouts, the deletion is not noticed. As you can see in Fig. 15-*b*, when the click in the upper waveform is deleted, the signal is much smoother, as shown in the lower waveform.

Delay-line circuits

Figure 16 shows a practical delay line using an RD5106 (512 stages), RD5107 (1024) stages), or RD5108 (4096 stages) delay line. Those IC's are manufactured by Reticon, Inc. (345 Potrero Avenue, Sunnyvale, CA 94086-9930); Radio Shack should have them in distribution by the time you read this.

Potentiometer R2 should be adjusted so

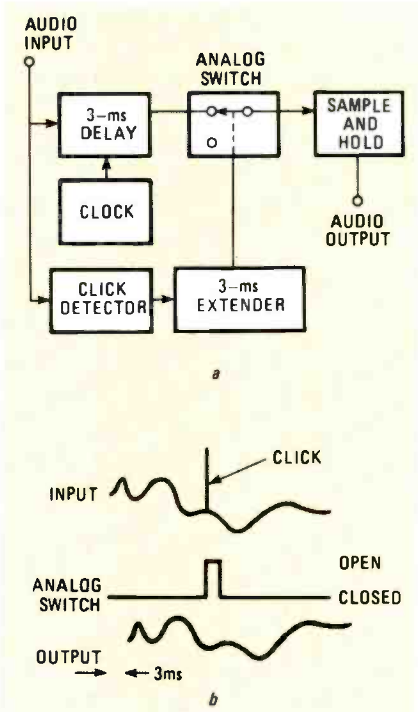


FIG. 15—AN AUDIO CLICK/SCRATCH FILTER can be built with an analog delay line and other components (*a*). The Click Detector opens the Analog Switch for 3 ms to delete a click (*b*).

that symmetrical clipping occurs under over-drive conditions. The maximum clock frequency is 1.6 MHz; the clock should be a fairly sharp squarewave with a risetime of less than 50 ns. The input signal should be limited to 1.5-volts rms to keep distortion less than 1%.

Clock circuits

The clock signal that is fed to a CTD delay line should be reasonably symmetrical, should have fairly fast rise and fall times, and should switch fully between the supply-rail voltages. CMOS devices make good clock generators

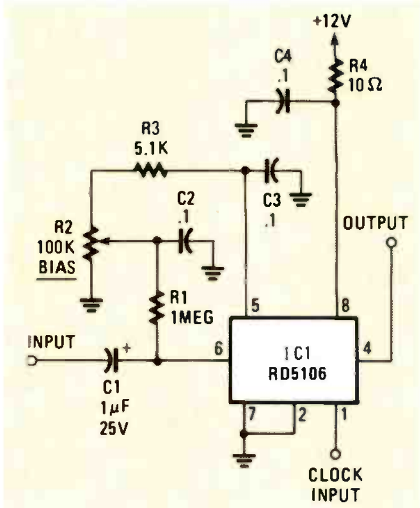


FIG. 16—AN ANALOG DELAY LINE can be built from just a few discrete components. Limit the input signal to less than 1.5-volt rms to keep harmonic distortion less than 1%.

because they are capable of generating waveforms that meet those requirements.

The general-purpose two-phase clock circuit shown in Fig. 17 is inexpensive and can be used in many applications where a fixed or a manually-variable frequency is needed. The frequency can be swept over a 100:1 range via R3; the center frequency can be altered by changing the value of C1.

A high-performance two-phase clock generator based on the VCO section of a 4046 phase-locked loop is shown in Fig. 18. That circuit is useful in applications where the frequency needs to be swept over a very wide range, or needs to be voltage-controlled. The frequency is controlled by the voltage at pin 9. Higher voltages correspond to higher frequencies. Maximum frequency is set by the values of C2 and R1, and minimum frequency is set by the value of C2 and the series values of R3 and R4.

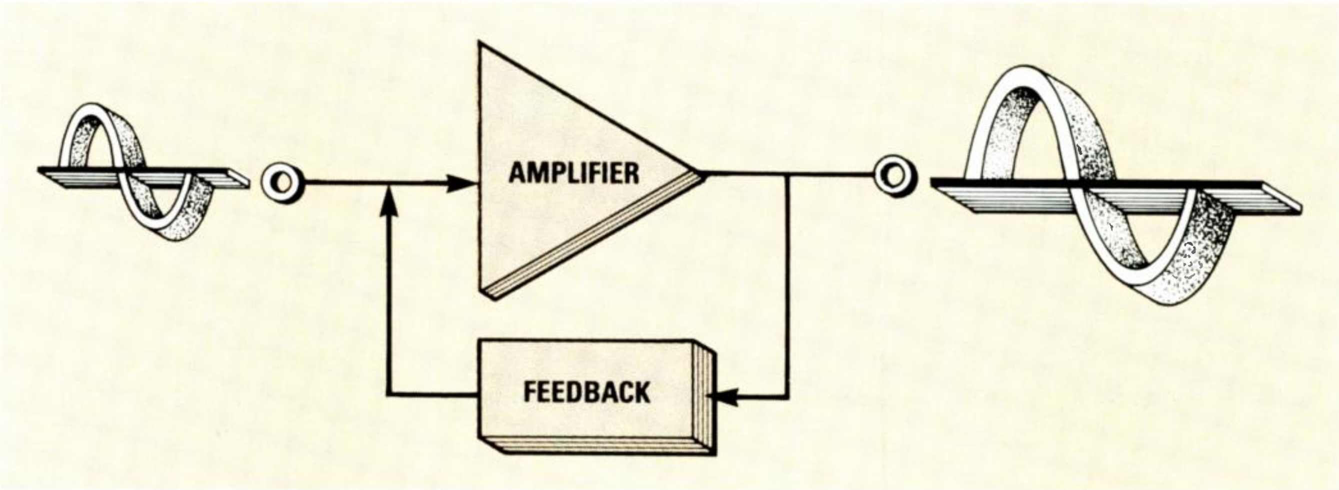
The preceding clock circuits can be used to clock many delay lines. Some, however, have high-capacitance (0.001 μF) inputs and therefore require a low-impedance clock drive. One way of providing a low-impedance clock driver is by connecting two 4013 "D" flip-flops in parallel, as shown in Fig. 19. That circuit is driven by a single-phase clock signal, which can be obtained from either of the preceding circuits.

Filter circuits

As we mentioned previously, in most applications a lowpass filter must be inser-

continued on page 80

How to Design OSCILLATOR Circuits



JOSEPH J. CARR

Our subjects this month include one-shots, squarewave, and triangle wave oscillators.

Part 4 LAST TIME WE DISCUSSED several types of sinewave oscillators. This time we'll investigate three different types of signal generators: one-shots, squarewave oscillators, and triangle-wave oscillators. All our circuits this month are based on op-amps, and they're easy to build and to customize.

The one-shot

The monostable multivibrator, or one-shot, is so called because it has one stable state, high or low, depending on the circuit configuration. A monostable produces one output pulse for each input pulse. Each pulse has the same duration and amplitude. Monostables are used in a variety of applications: pulse stretching, switch debouncing, and others.

The concept of pulse stretching may be somewhat confusing because a pulse is not really stretched. Instead, a pulse with a short duration is used to trigger one with a longer duration.

Switch debouncing is a common application for one-shots; it is actually a form of pulse stretching. The mechanical contacts in most switches don't make and break cleanly; they literally bounce. That means that the contacts open and close several times in quick succession. The multiple makes and breaks can fool the circuitry that follows into thinking that several legitimate closures were made. Some analog circuits can absorb the extra pulses, but most digital circuits cannot.

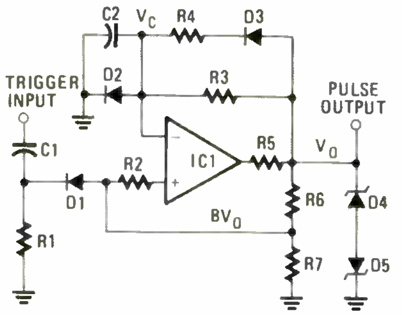


FIG. 1—A ONE-SHOT circuit's pulse output has a duration of R3 × C2, if R6 = 0.58 R7.

One way to debounce the switch closure is by connecting the switch to a one-shot, and using the output of the one-shot to indicate contact closure. For that to work, the duration of the output pulse must exceed the time during which the contacts are bouncing.

An op-amp based one-shot is shown in Fig. 1; waveforms present at the output of the circuit (V_O) and across C2 (V_C) are shown in Fig. 2. The one-shot has only one stable output state, which in this case is $+V_Z$. The one-shot is triggered at time t_1 so the output snaps to the unstable state, $-V_Z$. It will remain in that state for time T, which is defined as $t_2 - t_1$.

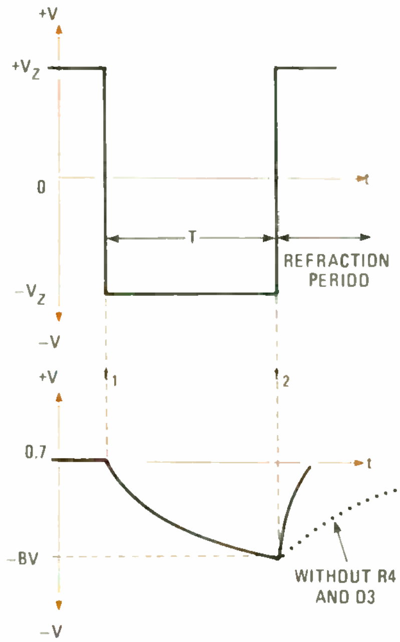


FIG. 2—DURING THE REFRACTORY PERIOD, the one-shot circuit will not respond to a trigger input. Adding a diode and a resistor can shorten the refractory period.

Normally the output of the op-amp is high ($+V_Z$), but when a pulse is applied to the trigger input, the output snaps low ($-V_Z$). At that instant capacitor C2 will still be charged to a positive voltage (not

$+V_Z$ because D2 clamps the voltage to about 0.7 volts).

However, the output voltage is $-V_Z$, so the charge across C2 will begin to approach that potential. It will never reach it, however, because the noninverting input of the op-amp is biased to a fraction of the output voltage, B, as determined by the voltage divider composed of R6 and R7. When the voltage across C2 exceeds BV_O, the output of the op-amp will snap back to the stable (high) state.

The refractory period

The period immediately after the output returns to the stable state is called the refractory period. The circuit will not respond to trigger inputs during that period. To understand why that is the case, first assume that R4 and D3 are not present. Then C2 can discharge only through R3, and that takes a long time. However, by including R4 and D3, we can shorten the refractory period. If the resistance of R4 is much less than that of R3, then the circuit will discharge much faster than it will charge. Diode D3 ensures that current flows through R4 only during discharge. The lower curve in Fig. 2 indicates the different discharge times with and without those components.

The duration T of the output pulse is given approximately by this equation:

$$T = R3 \cdot C2 \cdot \ln\,[1/(1-B)]$$

In that equation, T is given in seconds, R3 is in ohms, C2 is in farads, ln denotes the use of the natural logarithm, and B is the feedback factor. B is determined from the voltage-divider equation: $B = R6/(R6+R7)$.

That timing equation is derived from the time it takes C2 to charge from $+0.7$ volts to voltage BV_O. We can simplify the equation by making B a constant. For example, if the values of the resistors are equal, then $B = R/(R+R) = 0.500$, so the equation can be simplified as follows:

$$T = R3 \cdot C2 \cdot \ln\,[1/(1-B)]$$

$$T = R3 \cdot C2 \cdot \ln\,[1/(0.500)]$$

$$T = R3 \cdot C2 \cdot \ln\,[2]$$

Therefore,

$$T = R3 \cdot C2 \cdot 0.693$$

If $R6 = 2R7$, then $B = R/(R+2R) = R/3R = 0.333$. In that case we can simplify the timing equation as follows:

$$T = R3 \cdot C2 \cdot \ln\,[1/(1-0.333)]$$

$$T = R3 \cdot C2 \cdot \ln\,[1.500]$$

$$T = R3 \cdot C2 \cdot 0.406$$

B is often given a value of 0.632. Doing so allows us to reduce the timing equation to

$$T = R3 \cdot C2$$

Since $R7/(R6+R7) = 0.632$, we can do a a little algebra and find that $R6 = 0.582\,R7$.

In practical terms, we usually select a capacitor and then calculate resistor values, since there are fewer standard values of capacitance.

Automatic calculations

Listing 1 contains a BASIC program that will calculate component values for the one-shot multivibrator. The program is written for the dialect of BASIC used in the IBM-PC (and compatibles), but it should run on many other machines as-is, and it should be easy to translate into other dialects of BASIC, if necessary.

When you run the program it asks you for the duration of the pulse (in milliseconds) and a value of capacitance (in µF). The program then calculates the required resistance, and reports it. At that point you can either run the program again, or exit.

Squarewave oscillators

As you can see in Fig. 3, an op-amp-based squarewave generator is relatively

**LISTING 1—
ONE-SHOT CALCULATIONS**

```
100 REM Monostable Multivibrator
110 FOR I=1 TO 30
120 PRINT
130 NEXT
140 PRINT " Monostable
150 PRINT "Multivibrator
160 PRINT "  Circuit
170 PRINT "  Design
180 PRINT
190 PRINT
200 PRINT
210 INPUT "Pulse duration in ms: ",T
220 T = T/1000
230 INPUT "     Capacitor in uF: ",C
240 PRINT
250 C = C/10^6
260 R = T/(.693*C)
270 R = INT(R)
280 C = C*10^6
290 T = T*1000
300 PRINT "For a pulse duration of:"
310 PRINT
320 PRINT T;"milliseconds"
330 PRINT "      use a
340 PRINT R;"ohm resistor"
350 PRINT "      and a
360 PRINT C;"uF capacitor."
370 PRINT
380 PRINT
390 PRINT "What Now?"
400 PRINT
410 PRINT "1. Do another"
420 PRINT "2. Quit
430 PRINT
440 INPUT "Choose one: ",D
450 IF D = 1 THEN GOTO 200
460 END
```

simple. The timing diagram of that circuit is shown in Fig. 4. Refer to both during the discussion that follows.

In contrast to the one-shot, the squarewave oscillator is called an astable oscillator, because it has no stable output

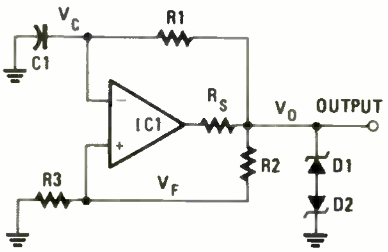


FIG. 3—THIS SQUAREWAVE OSCILLATOR'S frequency of oscillation is given by $f = 1/(3.2\,R1\,C1)$.

state. In other words, its output snaps back and forth between the high ($+V_Z$) and low ($-V_Z$) states.

The noninverting input of the op-amp is biased by a fraction of the output voltage, as determined by the R2/R3 network; the inverting input is biased by the voltage (V_C) across capacitor C1. That voltage is determined by V_O and by the R1C1 time constant.

When the circuit is initially turned on, the capacitor has no charge, so the inverting input has no potential with respect to ground. Therefore the output will be high. The capacitor will begin to charge toward $+V_O$ at a rate that is determined by the product of the values of R1 and C1.

When that voltage reaches the bias

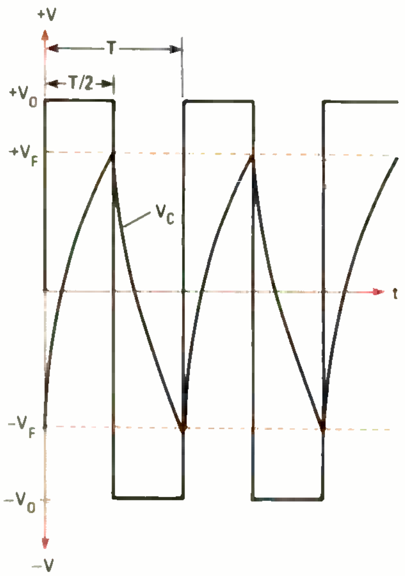


FIG. 4—THE VOLTAGE ACROSS C1 (in Fig. 3) varies between $+V_F$ and $-V_F$.

point of the noninverting input ($+V_F$), the output will snap low. At that point the charging of the capacitor reverses, and the voltage will discharge from $+V_F$ toward zero, and then toward $-V_F$. When it reaches that negative voltage, the output again snaps high, the capacitor begins to discharge toward zero and then toward $+V_F$. That oscillating cycle will continue for as long as power is applied to the circuit.

The time T that is required for one cycle is determined by the resistances in the circuit, and by the value of the capacitor:

$$T = 2 \times R1 \times C1 \times \ln\left(1 + \frac{2R2}{R3}\right)$$

In that equation, T is specified in seconds, C1 is specified in farads, and all resistors are specified in ohms; ln again signifies use of the natural logarithm.

By making the value of R2 equal to that of R3, we can simplify the equation to:

$$T = 3.2 \cdot R1 \cdot C1$$

Solving for the resistance,

$$R1 = T / (3.2\ C1)$$

To work in frequency rather than period, recall that T = 1/f. Then we can substitute:

$$1/f = 3.2 \cdot R1 \cdot C1$$

or

$$f = 1/(3.2 \cdot R1 \cdot C1)$$

Now let's work a practical example. Calculate the values of the components needed to build a 1500-Hz oscillator. Assume we'll use a 0.001-µF capacitor.

$$R1 = T / (3.2\ C1)$$

$$R1 = (0.00067) / (3.2 \times 10^{-9})$$

$$R1 = 209{,}375 \text{ ohms}$$

The duty cycle of the squarewave circuit in Fig. 3 is 50 percent; in other words, the output is high for the same amount of time that it is low. However, we don't always want a 50 percent duty cycle: sometimes we need the high portion of the waveform to be shorter than the low portion, or vice versa. There are several circuits that will yield different high and low times.

One alternative is shown in Fig. 5. That circuit uses different timing resistors for the high and the low portions of the cycle; the diodes switch R_A or R_B into the circuit at the appropriate time. When the output is high, D2 is forward-biased, so R_B controls timing. Similarly, when the output is low, D1 is forward-biased, so R_A controls timing.

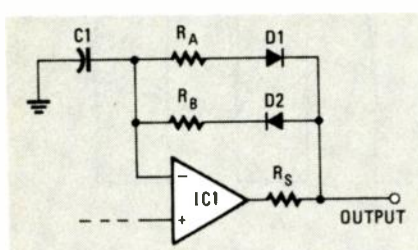


FIG. 5—TO OBTAIN UNEQUAL DUTY CYCLE in the squarewave oscillator, use two different timing resistors. Resistor R_B controls the positive half-cycle, and R_A controls the negative half-cycle.

LISTING 2—TRIANGLE-WAVE CALCULATIONS

```
100 REM Triangle wave generator
110 FOR I=1 TO 30
120 PRINT
130 NEXT I
140 PRINT "Fixed or Variable?"
150 PRINT
160 PRINT "1. Fixed
170 PRINT "2. Variable
180 PRINT
190 INPUT "Choice: ",A
200 IF A > 2 THEN GOTO 140
210 GOSUB 1100
220 ON A GOTO 230, 480
230 PRINT
240 PRINT "Fixed Frequency"
250 PRINT
260 INPUT "Frequency in Hz: ",F
270 PRINT
280 PRINT
290 INPUT "Capacitor in uF: ",C
300 C = C/(10^6)
310 IF K = 1 THEN R = .25/(F*C)
320 IF K = 2 THEN GOSUB 940
330 R = INT(R)
340 C = C*10^6
350 PRINT
360 PRINT "Fixed frequency ";
370 PRINT "component values:"
380 PRINT
390 PRINT "Frequency=";F;" Hz"
400 PRINT "Capacitor=";C;" uF"
410 PRINT "Resistor =";R;" Ohms"
420 IF K<>2 THEN 450
430 PRINT "RI =";Rl;" Ohms "
440 PRINT "R2 =";R2;" Ohms"
450 PRINT
460 PRINT
470 GOTO 820
480 PRINT "Variable Frequency
490 PRINT
500 PRINT "Enter upper and lower"
510 PRINT "frequency limits in Hz"
520 PRINT
530 INPUT "Lower Limit: ",FL
540 PRINT
550 INPUT "Upper Limit: ",FH
560 PRINT
570 INPUT "Capacitor in uF: ",C
580 C = C/10^6
590 IF K = 2 THEN GOSUB 1020
600 IF K = 1 THEN RL = .25/(FL*C)
610 IF K = 1 THEN RH = .25/(FH*C)
620 C = C*10^6
630 RL = INT(RL)
640 RH = INT(RH)
650 PRINT "Variable frequency
660 PRINT "component values
670 PRINT
680 PRINT "Frequency range:";
690 PRINT FL;" to ";FH;" Hz"
700 PRINT "Capacitor=";C;" uF"
710 PRINT "Resistor =";RH;
720 PRINT " to ";RL;" Ohms"
730 PRINT
740 IF K <> 2 THEN 770
750 PRINT "Rl =";Rl;" Ohms, "
760 PRINT "R2 =";R2;" Ohms"
770 GOTO 820
780 INPUT "Choice: ",W
790 IF W > 2, THEN GOTO 780
800 ON W GOTO 810,240
810 RETURN
820 PRINT
830 PRINT "What's next?"
840 PRINT
850 PRINT "1. The same again"
860 PRINT "2. Options menu"
870 PRINT "3. Quit"
880 PRINT
890 INPUT L
900 IF L > 3, THEN GOTO 820
910 ON L GOTO 220,140,920
920 PRINT "PROGRAM ENDED"
930 GOTO 1210
940 PRINT
950 INPUT "Value of Rl: ",Rl
960 PRINT
970 INPUT "Value of R2: ",R2
980 PRINT
990 R = Rl/(4*R2*C*F)
1000 R = INT(R)
1010 RETURN
1020 PRINT
1030 INPUT "Value of Rl: ",Rl
1040 PRINT
1050 INPUT "Value of R2: ",R2
1060 PRINT
1070 RH = Rl/(4*R2*C*FH)
1080 RL = Rl/(4*R2*C*FL)
1090 RETURN
1100 PRINT
1110 PRINT "Select One:"
1120 PRINT
1130 PRINT "1. Standard Version ";
1140 PRINT "(Rl=R2)"
1150 PRINT "2. Custom Values ";
1160 PRINT "(you enter Rl and R2)"
1170 PRINT
1180 INPUT "Select One: ",K
1190 IF K > 2, THEN GOTO 1110
1200 RETURN
1210 END
```

Another method of obtaining a nonsymmetrical waveform is shown in Fig. 6. In that circuit we bias the timing capacitor either positive or negative by the actions of potentiometer R2 and R_{OFF}. The polarity of the bias voltage is determined by the setting of R2; that voltage can vary anywhere from −V through zero to +V.

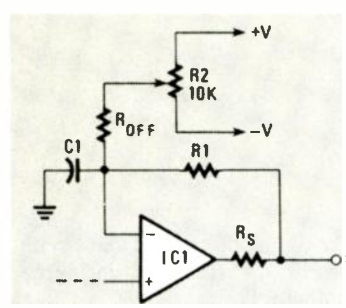


FIG. 6—UNEQUAL DUTY CYCLE may also be obtained by biasing the timing capacitor (C1) positive or negative through R_{OFF} and R2.

Triangle-wave oscillators

There are numerous ways of designing a triangle-wave oscillator, but few have the simplicity of a squarewave oscillator followed by a Miller integrator. The latter is shown in Fig. 7; its timing diagram is shown in Fig. 8.

The slope of the waveform in the lower trace depends on the R1C1 time constant. When that time constant is long compared with the period of the squarewave input, a

continued on page 79

PC SERVICE

One of the most difficult tasks in building any construction project featured in **Radio-Electronics** is making the PC board using just the foil pattern provided with the article. Well, we're doing something about it.

We've moved all the foil patterns to this new section where they're printed by themselves, full sized, with nothing on the back side of the page. What that means for you is that the printed page can be used directly to produce PC boards!

Note: The patterns provided can be used directly only for *direct positive photoresist methods*.

In order to produce a board directly from the magazine page, remove the page and carefully inspect it under a strong light and/or on a light table. Look for breaks in the traces, bridges between traces, and in general, all the kinds of things you look for in the final etched board. You can clean up the published artwork the same way you clean up you own artwork. Drafting tape and graphic aids can fix incomplete traces and doughnuts, and you can use a hobby knife to get rid of bridges and dirt.

An optional step, once you're satisfied that the artwork is clean, is to take a little bit of mineral oil and carefully wipe it

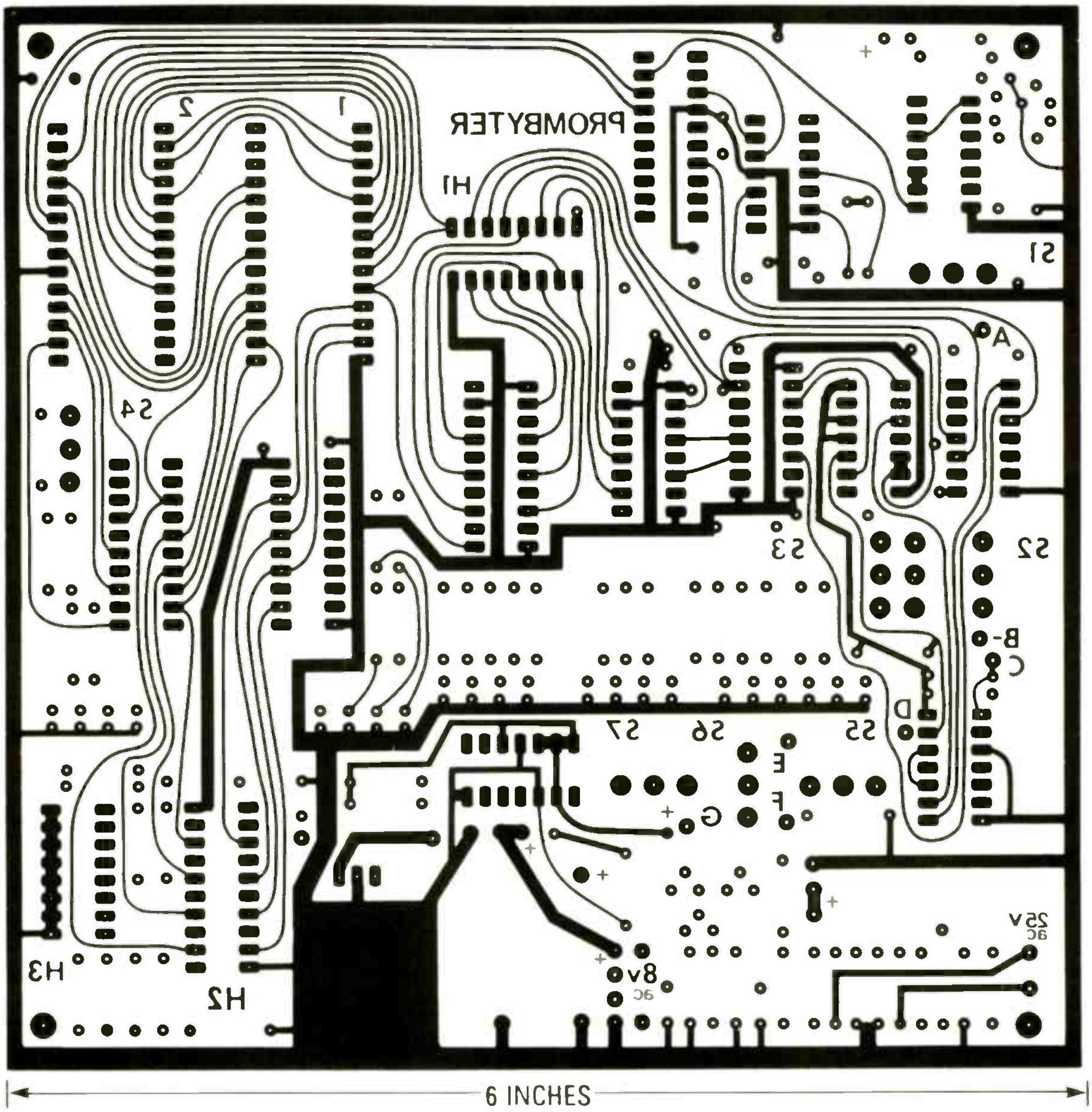
PC SERVICE

across the back of the artwork. That helps make the paper translucent. Don't get any on the front side of the paper (the side with the pattern) because you'll contaminate the sensitized surface of the copper blank. After the oil has "dried" a bit—patting with a paper towel will help speed up the process—place the pattern front side down on the sensitized copper blank, and make the exposure. You'll probably have to use a longer exposure time than you are used to.

We can't tell you exactly how long an exposure time you will need as it depends on many factors but, as a starting point, figure that there's a 50 percent increase in exposure time over lithographic film. But you'll have to experiment to find the best method for you. And once you find it, stick with it.

Finally, we would like to hear how you make out using our method. Write and tell us of your successes, and failures, and what techniques work best for you. Address your letters to:

Radio-Electronics
Department PCB
500-B Bi-County Blvd.
Farmingdale, NY 11735



THE COMPONENT SIDE of the EPROM programmer PC board is shown here. Due to space limitations, the solder side will be shown next time.

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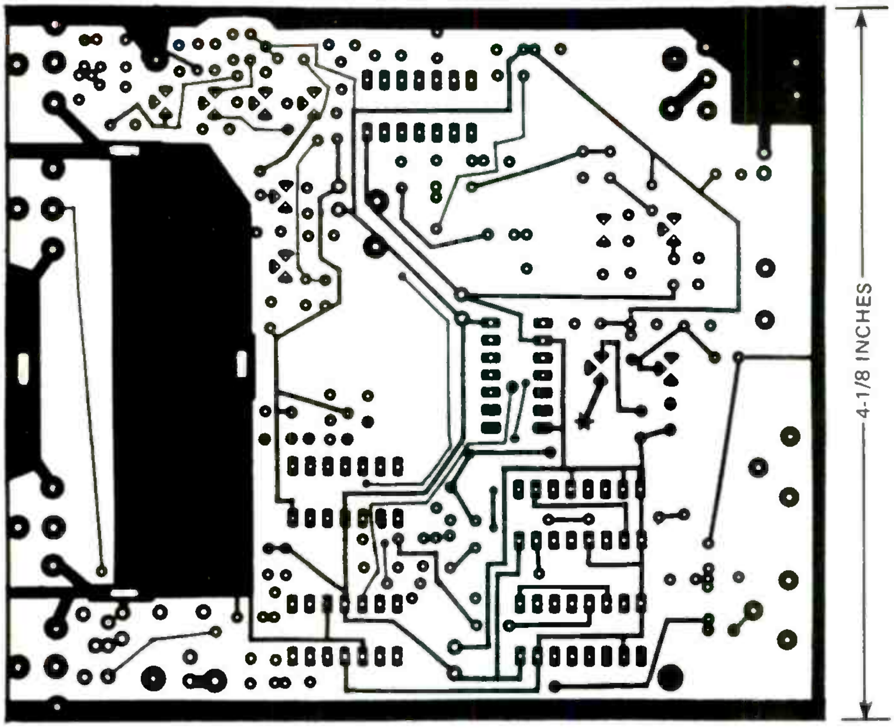

SINCE THE PC BOARD for the Telease-Maast decoder is double sided, feedthroughs should be installed at all unused pads. Also, be sure to solder all component leads on both sides of the board. The component side is shown here.

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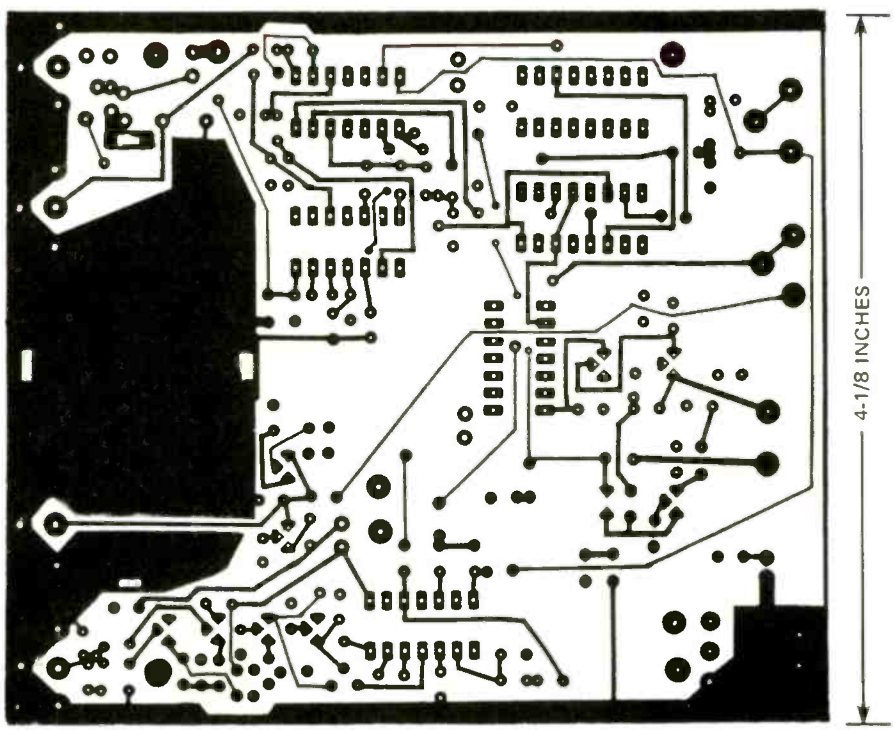

HERE'S THE SOLDER SIDE of our double-sided Telease-Maast decoder PC board. For more on the decoder, turn to page 50.

OSCILLATORS

continued from page 74

fairly linear output will result, because the capacitor is never allowed to fully charge or discharge. You can think of that graphically as restricting charging and discharging to a small portion of the curve shown in Fig. 4.

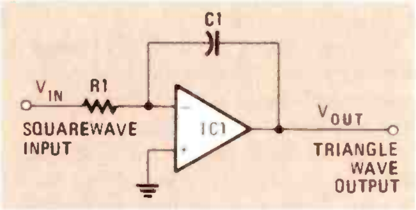

FIG. 7—A MILLER INTEGRATOR may be used to create triangle waves from squarewaves.

The schematic of a complete triangle-wave generator based on the Miller integrator is shown in Fig. 9. In that circuit a Miller integrator is connected to a squarewave generator. That circuit's frequency of oscillation is given by the following equation:

$$f = R2 / (4 \cdot R1 \cdot R3 \cdot C1)$$

In Listing 2 is another program (also in IBM-PC BASIC); that program will calculate the resistor and capacitor values of the triangle-wave circuit in Fig. 9. The program is very similar to the one for calculating the circuit requirements for a

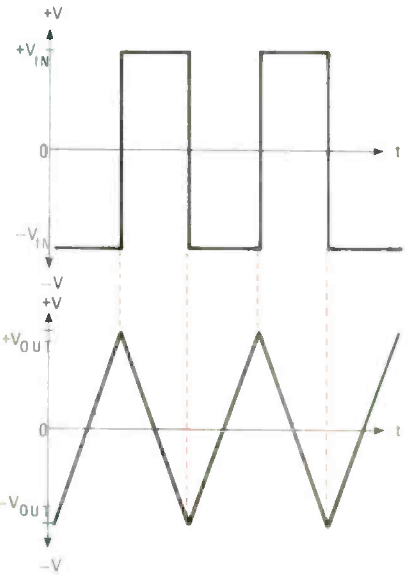

FIG. 8—LINEARITY OF A MILLER integrator is maintained by making the R1C1 time constant long compared with that of the incoming squarewave.

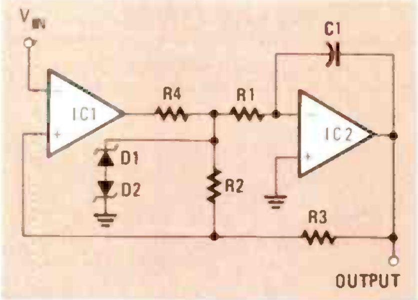

FIG 9—A COMPLETE TRIANGLE-WAVE GENERATOR may be built from a Miller integrator and a squarewave generator.

one-shot that is shown in Listing 1. The triangle-wave program, however, will calculate resistance values for both fixed- and variable-frequency oscillators. For the latter, a variable resistor (or a series combination of a fixed and a variable resistor) should be substituted for R2.

Next time

In the next installment in this series we'll discuss the crystal-based sinewave oscillator. Future installments will also deal with crystal-based squarewave oscillators; among other things, those circuitsw are used in computers and in other digital circuits for clocks and other sequence controllers. **R-E**

DELAY LINES

continued from page 71

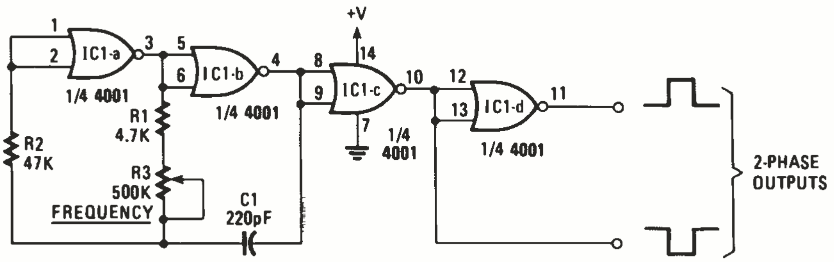

FIG. 17—A TWO-PHASE CLOCK is required by most analog delay lines.

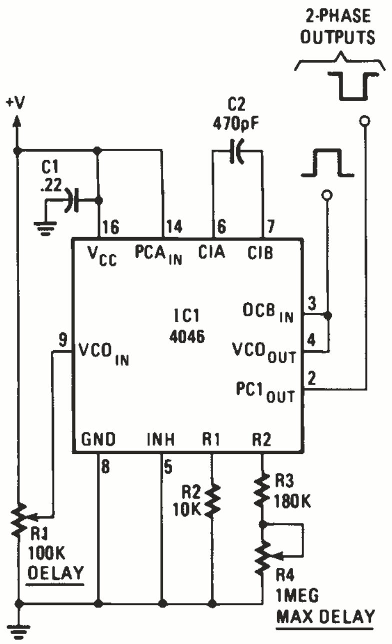

FIG. 18—A VCO CLOCK provides wider range and more precise control over clock frequency.

ted between the actual input signal and the input of the delay line to prevent aliasing problems. In addition, another delay line must be connected in series with the output of the delay line to provide clock-signal rejection and integration of the sample signals. For maximum bandwidth, both filters should have cutoff frequencies that are one third (or less) of the maximum clock frequency. The input filter usually has at least a 1st-order (6-dB per octave) response, and the output filter usually has at least a 2nd-order (12-dB per octave) response.

Figure 20 shows the schematic of a 25-kHz 2nd-order lowpass filter with AC-coupled input and output. The non-inverting terminal of the op-amp (pin 3) is biased at $V_{CC}/2$, usually by a simple resistor network. The cutoff frequency can be varied by giving C2 and C3 alternative values, but they should be maintained in a 1:6 ratio. For example, cutoff frequency can be reduced to 12.5 kHz by giving C2 and C3 values of 0.001 and 0.006 µF, respectively.

All delay lines suffer from a certain amount of insertion loss. Typically, if 100 mV is fed to a delay line, only 70 mV or so will appear at its output. So the lowpass filter on the output should be given some gain, in order to provide an overall circuit gain of one. That is done by designing the filter around an active element, such as an op-amp. **R-E**

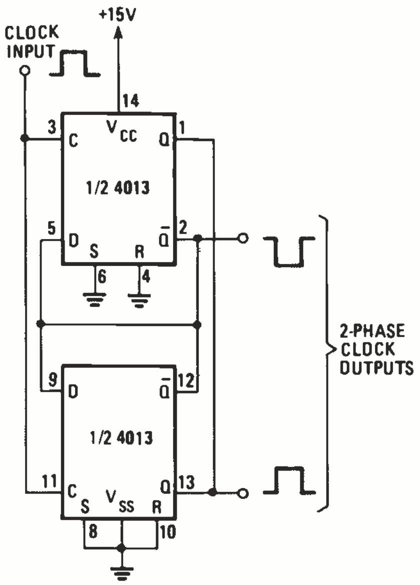

FIG. 19—A LOW-IMPEDANCE single- to two-phase clock converter is used with delay lines having high input capacitance.

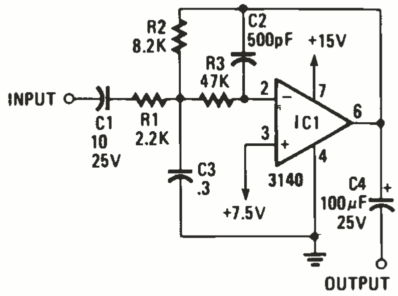

FIG. 20—THIS LOW-PASS FILTER has a cutoff frequency of 25 kHz and 2nd-order response.

RAID ON HBO

continued from page 49

receiver systems require that the RF level at the uplink receiver be kept within certain limits. HBO could, of course, increase power by a factor of 100, and place a 20-dB attenuator at the input to the receiver. But aside from being a crude solution, there's always the problem of getting to the uplink receiver.

Another approach would be to adopt a tactic used by 2-way radio repeaters to avoid unauthorized access. That is to require authorized users to place a subaudible tone on their carriers. The repeater cannot be activated by a signal that lacks the tone. Even more security is provided by using a digital access code.

However, once the transponder has been accessed, there is nothing to stop another signal from taking over the transponder, even if it is not encoded. That signal will control the transponder until the appropriate security circuitry detects an improper or absent access tone or code, causing the transponder to shut down. Therefore, even with such a system a pirate would be able to wreak havoc with the authorized user's signal. And, of course, the problem of reaching existing satellite equipment to make the required modifications remains.

What about the possibility of catching a video pirate? Typical dish beamwidths are 2° to 3°. Because of that, it is virtually impossible to detect a transmission from the ground using conventional means.

How about finding the signal from the air? Assuming that the pirate is using a really lousy dish, that is, one with a 3° beamwidth, sidelobes should be detectable out to about 10°. Sparing you the geometry, that translates to a detection area of about 3.14 square miles. (With a better dish, which is likely, the detection area would be even smaller). Consider for a moment the number of aircraft that would be required to cover the continental United States. And what if the signal originated off shore? Further, those aircraft would have to be in place constantly because no one aside from the pirate knows when he will strike next.

In summary, unless someone turns the pirate in, or unless his ego gets the better of him, the chances of finding Captain Midnight are just slightly higher than zero.

The possibility of deliberate interference to a satellite is a weak link in the satellite-communications chain. That fact has been obvious to the military since the dawn of the satellite age. But the military has the methods, and the money, to make their communications links secure. HBO and other programmers do not. It is little wonder that the industry is terrified. **R-E**

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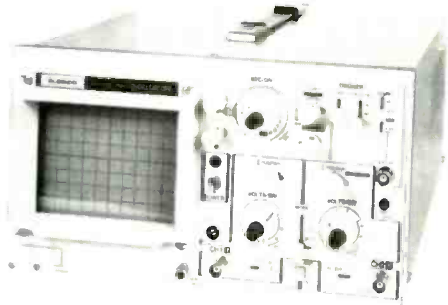

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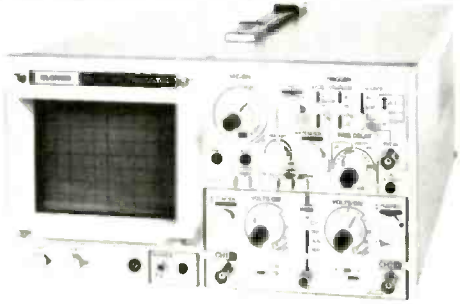

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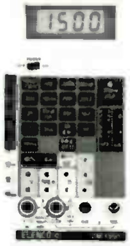

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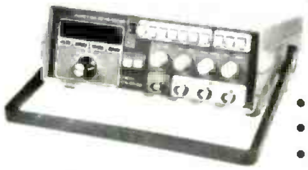

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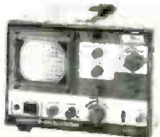

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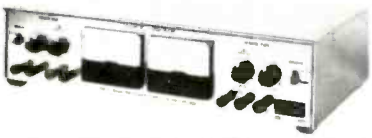

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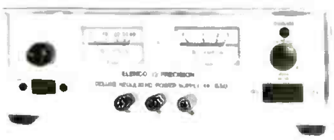

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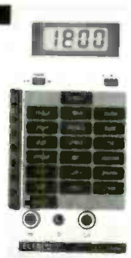

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ROBOTICS

MARK J. ROBILLARD,
ROBOTICS EDITOR

Rovers revisited

THOSE OF YOU WHO HAVE FOLLOWED this column since its inception will remember the simple two-wheeled mobile platform we presented in the September 1985 issue. That platform consists of a wooden base, two small wheels, and a surplus motor from a Milton Bradley *Big Trak*. No, there wasn't much to it, but apparently several readers thought that it was just right to start experimenting with robotics.

Then in the October issue we reviewed the *Scorpion* robot kit that is available from Rhino Robots (3402 N. Mattis, P. O. Box 4010, Champaign, IL 61820). Once again, based on the letters we've received, quite a few of you thought that was just the right way to get started in robotics.

This month we'll visit the subject of rovers again, for two reasons. One, a product has come to our attention that we feel warrants further investigation, and two, we've been revitalizing the simple platform robot.

Meet *Ernie*

Recently we received a large packet of information from a Canadian company called Microhmega (#6 918 16th Ave N. W., Calgary, Alberta, Canada T2M 0K3). The package contained the technical manual for their robot rover, who is named *Ernie*, and is shown in Fig. 1. My first impression was of *Ernie* was, "Oh no. Not another turtle." In fact, I was quite skeptical because of the Darth Vader sunglasses.

However, a day or so later I picked up the manual and began to read it. The image of a trivial toy robot slowly disappeared; as I read, it became clear that *Ernie* has designed-in features that I had not previously encountered in a product of his class. Let's look at *Ernie* in terms of both hardware and software.

FIG. 1

Ernie's hardware

Figure 2 shows a block diagram of the *Ernie* system. Keep in mind that *Ernie* is not *Hero 2000,* but, basically, a turtle. The CPU is a CMOS version of the popular 6502. That makes it easy to design custom programs for *Ernie* if you own an Apple II or a Commodore 64/128.

Storage is provided by 2K of static CMOS RAM. It is there that the programs you write and send to *Ernie* will be stored. The operating system that interprets your commands is contained in a 4K EPROM. I'll explain what's in the EPROM in the discussion of software later.

Motion is provided by two servo drive wheels. The servo mechanism is based on a small DC motor, and feedback to the controller (the microprocessor) is through an optical encoder wheel much like the ones described here in the September 1986 column. You can actually tell the microprocessor how far to move each motor, and it will take care of everything.

A rover needs more than a brain and some muscle to move around in our rather unpredictable world, so *Ernie* comes with a built-in sonar rangefinder. The sunglasses function as a bezel for the ultrasonic transducers. After discovering why the sunglasses are necessary, I never again winced at *Ernie's* style of dressing.

Microhmega has not neglected to include some entertainment value with *Ernie*. Whereas the Rhino *Scorpion* has a built-in tone generator and LED "eyes," *Ernie* is much more sophisticated. He sports an allophone-based speech

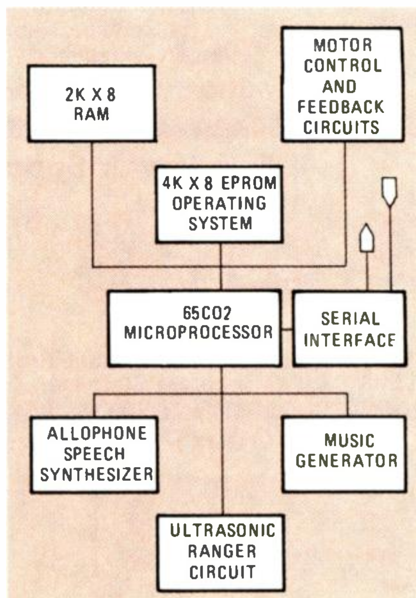

FIG. 2

synthesizer. (An allophone is a short sound segment that when combined with other allophones can be used to pronounce words in any language.) Although no provision has been made for a text-to-speech algorithm (which would convert ASCII-encoded text data into recognizable sounds), the manual does an excellent job of introducing the reader to the use of the synthesizer. A music synthesizer is also included.

Now for the important part. Sure, the CPU, memory, and the extra goodies are nice, but there is one aspect of *Ernie* I haven't seen in a rover before. *Ernie* has a built-in rechargeable battery pack. The machine comes with a portable charger that allows you to charge *Ernie's* batteries as simply as charging a calculator. No power-supply wires need be connected during operation (which can last for about two hours on a full charge).

Ernie depends on you for ideas. You write a program in his native language and download it to him. That is done over a simple TTL-level serial interface. If you have a computer with a ±12-volt RS-232 interface, use a pair of 1488 and 1489 IC's to convert those voltages to *Ernie*-compatible levels.

As you can see from our brief description, *Ernie* has the hardware to do some serious experiments. If you're a beginner and feel that your lack of experience would hamper your use of *Ernie*, I've got a pleasant surprise for you. The *Ernie* technical manual not only describes the robot from top to bottom, but it acts as a tutorial introduction to the field of robotics. Each subsystem—from the motors to the speech synthesizer—is described in detail from a beginner's point of view.

TABLE 1—ERNIE COMMANDS

COMMANDS	
Forward	Exit
Reverse	Again
Turnleft	Stop
Turnright	Look
Lookleft	Monitor
Lookright	Original
Wait	Sonaroff
Jump To	Sonaron
If Sonar	AvoidB
If Random	AvoidL
Else	AvoidR
Endif	AvoidS
Loop	Spk
Endloop	Auto
Do	M
	M2

Ernie's software

Built-in software includes a random roam program, a demo program, and a language interpreter. Upon power-up *Ernie* awaits a command. An action is initiated by pressing either of two microswitches located on his base. Pressing the left switch puts him into a "receive file" mode wherein a user-written program can be downloaded from another source.

The language interpreter, of course is what you use to write control programs for *Ernie*. Programs consist of sentences and paragraphs. Each sentence is composed of special command words that *Ernie* interprets and acts on. Table 1 lists *Ernie's* vocabulary. The language itself is called *Ernie's Mother*. Programs are written on your PC, compiled there, and then transmitted to the robot in special codes. *Ernie* comes with a special disk that aids the compiling and transmission process. The ability to write programs in *Ernie's* high-level language makes it easier to understand and modify those programs later.

As you can see in Table 1, *Ernie* has many typical commands for motion. In addition, there are conditional statements that check the sensors and act according to the presence or absence of a signal.

Ernie has much to offer the experimenter. The robot comes completely assembled and ready to go. The host software supports several popular personal computers, and more are on the way. The price for *Ernie* had not been fixed as of this writing, but it should be in the $500 range. Contact Microhmega directly for current price and availability.

Build it yourself

For those die-hards in the group, let's now revisit the motion platform mentioned earlier. Outside of the base and the motor controls, no electronic control circuits were presented. Since that discussion I've been busy adding to the system.

Figure 3 is a block diagram of the platform and the mechanical configuration as it now exists. The control circuitry is mounted on perfboard and the assembly is mounted on a second platform. After much investigation, I decided not to design the robot using any particular microprocessor. Instead, a "personality pack" plugs

continued on page 91

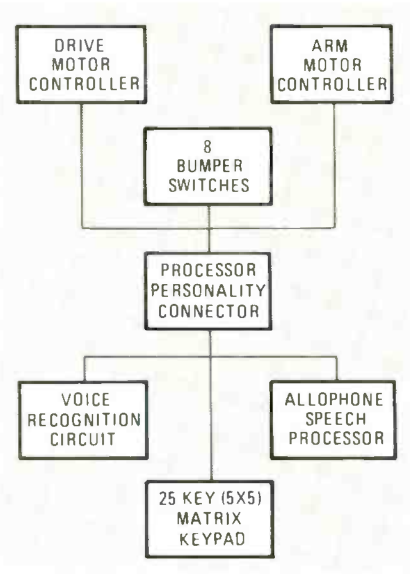

FIG. 3

SERVICE CLINIC

JACK DARR,
SERVICE EDITOR

The screwdriver serviceman

THERE ARE SO MANY DIFFERENT TYPES of screws and other fasteners in use today that you can never find the right screwdriver, nutdriver, etc., when you need it. So you have to maintain a collection of fancy expensive tools, like those shown in Fig. 1, that are seldom used, but indispensable when you need them.

However, as bad as things are now, they're much better than they used to be. In the (not necessarily good) old days, there were Phillips, Reed, and Prince screw heads, and several other types that showed up mostly on European sets. When you took the cover off a foreign set, you never knew what kind of arcane fasteners you would find. The Prince type has a crosspoint like the Phillips, but with smaller lands.

Fortunately, things are better today because parts of all kinds are much more standardized than they used to be. So we can often get by with only a few standard straight blade screwdrivers, a few Phillips cross-point screwdrivers, and a ¼-inch nutdriver.

Loose screws

I used to bring a bottle of screws on every service call. Then, if I ran into a set with oddball heads, I replaced all the non-standard screws with standard ones. (You can see that I was planning on being the next serviceman to work on that set!)

I'll never forget the TV that had four bolts in the bottom. After taking them out, the set remained as firmly fixed as before! I couldn't figure out what was going on until finally I woke up and found two

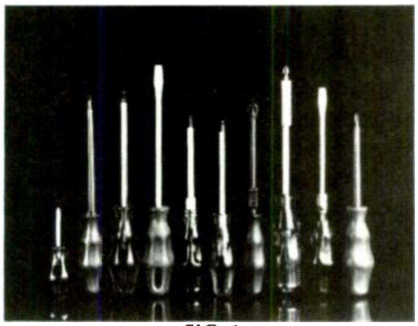

FIG. 1

more bolts that I hadn't seen! They were shipping bolts that were used to hold the chassis firmly in place during transit, and they should have been removed when the set was installed. I removed them and the chassis slid right out.

The good old days are gone, and it's all right with me if they never come back! I remember the days when my tube caddy was full of wrench sets and assorted thingamajigs for removing oddball fasteners. And I'm happy now that my toolbox is not so full of tools I hardly ever use. R-E

SERVICE QUESTIONS

CAN'T TUNE LOWER CHANNELS

I've been working on a Toshiba TV, model C998, that has a scanning tuner and a memory. The problem is that the higher channels—7 and up—can be tuned, but not the lower ones. Any help you can give would be deeply appreciated.—F.K., Port Hope, MI

It's times like these that make me understand why technicians are leaving the repair field by the droves. As television technology becomes more and more complex, the information that we have to work with becomes less and less helpful.

According to *Sams Photofact* for your set, the tuner has two input terminals (VHF high and VHF low). But the tuner schematic doesn't take us any further than that, so that we can see how the two inputs are used. However, we must conclude that each terminal is turned on by a voltage being applied to it at the right time.

If that is taking place, it's safe to assume that some other event is failing to occur in the tuner. But if it's not, you'll have to work your way back to the band-select switch and the control unit (IC101) to find what's happening in an earlier stage.

READER INPUT

Perhaps your readers might be interested in hearing about an experience we had at our Magnavox service center. We've had a number of sets come in recently that had repeated failures in various sweep-circuit components of several E34018 chassis.

On one set, we noticed that the flyback was running hot. After plenty of "hair pulling," we discovered that the picture tube required a higher G2 setting on our CRT tester. When we installed a new tube, the chassis ran much cooler.

We've spoken to the factory technicians who said that it was a new one to them, but that they would look into it.—Thanks to Chris Milda, Kirksville, MO

SATELLITE TV

BOB COOPER, JR.,
SATELLITE-TV EDITOR

The Ku change

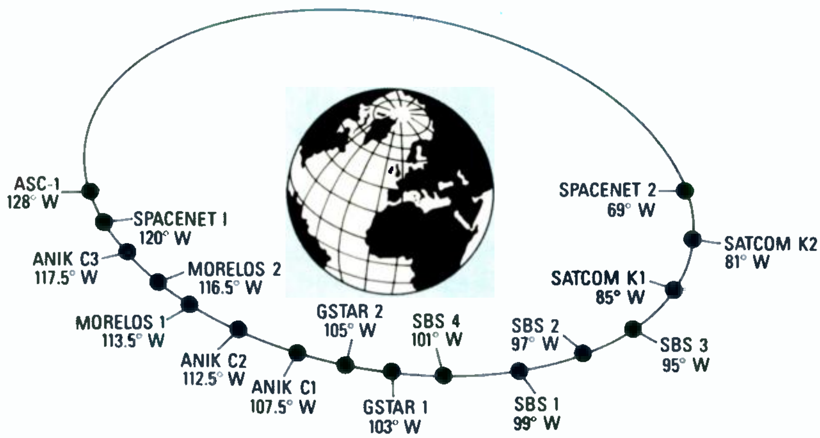

FIG. 1

THE NEW 11/12-GHZ OR KU-BAND SATELlites have had marginal impact on the video field to date. However, some people firmly believe that, as the Clarke Orbit Belt fills up, the next satellite revolution will take place on the higher frequencies. And the revolution has already begun; as you can see in Fig. 1, there are at least 15 satellites offering Ku-band service. But the Ku revolution is not going as smoothly as originally hoped; let's see why that is so.

The original C-band (3.7–4.2-GHz) satellites were launched in spite of the protests of AT&T and other terrestrial users of the C band. The Bell system's point-to-point microwave network covers the entire North American continent and is concentrated around major metropolitan areas. So there are many locations, in and around big cities, where you cannot install a C-band dish system without experiencing interference from signals originating from the Bell system's terrestrial communications network on C-band satellite channels.

Special filters and traps are available to reduce or eliminate that type of interference, but currently-available traps and filters leave much to be desired. The point is that the C band is not the ideal part of the spectrum to transmit weak signals back to Earth.

The Ku-band frequencies were reserved from the start for satellite-to-earth transmissions. There are actually two separate bands, both residing in the 11– to 12-GHz range. One is for something called "fixed service," which we won't discuss here; the other has been slated by the FCC for DBS (*D*irect *B*roadcast *S*atellite) service, which is the service we're interested in. Without interference from AT&T's terrestrial microwave sources in those two 500-MHz-wide bands, it is unlikely that there will be problems with those bands in and around metropolitan areas.

Currently there are only a few terrestrial users of those bands. They have been given a few years to move to a new band, but even today they operate in only a few locations, such as the Los Angeles basin.

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The FCC's original plan, which was formulated in 1979, called for satellite transmitter powers of about 230 watts per channel. Had that been technically feasible, dish antennas (on Earth) in the two- to three-foot range would have provided wideband video service. Since the plan was formulated, however, several technological changes have occurred:

- Receivers have become more sensitive, making it possible to receive weaker signals with smaller antennas.
- Attempts to produce satellite

transmitters at the 230-watt power level have failed.

Currently the only time-tested Ku-band transmitters operating on satellites can generate output powers of only 20 to 50 watts. That works out to be 6 to 8 dB less power than had been suggested for Ku-band service. Some of that shortfall can be compensated for by the improved receivers that are available today—they're much better than those that were available in 1979. The rest can only be made up with larger antennas that offer greater gain.

RCA and Ku

RCA, which pioneered the explosion of C-band services in the mid 1970's by launching a pair of 24-channel satellites for domestic use, has now launched a pair of 50-watt Ku-band satellites (Ku-1 and Ku-2). They are presently the most powerful satellites in orbit that offer commercial transponders for lease on the Ku band. Many of the transponders on the RCA birds have already been spoken for by the established cable programmers. And HBO is planning a partnership arrangement with RCA for the third satellite in this series, Ku-3.

So there is clearly much interest in the Ku band and the supposed advantages of shorter wavelengths. But, for all of the apparent advantages (mainly, smaller antennas and greater utility in metropolitan areas), there are some serious disadvantages as well. Rain is one. Moisture in the air, at either the uplink site or at any downlink site, can cause significant degradation of any passing signal. In a two-inch-per-hour rainstorm, losses of as much as 10 dB are possible for receiving sites with low "look" angles.

In 1978 Holiday Inn was a C-band pioneer; they installed terminals at hundreds of motels coast to coast. Now they are replacing the C-band terminals with 4.5-meter (that's about 14-3/4 feet!) Ku-band terminals, and are broadcasting a new five-channel TV service into their franchised and wholly-owned motels. Many of the 4.5-meter Ku-band dishes are actually larger than the C-band dishes they are replacing. Why is that the case, since Ku band is supposed to allow smaller antennas?

First of all, Holiday Inn is using a 20-watt (per channel) satellite; that's an automatic penalty of 4 dB, (compared with RCA's 50-watt satellites). Next, Holiday Inn's engineers are convinced that losses due to rain and heavy fogs will be severe, so they want as much reserve gain in their systems as possible to prevent loss of signal at any motel.

Years ago the careful planner of a small dish system always gave consideration to something called margin, extra gain simply tucked away in the closet to be used in the event of a rainy day (pun intended). A typical margin was 3 dB. You could build in margin by selecting a larger antenna than what was required for normal, clear-sky reception. The problem is that, on the Ku band, 3 dB will doubtless prove inadequate for many locations; especially those where heavy rains are possible. **R-E**

VOL. 3 NO. 10 October 1986

COMPUTER DIGEST

A NEW KIND OF MAGAZINE FOR ELECTRONICS PROFESSIONALS

OKIDATA UPGRADE

Breathing New Life Into An Old Workhorse

A GERNSBACK PUBLICATION

GRAPHIC BIOFEEDBACK MONITOR

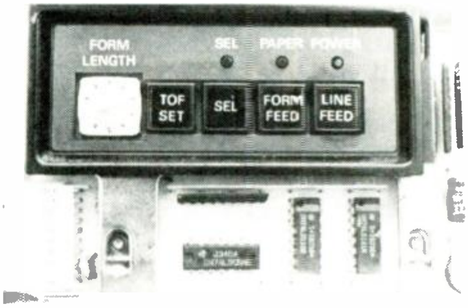
Using Your Computer to Control Emotions

TVRO ANTENNA POINTER

Taking Out The Guesswork

CONTENTS

Vol. 3 No. 10 October 1986



See Page 6

See Page 12

ON THE COVER

That big, beautiful OKDATA® printer you see on our cover may be little more than a gleam in your eye, but until you can afford to replace the one you have, you can upgrade to get more and better performance. See page 12.

COMING NEXT MONTH

We've got an absolutely dynamite issue coming up in November! We're kicking off with a story on streaming tape for computer backup, and following that with an easy-to-build protocol converter. Then we've got a handy-dandy program for helping design Schmitt triggers, and another program that gives you all the TV channel frequencies plus a lot more. And as a wrap-up, you'll find an excellent piece on retrofitting printers. Of course, we'll still have our Editorial, our Letters, and our Computer Products. It's going to be a winner, so don't miss it!

EDITORIAL

The changing face of computing

At one time, a "memory" unit consisted of tiny ferrite beads strung on three wires. Today, things have advanced radically And the room-sized computer that required a controlled temperature and raised floorboards has gone the way of the Reo, the Franklin, the Cord and the Tucker. Today's personal computer would appear to have reached a zenith, and the small "z" is intended.

But recently, we've seen advances in our own state-of-the-art technology that predict even greater things yet to come. Surface Acoustic Wave technology, optical disks, and advanced levels of miniaturization are aborning. If we could pull aside the veil, we'd see wonders as yet hidden and we can but speculate on what those might be.

Tomorrow's computer miracles are already here. We've already got fluorescent flat screens, we've got bi-directional high-speed printers, and scientifically-designed keyboards that allow you to almost think with your fingers. And our computers operate faster than the human mind, and accept your input at a faster rate than you can type it in.

Which reveals almost instantly what the weakest link in computing is... It's us, the human element that slows computing from what it could be to what it is. Our next great advance in computing is to design a new type of human. We should have *four* eyes instead of just two. In that way, those of us that have to look at the keyboard while inputting would be able to keep two eyes on the keys and two eyes on the screen. And since the typical computer keyboard has 83 keys, we should develop hands with at least 42 fingers on each one. In that way, one finger could rest on a separate key and the need to move the fingers while typing would be obviated. Imagine how that would increase your speed!

While I'm on the subject, we should have an RS-232 jack at the backs of our skulls so we could do away with the monitor entirely. When you're plugged into your computer, all you'd be able to see would be the screen, and you'd be able to do it without using a separate monitor.

And finally, I want to build an illuminated sign for the top of my monitor, that when it hears the words "DINNER'S READY" it automatically lights up and says "IN A MINUTE!"

Yes, some great, new advances are coming in the world of computers. I just don't believe that I've outlined any of them.

Byron G. Wels

Byron G. Wels
Editor

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LETTERS

The Cost of Change

I bought a new computer and find that my old serial printer won't work with it. An interface would cost almost as much as a used parallel printer. Could any of your readers use my old printer? It's letter quality, and I'd like to get a hundred bucks plus shipping costs.—P.T., Trenton, NJ.

We never meant the Letters Column to be "swap shop," but we're willing to help out.

Errors

Whenever I want to build a project in a magazine, I always wait a couple of months to see if there are going to be any corrections. Considering the number of projects you publish, there are relatively few mistakes! —R. S., Sioux Falls, SD.

Thank you! We thought we made a mistake once, but we were wrong!

Help!

I'm desparately looking for a program called "Computer Novel Construction Set" from Hayden Software. It's no longer being produced, and I'm willing to pay for it, or a copy of it. Can anybody help me?—L.S., Massapequa, NY.

If you can help, write to **ComputerDigest.**

Caveat Emptor!

If I buy a piece of computer equipment am I better off to buy something expensive or something far-less costly and upgrade it by putting in add-ons? I am a capable electronics technician but was wondering about the economics.—F.L., Ft. Lauderdale, FL.

It's hard to say. Usually we advise people to buy the best they can afford, thereby making their first expense their last. But if you construct your own, work carefully and install with equal care, you have the advantage of choosing your own times and costs.

Wants A Book

I read in a recent editorial that **ComputerDigest** is now three years old. Are you planning a book of "The Best Articles?"—R.S., Atlanta, GA.

Not yet.

Goof-Off

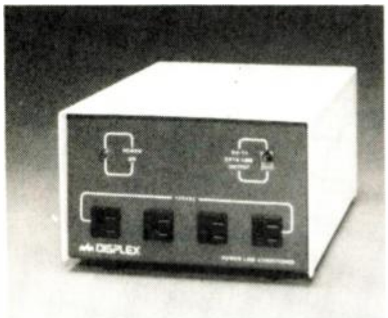
I'm trying to stall a science project for school and told the teacher I had written to you for information. So what's the value of a resistor with three red bands?—M.P., Portland, RI.

2.2K. Now get to work.

COMPUTER PRODUCTS

For more details use the free information card inside the back cover

LINE CONDITIONER, features a surge-protected RJ-11 data link, in addition to a plug-in AC power-surge suppressor, protecting sensitive electronics equipment against voltage spikes and surges, as well as virtually eliminating common-and-normal-mode noise. There is a noise rejection of 130 dB common-mode and 80 dB normal-mode.



CIRCLE 18 ON FREE INFORMATION CARD

A field-replaceable power-line surge arrestor is plugged into the unit and isolates itself if damaged by high-energy strikes. An LED status light continuously monitors its condition. The unit features better than 95% efficiency, potential to handle inrush current up to 10x rating, and multiple service outlets.

Line-conditioner units are available in 500VA, 1, 2, 3k VA power ratings, with end-user prices ranging from $395.00 to $935.00.—**Displex, Inc.,** 1 Alexander Place, Glen Cove, NY 11542.

GRAPHIC TABLET, the model *GT 1510,* is compatible with every personal computer available today; it interfaces easily with PC's when it is used in conjunction with CAD software.

Included with the model *GT 1510* are a pen and puck. It is the only tablet to offer the following as standard features: a relegendable menu-strip area with strips for AUOTCAD and blank for customized CAD instructions. In additon, it comes with a power supply and all cable connections.

CIRCLE 19 ON FREE INFORMATION CARD

The model *GT 1510* Graphic Tablet, complete with cursor puck and pen, is priced at $795.00.—**Cherry Electrical Products Corporation,** 3600 Sunset Avenue, Waukegan, IL 60087.

SOFTWARE REVIEW

How to back up a protected disk...

■As long as there were newcomers to personal computing the distributors of the most popular programs justified the prices for their software by the myth of *software pirates*, who made millions of unpaid for and unauthorized copies. Although it was the best of times for software sales—creating multimillionaires overnight—the distributors went to great lengths to prevent unauthorized backups, "unauthorized" meaning a backup for the user who might have just plunked down $300 to $500 for the program. Now, software sales are tough to come by. There are at least five decent versions of every kind of program, and with competition much of the top-selling software is now available in unprotected versions. Meanwhile, thousands of users are stuck with unbackable software, dreading the day when the "original" disk actually wears out (yes, oxide wears), while those who have converted to hard disk find the protected software won't run on a hard disk at all, or requires a "key" disk to be in drive A:. (Requiring a key disk eliminates the advantage of a hard disk, as well as wearing the unbackable original.) Either way, the protected programs provide limited use, and the distributors won't swap the protected software for the unprotected version.

A low-cost solution to the problem of older, protected software is a program called COPYIIPC, which can back up either protected disks or protected working disks, or it can bypass hard disk restrictions. A *protected working disk* is an uncopyable working disk that was created from the distribution (original) program disk by an *install* program. Either the working copy contains the DOS and is self-booting (but cannot be backed up), or it does not contain the DOS and must be used in Drive B: while the original distribution disk in Drive A: functions as a *key*. Often, the install program permits an extra backup working disk to be made from the original, but the original disk cannot be run by itself.

There are two kinds of hard disk restrictions. One precludes the program running from a hard disk even if the user can copy it to the hard disk. The other requires the distribution disk to be in Drive A: as the "key." If your computer has the usual one floppy and hard disk configuration, it's obvious that you can't write to a floppy data disk.

COPYIIPC which resolves the problems, consists of six utilities. Only four are used for making backups and by-passing hard disk restrictions. One of the others is a SETUP program which installs DOS on the disk so it can be made self-booting. (But the DOS must be an unmodified version.) The other is BULKERAS which electronically wipes a disk by destroying all data, leaving only the track formatting.

The backup utilities consist of the main COPYIIPC program itself, a special version for the IBM-PC-Jr., NOGARD, which backs up software that resists the normal COPYIIPC backup procedure, and NOKEY, which is loaded into RAM prior to a program from a hard disk and eliminates the need for a "key" disk in Drive A:.

COPYIIPC needs a minimum of 64K RAM but it will use all available memory to speed things. It will back up either single or double sided disks as written. It's equal to the DOS's DISCOPY and DISCOMP utilities combined. The COPYI PC program also tests the speed of the disk drives used for making backups because even with the drives running at the normal tolerance of 200 rpm backups should be made from the faster drive to the slower (you can run out of disk space if copying from a slower to a faster drive). While the easiest procedure uses two drives, backups can be made using one drive by following the screen prompts on when to swap disks.

COPYIIPC cannot make a functional backup of certain programs. although it might appear the backup is successful the program won't run from the copy. However, it will usually indicate this problem and prompt for the user to run the NOGUARD utility, which uses both the original distribution disk and the non-functional backup to create a functional unprotected copy that can even be installed on a hard disk.

Users of hard disks having several hundred dollars invested in software that won't run unless the original distribution disk is installed in drive A: as a "key" will find the most valuable feature of COPYIIPC to be the NOKEY utility, which is loaded into RAM just before the main program. NOKEY "tricks" the restricted program into believing the key disk really is in drive A:. Drive A: cycles once and as far as the hard disk is concerned the key disk really is in drive A:. However, drive A: is empty and available for a data disk, a disk file source, or whatever.

Although COPYIIPC backs up the distribution disk and frees the hard disk restrictions of many commonly-used programs, it doesn't work for everything.; at least that's what's implied in the documentation. (Since our collection of software is more or less conventional, everything we tried could be backed up or used on a hard disk.) Central Point Software supplies a long list of some 150 popular programs with which users have reported success using COPYIIPC. If you have software that isn't on the list the best thing to do is phone the distributor direct at (503) 244-5782.

COPYIIPC is available for $39.95 (plus $3.00 shipping and handling) direct from Central Point Software, Inc., 9700 SW Capitol Highway, #100, Portland, OR 97219. It runs on the IBM PC, XT, AT and PCjr., the Compaq, the Columbia, the Corona, and some other very compatible compatibles. If you're not certain it will run on your computer, call the distributor before you buy.

CIRCLE 17 ON FREE INFORMATION CARD

GRAPHIC BIOFEEDBACK MONITOR

Here's a simple and interesting experiment...

Ronald A. Peterson

■Biofeedback is a fascinating area of exploration in that it allows you to mechanically produce a physical reaction that is associated with a change in your thoughts. Perhaps some of the fascination comes from the possibility that with a subtle enough device one could draw a line on a computer screen or direct a robot to move an object. Such an advance would give us the ultimate in remote control and would provide an end to many excuses for not doing things, since the thought would be sufficient to trigger the action.

This article describes the interfacing of a simple biofeedback device to a Commodore 64 computer to provide a graphic display of your state of mental relaxation. The most easily measured property of your body which can be linked to changes in state of mind

```
1 REM---BIOFEEDBACK ROUTINES
2 REM---RE DECEMBER 5,1985
3 REM--- RONALD PETERSON
10 REM---LOAD MACHINE ROUTINES
20 FOR I=4096 TO 4165
30 READ A:POKEI,A:CK=CK+A
40 NEXT I
50 FOR I=12288 TO 12386
60 READ A:POKEI,A:CK=CK+A
70 NEXT I
80 FOR I=12544 TO 12557
90 READ A:POKEI,A:CK=CK+A
100 NEXT I
110 IF CK=22442 THEN 120
115 PRINT"ERROR IN DATA STATEMENTS"
116 STOP
120 REM---SET FREQUENCY
130 SYS4096
140 PRINTPEEK(8192)+256*PEEK(8193)
150 FORI=1TO100:NEXT
160 PRINT "[CLR]SET TO 50-->";
170 GETA$:IFA$<>"" THEN 200
180 GOTO130
190 REM---CLEAR SCREEN
200 POKE53280,0:POKE53281,0
210 FOR I=1024 TO 2023
215 POKEI,160:NEXT I
220 FOR I=55296 TO 56295
225 POKEI,0:NEXT I
230 REM---UPDATE GRAPHICS
240 SYS4096
250 Q=PEEK(8192)+256*PEEK(8193)
260 CL=CL+1:CL=CLAND15:POKE12434,CL
270 FOR J=1 TO 3*Q:NEXT
280 SYS12288
290 GOTO 240
295 REM---READ JOYSTICK PORT
300 DATA  120 , 169 , 0 , 141
310 DATA  0 , 32 , 141 , 1
320 DATA  32 , 173 , 0 , 220
330 DATA  41 , 1 , 240 , 249
340 DATA  173 , 0 , 220 , 41
350 DATA  1 , 208 , 249 , 32
360 DATA  64 , 16 , 173 , 0
370 DATA  220 , 41 , 1 , 240
380 DATA  246 , 32 , 64 , 16
390 DATA  173 , 0 , 220 , 41
400 DATA  1 , 208 , 246 , 88
410 DATA  96 , 173 , 0 , 32
420 DATA  24 , 105 , 1 , 141
430 DATA  0 , 32 , 173 , 1
440 DATA  32 , 105 , 0 , 141
450 DATA  1 , 32 , 173 , 0
460 DATA  220 , 41 , 1 , 240
470 DATA  232 , 96
480 REM---DISPLAY ROUTINES
490 DATA  169 , 0 , 133 , 251
500 DATA  169 , 216 , 133 , 252
510 DATA  169 , 0 , 141 , 144
520 DATA  48 , 169 , 40 , 141
530 DATA  145 , 48 , 162 , 12
540 DATA  173 , 146 , 48 , 172
550 DATA  144 , 48 , 234 , 234
560 DATA  145 , 251 , 234 , 200
570 DATA  204 , 145 , 48 , 208
580 DATA  247 , 32 , 0 , 49
590 DATA  238 , 146 , 48 , 238
600 DATA  144 , 48 , 206 , 145
610 DATA  48 , 202 , 16 , 224
620 DATA  234 , 234 , 234 , 206
630 DATA  144 , 48 , 206 , 144
640 DATA  48 , 238 , 145 , 48
650 DATA  238 , 145 , 48 , 162
660 DATA  12 , 173 , 146 , 48
670 DATA  172 , 144 , 48 , 145
680 DATA  251 , 200 , 204 , 145
690 DATA  48 , 208 , 248 , 32
700 DATA  0 , 49 , 238 , 146
710 DATA  48 , 206 , 144 , 48
720 DATA  238 , 145 , 48 , 202
730 DATA  16 , 227 , 96
740 REM---SUBROUTINE
750 DATA  165 , 251 , 24 , 105
760 DATA  40 , 133 , 251 , 165
770 DATA  252 , 105 , 0 , 133
780 DATA  252 , 96
```

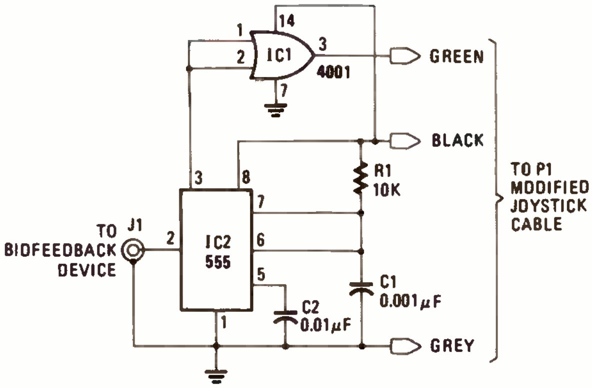


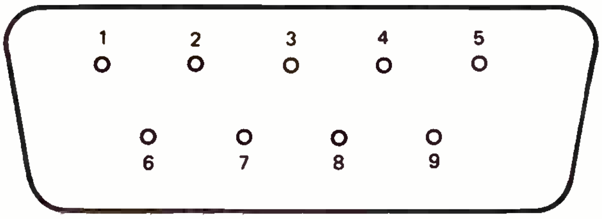
Fig. 1—SCHEMATIC DIAGRAM of interface device between joystick port and the biofeedback monitoring device.

is the resistance of your skin. To measure skin resistance we will use a biofeedback device made by Radio Shack (catalog #63-675, $12.95) The output of this device will be connected through a simple interface circuit to the joystick port on the computer and used to control the speed at which a graphic patterr changes.

To begin, build the circuit shown in figure 1. Since circuit speed is not a problem and there are no dangerous voltages, the construction technique is not critical. Building the circuit on perfboard or an experimenters socket is fine. A 1/8-inch miniature phone plug is used to connect the earplug outout from the biofeedback device to the circuit. A joystick extension cable is modified by cutting off the end that goes to the joystick in order to connect the circuit to the computer's joystick port. Pay attention to the color coding of the modified cable. (See figure 2.) Improper wiring could short out the five volt power supply in your computer, destroying it!

Next type the program into the computer and Save It BEFORE running it. Since the program uses machine code routines, any error in typing it in could cause the computer to hang up, thus making it necessary to type the program in again. When you run the program the machine code will be loaded into memory and automatically checked. Examine the DATA statements if an error occurs when it is run. The program can be tested by connecting a joystick to port 2 and running the program while moving the joystick up and down. A message will appear with a number next to it while you move the joystick. Keep moving the stick and hit the space bar on the computer. After a few moments the screen will clear and a graphic pattern will appear. If you do not get the pattern then something is wrong and you should check the program for typing errors.

To make it all work together, first load the program and run it. Then plug the biofeedback device into the circuit and connect the circuit to joystick port 2 on the computer. Next you need to set the frequency of the oscillator in the biofeedback device. It will not oscillate unless it is connected to something so attach it to your fingers and then turn it on and adjust its pitch control until the number next to the message on the computer screen begins to change. When you have a reading in the 50 to 200 range, hold down the space bar to activate the display. The screen will clear and a moving pattern will appear. Then sit back and relax! The speed with which the pattern changes should now alter depending on how relaxed you are. Since the device is sensitive to changes in skin resistance be careful not to move the hand with the electrodes attached to it or you will alter the pattern speed.



Pin	Color	Type
1	Green	Joy Up
2	Yellow	Joy Down
3	Orange	Joy Left
4	Red	Joy Right
5	Brown	Pot DY
6	Blue	Fire Button
7	Black	+5Vdc
8	Grey	Ground
9	White	Pot AX

Fig. 2—JOYSTICK PORT pinout diagram for the Commodore. Refer to the text for further clarification.

How it works

When you are relaxed your breathing slows, your heart slows down and your muscles loosen up. In this state your body doesn't need to burn as much fuel to keep going, and so with the furnaces damped down there is less oil, water and other wastes expelled through your skin. This causes a change in the resistance of your skin and it is this change that can be measured and fed back to your senses with the proper device.

Radio Shack's biofeedback device is essentially a variable frequency pulse generator where the frequency is controlled by resistance. A small current is fed through your skin, amplified, and then used to control the oscillator. The pulse output from the oscillator is fairly sloppy however so it has to be cleaned up before being sent to the computer. The 555 timer is configured as a monostable multivibrator (one-shot flip-flop) to extend the duration of the pulses which are then fed to an inverter made from a NOR gate to further square them up. Power for the circuit is provided by a +5Vdc line from the joystick port. The output of the inverter is fed to a pin on this port which is usually connected to the UP switch on a joystick. Thus each pulse from the biofeedback device is made to look to the computer like a joystick switch opening and closing.

The software contains three fundamental parts. The first is a BASIC routine which provides master control. The second is a machine language subroutine that reads the joystick port and counts the time between pulses. Lines 140 and 250 in the BASIC program read this count from where it is stored in RAM. The third is another machine language routine that draws the colored pattern on the screen. Line 260 in the BASIC program sets the starting color for the pattern every time it is redrawn. Machine language is used here for speed. The pulses from the biofeedback device are at audio frequencies and BASIC is far too slow to count the length of time between pulses. Changing all the colored bars on the screen would also be too slow in BASIC as shown by how fast the screen is cleared initially.

The software and hardware described here can be used for a variety of other purposes with little or no modification. The duration of events lasting less than a few seconds can be measured by connecting a switch to the joystick port in place of the circuit. A crude audio frequency meter could be built by using the machine code routine to measure the duration of one cycle. (A comparator and amplifier will probably be needed to square up and increase gain of the signal.) The code could also be modified to read the other joystick switch connections in order to sense several events simultaneously. (The lowest four bits at memory location 56320 represent the four joystick positions. The fifth bit is the fire button.) Experiment with it! Maybe you'll be the first to build a thought-controlled robot!

PARTS LIST
Semiconductors
IC1—4001 quad NOR gate
IC2—555 timer
Resistor
R1—10,000 ohms, ¼ watt, 5%
Capacitors
C1—.001μF., ceramic
C2—.01μF., ceramic
Miscellaneous
J1—Miniature phone plug
P1—Modified joystick extension cable (see text)
BF1—Biofeedback monitor (Radio Shack #63-675)
Wire, perfboard, solder, etc.

TVRO ANTENNA POINTER

Let your computer nail those satellites!

Elery C. Smith, Jr.

■Okay, you've got a computer and you're into Satellite reception for your TV. The program offered here will help you in aiming your dish right on the money, and we're even going to give you a way to check and make sure that everything's working right.

The TVRO Antenna Pointing program is written in BASIC and can easily be programmed into almost any computer. All your entries must be in decimal. If your

```
10 PRINT"TV CHANNEL FREQUENCY DIRECTORY"
20 PRINT"**********************"
30 INPUT"TV CHANNEL ";A$
40 A=ASC(A$):IFA>64THEN300
50 C=VAL(A$)
100 IFC<2THEN600
110 IFC<5THEN200
120 IFC<7THEN190
130 IFC<14THEN180
140 INPUT"UHF OR CABLE ";B$
150 IF LEFT$(B$,1)="C"THEN320
160 IFC>83THEN600
170 BC=14:BF=470:GOTO400
10 BC=7:BF=174:GOTO4 BC=5:BF=76:GOTO400
200 BC=2:BF=54:GOTO400
300 IFA>90THEN600
310 C=A-51:PRINTA$;" =CABLE CH# ";C
320 IFC>65THEN600
330 IFC<23THENPRINT"MID BAND CHANNEL":GOTO360
340 PRINT"SUPER BAND CHANNEL"
350 BC=23:BF=216:GOTO400
360 BC=14:BF=120
400 LB=BF+(C-BC)*6
410 UB=LB+6
420 FV=LB+1.25:FC=FV+3.58:FA=FV+4.5
430 FL=LB+47
440 IL=UB+41*2:IU=LB+47*2
450 PRINT"FREQUENCY RANGE=";LB;"TO";UB;"MHZ."
460 PRINT"PIX CARRIER=";FV;"MHZ."
470 PRINT"COLOR CARRIER=";FC;"MHZ."
480 PRINT"SOUND CARRIER=";FA;"MHZ."
490 PRINT"NOTE: THE FOLLOWING"
500 PRINT"ASSUMES A RECEIVER"
510 PRINT"WITH A 41-47MHZ I.F."
515 PRINT"(41.25MHZ SOUND, 45.75MHZ PIX.)"
520 PRINT"LOCAL OSCILLATOR=";FL;"MHZ."
540 PRINT"IMAGE RANGE=";IL;"TO";IU;"MHZ."
550 PRINT"MORE?"
560 GETC$:IFC$=""THEN560
570 PRINTC$:IFC$="Y"THEN20
580 END
600 PRINT"NON-EXISTENT CHANNEL":GOTO20
```

PROGRAM LISTING ABOVE is written in BASIC and lets you use almost any computer to help aim your satellite antenna.

```
TV CHANNEL?
36
UHF OR CABLE?
CABLE
SUPER BAND CHANNEL
FREQUENCY RANGE= 294 TO 300 MHZ.
PIX CARRIER= 295.25 MHZ.
COLOR CARRIER= 298.83 MHZ.
SOUND CARRIER= 299.75 MHZ.
NOTE: THE FOLLOWING
ASSUMES A RECEIVER
WITH A 41-47MHZ I.F.
(41.25MHZ SOUND, 45.75MHZ PIX.)
LOCAL OSCILLATOR= 341 MHZ.
IMAGE RANGE= 382 TO 388 MHZ.
MORE?
Y
**********************
TV CHANNEL?
W
W =CABLE CH#  36
SUPER BAND CHANNEL
FREQUENCY RANGE= 294 TO 300 MHZ.
PIX CARRIER= 295.25 MHZ.
COLOR CARRIER= 298.83 MHZ.
SOUND CARRIER= 299.75 MHZ.
NOTE: THE FOLLOWING
ASSUMES A RECEIVER
WITH A 41-47MHZ I.F.
(41.25MHZ SOUND, 45.75MHZ PIX.)
LOCAL OSCILLATOR= 341 MHZ.
IMAGE RANGE= 382 TO 388 MHZ.
MORE?
N
```

SAMPLE PRINTOUTS are for Orlando, Florida, and Huntsville, Texas. Enter our numbers after the program is installed and see if you come up with the same answers.

longitude is 95 degrees, 30 minutes, it must be entered as 95.5. And of course, you must not reverse longitude and latitude.

Included here are two typical samples of entries, one for Orlando. Florida, the other for Huntsville, Texas. To check your program once it's installed, simply enter my numbers and see if you come up with the same answers. It's that easy.

There's one other thing. Most computers calculate angles using radians. The .01745329 changes your "degrees" entry to radians and back to degrees again. If your computer compensates for a direct entry, simply leave the .01745329 out of the program.

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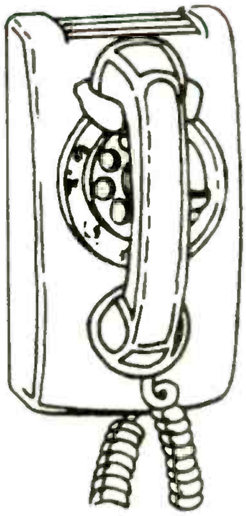

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OKIDATA UPGRADE

How to get more out of your Okidata— Without putting a lot more into it...

Elliott S. Kanter

■The Okidata Models 82 and 83A have for years been a part of many home and business computer systems. Their reasonable cost and good reliability and speed have made them a staple for the medium- or small-volume printer user who was willing to put up with inconvenience in exchange for the durability and reliability usually associated with an army tank.

One of the minor inconveniences present with both printers, which only vary in column width capability (82A-80 col., 83A-132 Col.) is clearly shown in Table 1, an actual print sample of the rather limited selection of (4) type sizes. However, to further complicate this limitation, there was no easy way other than writing a simple BASIC program with an appropriate "LPRINT" command to change these type sizes, unless you went to the trouble of customizing your wordprocessing program and convert these command codes to others which a program such as WordStar™ could recognize. As if to placate those users of the Okidata line, the company included some values/benefits which were not present on other printers. Okidata 82A and 83A supported your choice of either serial or parallel ports, to a degree. The serial port had a built-in speed limitation of 1200 baud and could only support certain protocols without the addition (at extra cost) of what Okidata referred to as a High-Speed Serial Card. Essentially, the parallel port followed the Centronics conventions, but the printer codes, those control sequences which determined what type size was selected, *i.e.* 10 CPI (normal type), 16.5 CPI (condensed type), 8.3 CPI (expanded type) or CPI (wide type) were not compatible with the defacto industry standard Epson codes. This made interfacing many of the features available to IBM™ PC users difficult unless you purchased a replacement set of ROM chips called the "Plug 'N Play" option or added the Okidata OKIGRAPH option. You had to really love the 82A/83A to put up with these minor inconveniences—but considering the fact that it would run forever with a change or two of ribbon, and was faster than the Epson competition, the printers found their way into many computer applications.

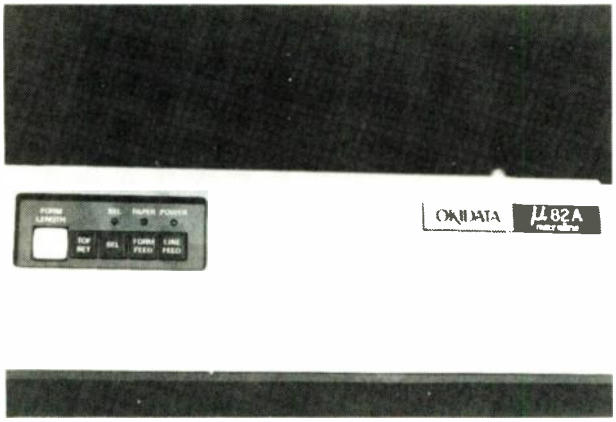

Fig. 1—Front view and orientation of the Okidata ML 82A Printer.

While offering two options to enhance the ability of the Okidata Printers to respond (much in the same fashion) as the IBM Graphics or Epson MX-80/MX-100 printers, not much else was done to improve upon the printing quality except perhaps by some diehards with the expertise to write custom programs and make the printers do other and somewhat better printing jobs. Yet at the same time there were aftermarket products available for the Epson products which permitted alternative type styles, sizes and even near letter-quality at fairly reasonable cost adding in the neighborhood of about $130.00 to the basic cost of the printer. When the Okidata owners called or wrote these companies whose ads said "...enhances dot-matrix printers....offers near letter quality...etc." they found out, sorry, but we only support the Epson and true-Epson compatible printers, we have no plans to support the Okidata products. This remained true until a Costa Mesa and now Irvine, California Company called Rainbow Technologies Inc., introduced the first in a series of enhancements for the Okidata printers. The original or parent product, OK-Writer™ added near letter quality, dot addressable graphics and other features to the printer via a PC card which replaced the existing three ROM chips, it also expanded the speed of the built-in serial port from its 1200 baud limitation to 2400 baud and provided some other goodies which were front panel selectable and didn't require any skills in computer programming.

Progress, like time, stands still for no person, company or computer and Rainbow Technologies built its second generation product, the PC-writer™, incorporating many of the features of the OK-Writer and adding just a few more enhancements like:

* Pica, elite or compressed type styles
* Double width characters in any type style
* Draft (DQ 120CPS) or Near Letter Quality (LQ 30 CPS)
* Ability to print all IBM printer symbols
* Ability to print double line box drawing symbols
* Backspace for easy overstriking

The items listed above can't really do the PC-Writer as much justice as the print sample of the self-test. This actual print sample is the result of the built in self-test activated from the front panel in much the same manner (pressing and holding the LINE FEED button while turning the power ON) as the conventional and unmodified self-test runs on the 82A/83A. However the results and printout are outstanding.

In order to gain some things you sacrifice others. In the case of near letter quality, the PC-Writer, like its competition, the super-enhanced Epsons will not operate at the nominal 120 CPS, but will slow to around 30 CPS, however, because near letter quality requires multiple passes, there's always a chance of a higher noise level due to vibration. In the case of the PC-Writer, this problem is minimized by converting the horizontal emphasis commands into vertical emphasis or double strike commands.

To make any dot-matrix printer's output more closely resemble near letter or letter-quality, the dots formed by the print head must be made to form a denser pattern. This is accomplished by multiple-passes and

Sample Printouts for Unmodified Okidata 82A

THIS IS A SAMPLE OF CONDENSED 16.5 CPI TEXT

THIS LINE RETURNS YOU TO NORMAL

EXPANDED 8.3CPI TEXT

RETURN TO NORMAL 10 CPI

WIDE 5CPI SAMPLE TEXT

RETURN TO NORMAL

Sample print out unmodified Okidata ML 82A printer. All print styles were accessed via "LPRINT" commands.

results in a decrease in speed. However, these usual techniques do not allow for all of the type fonts available with PC-Writer, and are the result of creative approaches to command code programming in order to make a printer whose average retail price (my area) was about $239.00 plus the PC-Writer (at a suggested list price of $112.95) perform like a letter quality printer selling for double its price! One catch, you have to be handy enough to install the small circuit board yourself.

For those of you who read and followed my articles in the July and August issues of Radio Electronics and built your own compatible PC/XT's what comes next will be a piece of cake. If you haven't worked on any electronics devices, the instructions and illustrations that follow will make the conversion seem easy enough to follow. A note of caution to either group of installer/builders, once the cover of your printer has been removed, there is a potential for accidental electric shock. Before proceeding any further, unplug your printer from the AC wall outlet and disconnect the cable leading to your computer.

You will need the following hand tools to accomplish the modification: Phillips Head screwdriver with at least a 4-inch shaft, IC Puller (Radio Shack) or small flat-bladed screwdriver.

These items are desireable, but not essential to the modification: Anti-static wrist bracelet, Diagonal Cutters, or A length of hookup wire, a 25K ohm (or greater) resistor and two alligator clips.

Warning

The PC-Writer circuit board module can be damaged by static electricity. Do not remove it from its protective packaging until you are ready to install it in your printer.

INSTALLATION

After you unplug your printer from the wall and computer, position it as shown in Figure 1. As you view the printer from the front, you will see to your right, a large black plastic knob coming out of the right side of the case. This knob is the platen knob and must be removed before we can proceed. Remove this knob by gently pulling it off and set it aside.

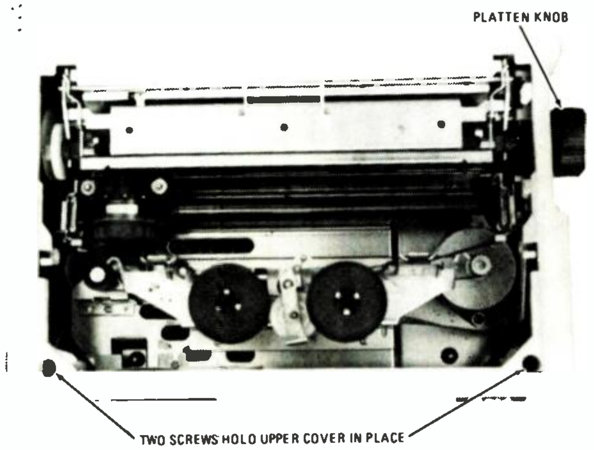

Fig. 2—Detail view with call outs of the upper cover showing the two screws which must be removed as well as the platten knob.

Remove the access cover by gently lifting it up and set it aside.

Refer to Figure 2 and loosen the two recessed phillips head screws which hold the front upper cover in place. Remove the cover by lifting it up and pushing it back to release the hooks located on the back panel of the printer. Carefully set the cover aside, taking the necessary precautions to avoid losing the two screws.

Turn your printer around as shown in Figure 3 and locate the control circuit board. It is normally located in the first slot from the rear unless you have the optional high speed serial card. If you have the high speed serial card installed, you will have to remove this card before going any further. If you have the high speed serial card, locate the two hold-down screws one at each side of the circuit board and carefully remove the board to enable you to access the control circuit board.

If you do not have the high speed serial card installed, loosen the two hold-down screws at either end of the control circuit board and carefully lift it up until you can identify the three large ICs located at the top right hand corner (as viewed from the rear) and shown in Figures 4. Using either the small flat bladed screw driver or the IC puller, remove these three 24-pin ICs by gently prying them loose from their sockets. The ICs are numbered 004, 005 and 006. You may have to remove cable CN5 from its socket on the control board in order to access these 3 ICs. Once you have removed the ICs you may put them aside, they will not be required when you install the PC-Writer module. Before proceeding with the installation, check that capacitors C27, C28 and C29 are at approximately a 60 degree angle relative to the control circuit board, if they are not, bend them as required. Check to see that capacitor C28 is at approximately a 90-degree angle and correct if need by bending. This will facilitate the installation of the PC-Writer Module.

If you have the anti-static bracelet, place it around your wrist and connect the alligator clip at the end of the wire to a suitable ground connection. If you are wearing a metal watch band, you can use the wire, resistor and two alligator clips to form a similar protective device. Connect one end of the resistor to one of the alligator clips. The other end of the resistor is fastened (twisting is suitable) to a bare end (either end of the wire), the remaining alligator clip should be attached to the end of the wire and connected to a suitable ground connection. The reason for these anti-static precautions is to eliminate the chance that static electric discharges could damage the PC-Writer module. Now you may open the PC-Writer container and carefully remove the module. Refer to Figure 5, the PC-Writer and locate it with the arrows pointing upwards and the circuit components facing you. If you are installing the PC-Writer in an Okidata 83A, locate resistor B labeled "CUT FOR ML83A." Using a diagonal cutter, carefully cut the wires attaching this resistor to the circuit board and discard the resistor. Carefully remove the protective foam from the underside of the circuit board, and observe the pins extending from the non-component side.

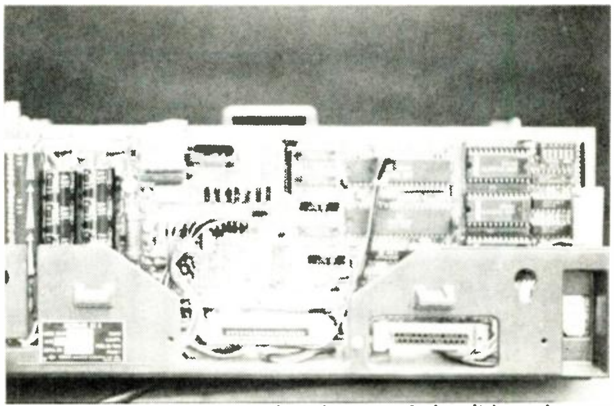

Fig. 3—Rear view of the printer's control circuit board visible when the upper cover has been removed.

Align these pins with the corresponding locations of sockets 004 and 006 on the circuit control card. Gently press the module into these two sockets and continue the pressure until all pins have been seated in the sockets. Your PC-Writer does not use socket 005. Check your work and ensure that all pins are firmly seated as shown in Figure 6. If you had to remove cable CN5, reconnect it at this time. Carefully slide the circuit board down and refasten the two hold down screws located at either end of the circuit board. Be careful not to pinch any wires under the circuit board during this step.

Turn your printer around so that it is facing you and set the front operator control DIP switch as follows:

Position	ON	OFF
1		X
2	X	
3		X
4		X
5		X
6		X
7		X

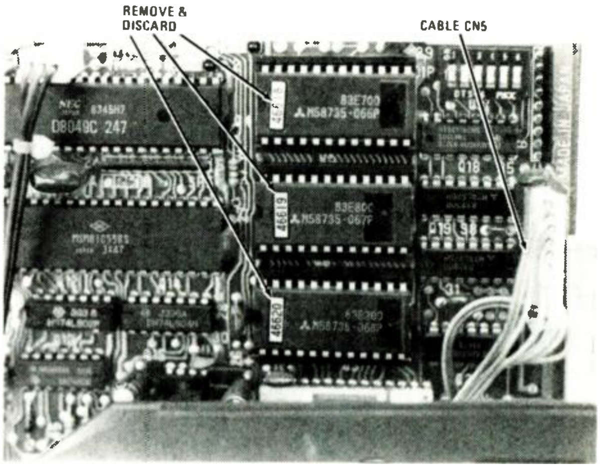

Fig. 4—Detail view of the ROM's (3) and the cable CN5. The 3 ROM ICs are removed and discarded, the cable CN5 may require disconnection.

If you wish, you may refer to Section 4 or Appendix C of the manual which comes with your PC-Writer to select other conditions, however, the conditions selected as shown above (2 on, all others off) are the recommended power-on conditions.

Replace the upper cover by reversing the process used to remove it. Hook the cover at the rear panel and seat it, ensuring that the wire paper guide is flipped forward. Using the Phillips screwdriver tighten the two recessed hold down screws. Replace the access cover and replace the platen knob previously removed. You have now completed the installation of the PC-Writer. The protective foam may be used to store the 3 ROMs removed from the printer. Proceed to the following section and test your installation.

Testing

Load your printer with paper. Plug the printer into the AC wall outlet. Press and hold the line feed button while you turn the power switch on. Release the LINE FEED button and your printer will begin to print the one page document/type sample. This one page will be repeated until you depress the SEL button or turn the printer OFF.

In case of problems

If the printer does not operate immediately and begin the self-test printout, turn the power off, disconnect the AC power cord and recheck all of the installation steps.

Exploring your new PC-Writer

Now that you have installed the module, the normal control functions of the Okidata Printer (See Figure 7) have been enhanced and have additional functions which will be described at this time.

LINE FEED BUTTON-With the printer deselected (RED LED SEL is OFF), pressing the button for more than one second causes the line feeding paper motion to repeat until the button is released. This can make it easier to move the paper over a short distance to the next top-of-form. It can also be used in conjunction with the TOF (top-of-form) button to advance the paper upwards by small amounts. Holding the TOF SET button down and gently pressing the LINE FEED button continuously will advance the paper, when you reach the desired position, relax the LINE FEED button and the new top of form will be set.

SEL (Select) BUTTON-Each time this button is pressed the print head will move to a new position. When the printer is first selected the print head will move to the left margin to recalibrate for proper printing. When you deselect the printer by pressing the button and the RED LED is off, the print head will move to the center to permit you to install the paper without the need to manually move the print head. It is also possible to put the printer ON-LINE after starting a form feed action even though the paper is still moving. Briefly press and release the SEL button and the SEL LED will come on as soon as the paper has stopped moving.

FORM LENGTH ROTARY SWITCH-This switch now has several new functions. If you are using the 132 col. 83A, switch setting 6 now selects a page length of 8½ inches rather than the 8 inch page length shown in the printer manual and repeated on the 83A's access cover. This will allow you to use paper 11 inches wide by 8½ inches high. The other uses of this rotary switch will be covered under the "Feature Selection" category.

Now that you have installed your PC-Writer, your Okidata Printer will provide full emulation of the IBM Graphics printer and more. How much more will depend on what you elect to set by using escape sequences described in detail in the PC-Writer manual (Section 6.2), how you make use of the front panel Features Selection which will be described in detail and your own specific requirements.

The default setting you made earlier on the DIP switch located on the form of the operator control panel enables the selection of all of the enhanced functions. If you desire to use only those functions used or supported by the IBM graphics printer, and no more, you would set switch 5 to ON and 1 and 8 to OFF, and not use any of the unique escape sequences for the PC-Writer. A description of some of the possible settings can be found in Section 4 and 6 of your PC-Writer's manual. For the present, let's leave the switch as

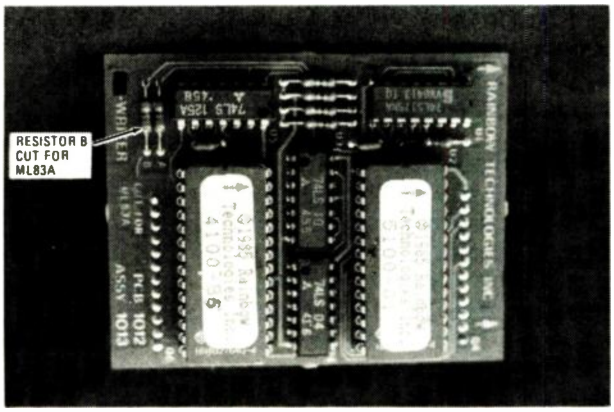

Fig. 5—The PC WRITER Module with call out for location of Resistor B. This resistor is not used with the wide carriage ML 83A printer.

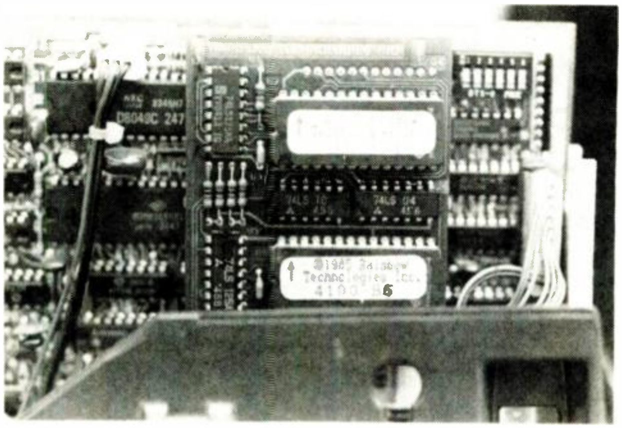

Fig. 6—The PC WRITER Module installed on the control circuit board.

set previously, and enjoy as much of the ease-of selection and feature as possible.

Feature selection

The PC-Writer's features can be accessed in two ways. The first is via traditional computer control mode, this will require that you use the escape sequences unique to your PC-Writer and for the present, we suggest that you confine yourself to the second mode, the user of the now enhanced Front Panel Selection Mode which will allow you access to the most desirable features without the need to program or refer to charts or tables.

FRONT PANEL SELECTION MODE-In this mode, you will use the SEL button, the LINE FEED button and the FORM FEED button and the FORM LENGTH rotary switch. Each of these controls and their function will be explained separately.

Selecting a feature

To convert the front panel control to feature selection, depress the SEL button for one or more seconds to activate the front panel selection mode. This is indicated by an audible tone and the SEL LED flashing at a rate of about 2 or 3 times per second.

To select a feature rotate the FORM LENGTH switch from its normal forms length setting to the desire setting as listed below:

Setting#	Feature Selected
0	Print HELP Menu
1	Letter quality
2	Elite character pitch
3	Compressed character mode
4	Wide characters
5	Shortened characters at 12 lines per inch (1pi)
6	Emphasized printing (bold faced)
7	Double Strike printing
8	Dumb terminal mode
9	Print shifting alphabet test

If position 1 through 8 is selected the SEL LED will indicate if that feature in ON (selected) or OFF. If the feature is ON the SEL LED will be ON more than it is off, if the feature selected is OFF, the LED will be OFF more than it is on. To change the setting or state of the selection, press the LINE FEED button once. Pressing it

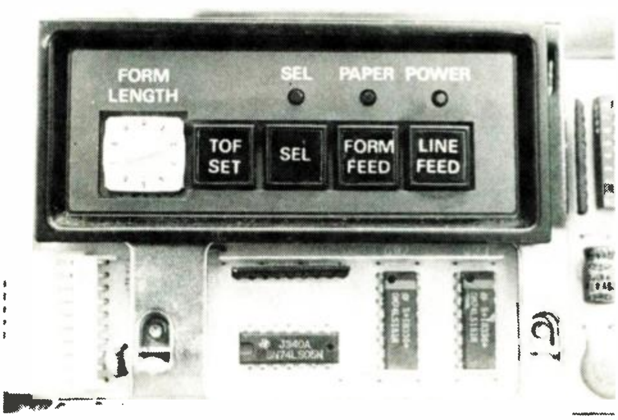

Fig. 7—Detail view of the front panel controls. All controls now have enhanced functions under the PC WRITER.

again will change the selected feature to its opposite setting (off becomes ON, or on becomes OFF). If the FORM LENGTH switch is at the 0 position, pressing the line feed button will print a list (menu) of the features available from PC-Writer and their status (ON or OFF). Position 9 if selected will immediately begin to print a shifting alphabet test as shown in Table 3. To stop this test, press the SEL button.

Draft quality is selected whenever letter quality is not selected. The compressed mode has no effect while the Elite character pitch is selected. Pica character pitch of 10 cpi is selected whenever neither elite or compressed mode is selected. Turning off the shortened character mode (Position 5) will also select 6 LPI spacing. In the dumb terminal-mode, all control codes except Carriage Return (CR), Line Feed (LF) and Form Feed (FF) are ignored.

You can also print out the part numbers of the PROMs installed in the module. This information could be helpful whenever you need to discuss either a problem or performance with a factory representative. To print these parts numbers, press the TOF SET and FORM FEED buttons simultaneously.

Once you have selected the desired features, briefly press the SEL button. The LED lamp will go off and an audible tone will sound to indicate that the normal off line (deselected) mode is in effect. Return the FORMS LENGTH switch to its normal forms length setting and press the SEL button again to place the printer ON-LINE. The printer will now be ready to print using the selected PC-Writer Feature.

While the normal functions of the operator front panel controls are well described and documented in your printer manual, using PC-Writer you can also make power-on selections of these features by pressing and holding the button while turning the printer power on. The buttons and their Power-On features are as follows: Operator Button Feature Activated TOP SET Compressed character pitch in draft mode FORM FEEDPica character pitch in letter quality mode SELElectronically reverses the operator DIP SW Pos 8 for ON/OFF or OFF/ON, allows both a serial and parallel cable to be connected to the printer (DO NOT USE WITH HI-SPEED SERIAL CARD!) LINE FEEDSelf-test and demonstration mode. FROM & LINE FEEDDiagnostic Hex dump mode

All features can be deactivated by depressing (deselecting) the SEL button once or when you turn off the printer.

There are many more things you can do with PC-Writer, but if they were all described here, Rainbow Technologies wouldn't have to print a manual. The manual that comes with PC-Writer has sections on code information which is well structured and complete enough to enable you to really take charge of your new printer and exploit it to the limit, after all that's one of the best reasons for buying an enhancement in the first place.

For more information about PC-Writer and any of Rainbow Technologies other products write to them at: Rainbow Technologies Inc., 17971-E Skypark Circle, Irvine, CA 92714. (714) 261-0228.

STATE OF SOLID STATE

Dual-condition sensing

ROBERT F. SCOTT,
SEMICONDUCTOR EDITOR

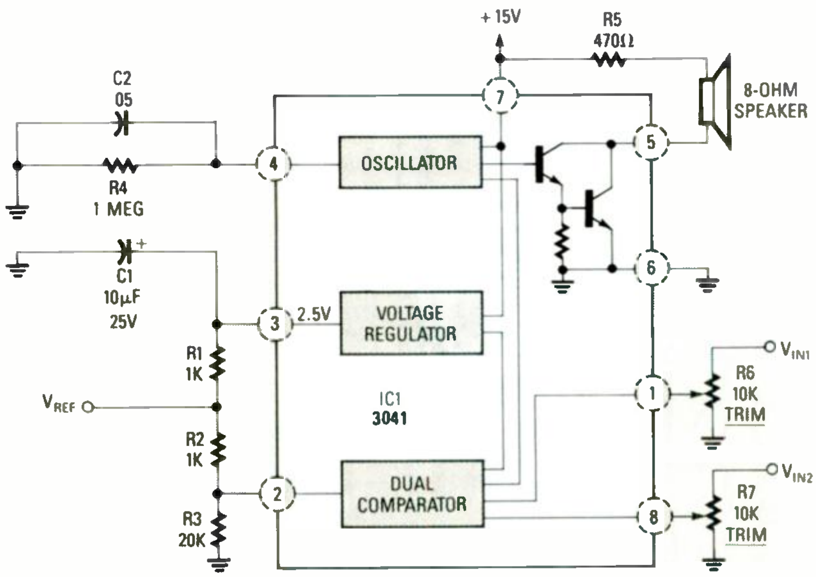

FIG. 1

OFTEN WE NEED TO MONITOR TWO DIFferent conditions and raise an alarm when either condition falls above or below a normal value. Those conditions might be, for example, the outputs of a dual-voltage power supply, indoor and outdoor temperatures, or the high and low levels of the contents of a tank.

The electronics of such a two-input monitoring circuit has been greatly simplified by the introduction of the 3041 Monitor/Alarm IC by the Microcircuits Division of Intech. The 3041 is a dual-input circuit designed to monitor two different voltages and give an indication if either varies from the preset level by more than a user-settable predetermined percentage. The IC can provide a steady or an oscillating output, depending on the state of pin 4. The steady-state output is suitable for driving an LED, a lamp, or a TTL gate; the oscillating output is suitable for driving a speaker or a lightbulb.

The 3041 is packaged in an eight-pin mini-DIP. As shown in Fig. 1, it consists of a dual-input voltage comparator, a voltage regulator, and an oscillator. The 2.5-volt reference that is supplied by the regulator may vary between 2.2- and 2.7-volts DC. The reference voltage is available at pin 3. Maximum current drain (with the alarm on) is 13 mA from a 5-volt supply, and 25 mA from a 15-volt supply. Temperature stability is typically +50 ppm/°C.

The dual-input comparator monitors the voltages applied to pins 1 and 8, and compares them with reference voltage V_{REF}, which is present at the junction of external resistors R1 and R2. Actually, the voltage at pin 2 of the IC is used as the reference voltage, but the voltage at the junction of R1 and R2 is a more accurate representation of the voltage to which the comparator inputs are compared.

Only six discrete components are needed to build a basic monitor/alarm circuit. External resistors R1 and R2 are typically 1000 ohms each. Resistor R3 is determined by the desired "trip" tolerance, the percentage deviation from normal that will cause the alarm to trip. The resistor's value can be calculated as follows:

$$R3 = (100{,}000 \div \%\ \text{Tolerance}) - 1000$$

The accuracies of resistors R1, R2, and R3 affect the tolerance of the comparator outputs by a factor of 10:1. For example, if the value of R3 is off by 5%, the comparator output will be off by 0.5%.

Capacitor C1 filters the voltage regulator's output, reduces noise to the comparator, and ensures a high-resolution trip point.

The internal oscillator can be disabled by grounding pin 4. For an AC output, connect an RC network to that pin as shown in Fig. 1. The values shown there will produce an output of about 1000 Hz; other frequencies are easily obtainable by using other components. Intech's data sheet contains a nomograph that aids component selection for various frequencies.

The 3041's open collector output (pin 1) can supply as much as 30 mA of current. The output is off (high) when both comparator inputs are within tolerance, and on (low) when either input is out of tolerance. With the component values shown in Fig. 1, when either V_{IN1} or V_{IN2} varies more than 5% from V_{REF}, a 1-kHz tone will be heard.

The 3041 can be used to monitor negative voltages. To do so, just connect pin 6 to the most negative point rather than to ground. If only one input is used, the other must be connected to the V_{REF} pin.

Ripple detection

The 3041 can be used to detect ripple or oscillation at the inputs. To do that, connect a capacitor between the arm and the upper end of one of the input potentiometers. The DC voltage level is set by adjusting the pot while the AC signal is fed directly to the input through the capacitor. The circuit will respond to a peak AC voltage of 150 mV with a 5% tolerance setting, 230 mV with a 10% setting, and 420 mV with a 20% tolerance setting.

The value of the capacitor is determined by the value of the pot and by the lowest frequency of the signal that is to be detected. After setting the potentiometer for the desired DC level, measure the resistance between the arm and the high end. Select a capacitor whose reactance at the lowest frequency is small compared with the resistance it will be shunting.

For a data sheet and additional information on the 3041, write to **Intech, Inc.** Microcircuits Div., 2270 Martin Ave., Santa Clara, CA 95050-2781.

New dual JFET op-amp

NEC Electronics has introduced the μPC812, a new low-offset-voltage dual-JFET-input op-amp designed for stable operation when driving high-capacitance loads. Even when working into a 6800-pF load, the μPC812's output is absolutely stable. That stability is the result of using NEC's high-speed (f_T = 300 MHz) PNP transistor in the output stage. The high-speed transistor eliminates oscillation problems when sinking current into a large capacitive load.

Other features of the device include low input-offset voltage (3 mV maximum) and low input-offset voltage temperature drift (7 μV/°C). In addition, the device has output short-circuit protection, internal frequency compensation, and a high slew rate (13 V/μs).

Applications include fast sample-and-hold, high-speed integrators, and any circuit requiring high-performance input and output characteristics. The μPC812 is available in standard 8-pin plastic DIP and surface mount packages. Pricing for the DIP package is $0.66 for 100+ lots. **NEC Electronics, Inc.**, P. O. Box 7241, Mountain View, CA 94039.

Quad multiplying D/A

Precision Monolithics' DAC-8408 quad 8-bit, multiplying CMOS D/A converter with memory is designed for applications that require data-path verification, self diagnostics, and PC-board space savings.

The IC contains four identical 8-bit DAC's on a single CMOS chip. Each DAC has its own reference input, feedback resistor, data latches, and internal 3-state buffers. The IC uses an 8-bit TTL/CMOS-compatible data port that is bus-compatible with most 8-bit microprocessors, including the 6800, the 8080, the 8085, and the

Z80. The port is common to all DAC's in the IC; doing so reduces pin count and allows the device to be packaged in a 28-pin, 0.6" DIP.

The DAC-8408 features a read/write capability that allows each DAC's data word to be read from an addressable memory location. By reading the latched register contents back, the controlling computer can execute data-path verification, self-checks, and analog output updating.

The device is available in two grades in both military/industrial and commercial temperature ranges. Prices in 100-piece lots range from $8.03 for the lower-grade commercial devices to $35.82 for the top military grade. **Precision Monolithics**, P. O. Box 58020, Santa Clara, CA 95052.

New P-channel JFET's

The 2N5460–2N5465 from Siliconix are low-cost P-channel JFET devices designed for a broad range of applications, including servo amplifiers, analog switches, level shifters, and control loops. Featured are high breakdown voltages of 40 to 60 volts, low operating currents of 1 to 9 mA, and high gain (1000 to 6000 µmhos, minimum). Fast switching is made possible by the devices' low interelectrode capacitance (typically 1 to 5 pF). The JFET's come in TO-92 packages. In 1000 piece lots the 40-volt 2N5460, 2N5461, and 2N5462 are $0.40 each. The 60-volt 2N5463, 2N5464, and 2N5465 are $0.60 each. **Siliconix, Inc.,** 2201 Laurelwood Rd., Santa Clara, CA 95054.

High-power Darlingtons

The ZTX600 is the latest addition to Ferranti's family of E-Line (TO-92) NPN Darlington transistors. The new series of high-performance, medium-power devices handle collector currents of as much as 1 amp, and that makes them ideal for automotive and industrial applications. Pulsed currents (I_{CM}) of up to 4 amps, and gains (h_{FE}) up to 100,000 at continuous currents ranging from 500–1000 mA are attainable.

The ZTX600 series offers V_{CEO} ratings of 140 to 160 volts. The construction of the E-Line package permits high junction temperature operation (200°C) that is usually associated with metal-can devices, which can dissipate up to 1.5 watts.

The ZTX600 series is available with several lead configurations and on radial or surface-mount tape for auto-placement. Unit prices are below $0.18 in quantities of 50,000. **Ferranti Semiconductor,** 87 Modular Ave., Commack, NY 11725.

Four new MOSFET's

Four ITT-type MOSFET transistors that complement its line of N- and P-channel devices have been announced by Ferranti Semiconductors. The devices, BS170P, BS107P and BS107PT (N-channel), and BS250P (P-channel) are numbered according to the Pro-Electron or European system. They provide low threshold, low leakage and fast switching at breakdown voltages between 60 and 200 volts. The BS107P and BS107PT can withstand lightning surges of 1500 volts.

The BS107P costs $0.31 in lots of 1000. The BS107P and BS107PT cost $0.41 and $0.42, respectively, in similar quantities.—**Ferranti Semiconductors,** 87 Modular Ave., Commack, NY 11725. **R-E**

ROBOTICS

continued from page 84

into the control board; the personality pack provides the CPU and any memory it requires.

The arm used for the robot is an adaptation of the Milton Bradley *Robotix* series we discussed in the July 1986 issue. Optical encoders are placed on all joints; feedback from them is routed to the control circuitry. Motor control is by means of subminiature mechanical rather than solid-state relays.

The mobile platform also includes an allophone speech synthesizer. The IC set is available through Radio Shack.

Because of the complexity of the construction details, it is not feasible to present them here. If you are interested in obtaining a full packet of information on the robot (schematic, theory, programming, and mechanical details) drop me a note and include a self-addressed stamped business envelope. **R-E**

COMMUNICATIONS CORNER

Closed-captioning

HERB FRIEDMAN,
COMMUNICATIONS EDITOR

IN THE OLD DAYS, WHEN TECHNICIANS showed up for a remote broadcast in black tie, a remote broadcast generally required a separate cue and chit-chat circuit that was independent of the primary signal path. But just about any sort of communications circuit costs big bucks, whether it's a private radio or telephone system, or someone with a pocketful of change ducking into the nearest phone booth. So, as soon as it became technically feasible, broadcasters began to piggyback subsidiary communications on the main TV and FM broadcast channels.

The FM SCA (*S*ubsidiary *C*ommunications *A*uthorization) subcarrier channel was legal as far back as 1945, but until recent times the FM subcarriers were used almost exclusively for telemetering the transmitter, or as a second broadcast channel for background music and "storecasts." FM subcarriers were not used as a substitute for a conventional communications system.

But thanks to modern technology it is now relatively easy and convenient to integrate independent cue and control signals with the main broadcast signal. And it's also possible to piggyback special programming with the main broadcast signal.

Piggyback channels

Two examples of commonly used piggyback communications are the television professional subcarrier channel and closed-captioning for the hearing-impaired. The professional channel is an audio subcarrier that is displaced 102.3 kHz from a TV station's main audio carrier. It can have a maximum power output no more than 10% of the main audio carrier. Unlike the TV SAP (*S*econd *A*udio *P*rogram) channel, which is locked to the horizontal sync, the professional subcarrier is crystal controlled and limited to ±3 kHz deviation. It is intended specifically for station business such as the control tones that are used for electronic news gathering, and for cuing and coordinating remote broadcasts. Pro subcarrier signals might also be used to aim the antenna that is used to receive microwave signals from a remote pickup truck, or it might simply turn on a light that means "You're on the air."

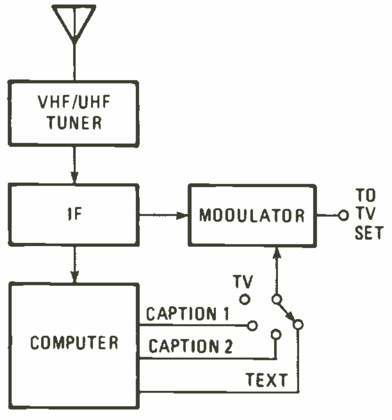

FIG. 1

Closed-captioning is a means whereby titles and "balloons" are superimposed on a TV picture so the hearing-impaired can understand TV programs and commercials (yes, commercials). Titles are similar to the subtitles used in foreign films, in that they run across the bottom of the picture. Balloons are shorter subtitles that resemble the "speech balloons" used in comic strips. The words are positioned adjacent to the person speaking, and that helps convey the flow of conversation when several persons are in the picture.

Closed-caption reception requires a special adapter which is nothing more than a special-purpose microcomputer combined with a VHF/UHF tuner and an RF modulator that can deliver a signal to TV channel 2 or 3. As shown in Fig. 1, the adapter connects to a standard TV set just like a VCR or a cable converter. The major difference is that the computer decodes the captions and inserts them into the conventional TV picture. (We'll present plans for a closed-caption decoder in the next month's issue.—*Editor*)

Closed-captions do not interfere with normal video because the ASCII captioning codes are inserted into the TV signal during line 21 of Field 1, which occurs during the vertical blanking interval. The microprocessor in the closed-caption adapter extracts the data from line 21, converts it into displayable form, and applies it to the modulator for output. (Line 21 of Field 2 is generally not used for other than perhaps a control signal because only half the line is available for ASCII encoding.)

The ASCII data in line 21 represents a single character which may be preceded by a "preamble" that contains information needed to position the inserted text: the line on which it is located, and its indentation from the left edge of the picture. The preamble permits the title or balloon to be located any-

continued on page 97

R-2000

All-mode receiver

Superior engineering, quality, and performance describe Kenwood's multi-mode communications receiver.

The R-2000 receiver has the most often-needed features for the serious or casual shortwave broadcast listener. Listen in on overseas news, music, and commentary. "Listen up" on the VHF public service and Amateur radio frequencies, as well as aircraft and business band communications with the R-2000 and VC-10 option. The R-2000 has a muting circuit so you can monitor your Amateur radio station's signal quality.

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- Memory scan.
- Programmable band scan.
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- Squelch circuit, all mode, built-in.
- Noise blanker built-in.
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Service manuals are available for all receivers and most accessories
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Optional accessories:

- VC-10 VHF converter for R-2000 covers 118-174 MHz
- YG-455C 500 Hz CW filter for R-2000
- HS-4 Headphones
- HS-5 Deluxe headphones
- HS-6 Lightweight headphones
- HS-7 Micro headphones
- DCK-1 DC cable kit for 13.8 VDC operation

Additional information on Kenwood all-band receivers is available from authorized dealers.

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ANTIQUE RADIOS

RICHARD D. FITCH,
CONTRIBUTING EDITOR

Antique radio cabinets

IT'S HARD TO TALK ABOUT ANTIQUE RAdios without also talking about the cabinets of antique radios. Those cabinets are as collectible as the chassis they contain. In the early days of radio, it was not unusual to have an elaborate cabinet for the speaker and none at all for the chassis. Some early speaker cabinets were so large that there was room inside to mount the chassis, which many listeners did. And many chassis were mounted in cabinets made for purposes totally unrelated to radio.

The antique of the month

Speaking of large cabinets, the massive 1940 Philco Model *41-616* combination radio/phono shown in Fig. 1 has the largest cabinet in my collection. Measuring 40 inches across and about 48 inches high, it completely dominates my "shack." Usually the shack is used only for quarantine and preliminary inspection. However, that console was too large to carry down to my "museum" (the cellar).

I received the Philco just for removing it from a location where it was unwanted. Not being one to turn down anything free, I planned to restore that monster and then sell it (or trade it) for some older (and smaller) collectibles. But, after repairing the chassis and hearing the big-band sounds emanating from the grille cloth, I decided to keep it. Now I listen to it whenever I work in the shack. My only problem is getting in and out of the shack, because the Philco almost completely blocks the door.

Its 15-tube chassis has a broadcast band and three shortwave bands; and a 14-inch dynamic speaker is located under the record changer.

Antique cabinets

Over the years, the radio cabinet took the form of everything from a simple box to a huge elaborately scrolled cabinet. When the chassis was no longer repairable, a nice cabinet might be converted into a bookcase, a grandfather clock, a lamp, a bird house, a phonograph, a secretary, or any of a number of other things.

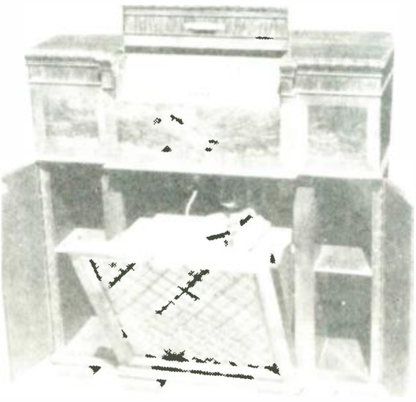

FIG. 1

On the other hand, many clocks, etc., had more than enough space to mount a radio chassis and a speaker. These days many collectors come into possession of an unidentifiable radio built into a clock or some other device by an early radio hobbyist. In fact, the only identifying information may be the tube numbers. Many readers have indicated that that lack of identification is a common problem.

For many years radio cabinets followed (and sometimes led) fashions in furniture design. Of course, being beautiful was not the only function of a radio cabinet. In addition to protecting the internal circuitry, the cabinet also provided a baffle arrangement for the loudspeaker.

Both the magnetic loudspeaker and the dynamic cone loudspeaker (both of which were discussed here in the September 1986 issue) sound better when mounted in a cabinet. Because it has trouble reproducing low notes, the magnetic loudspeaker greatly benefits from a baffle.

Enclosure design

Speaker cabinets weren't used just for looks and to house the chassis; they were designed to improve the sound produced by speakers. So designers spent a great deal of effort trying to match enclosure and loudspeaker to get the best looks and the best sound. Some designers went to fantastic lengths to come up with better-sounding speaker enclosures. In fact, collectors who dismantle the cabinets of some 1930-era consoles may well be baffled by the baffle arrangement (pun intended). You may not be able to find the speaker because of all of the internal parts! Another area of much engineering effort was the fabric design of the loosely-woven grille cloth. It was hoped that the grille cloth wouldn't interfere with the sound waves.

Through the 1930's the ability to reproduce bass notes was the most desirable feature, and one of the hottest selling points, of many console radios. Bass response was improved by using a large reproducer, by adding bass and treble controls, and by using a well-designed enclosure.

In the developing days of radio, not just the type of speaker, but its location were items of contention among designers. In an effort to improve reproduction, shelves were installed, removed, installed in another location, and so on, in early cabinet designs. Information on that type of alteration, and others, could be obtained from the early radio magazines.

For some unknown reason, cabinets for radio chassis were not very popular. Buying radios in bits and pieces was the beginning of "component" sets, which younger readers may think began with hi-fi in the 1950's. Actually, component sets are as old as radio itself.

Many speaker cabinets were large enough to use as closets. Enterprising experimenters knew that an oversized speaker cabinet and a cabinet-less chassis could be combined. Even then, as little as 25% of the grille area might be taken up by the speaker.

Of course, it would have been a crime to destroy the front of a beautiful speaker cabinet to mount a chassis with tuning dials, volume controls, etc., protruding through the front. But there were ways around that. To maintain the integrity of the front panel of the cabinet, one place to put the tuning knob, volume control, and power switch was on the side. Of course, the chassis had to have provision for appropriate shaft extenders, as well as for other mechanical fixes.

Converting a console speaker cabinet to a complete self-contained radio was a very popular activity in the late 1920's. There were thousands of builders, and that explains why many collectors have attractive, professional-looking radios that they can't seem to be able to identify.

The cabinets themselves were made by hundreds of different cabinet makers; many of them didn't bother to label their work. All it took was a few simple alterations, such as adding a shelf, to be able to mount the chassis in the cabinet.

A homemade tuning knob (with a painted dial) that is mounted on the side of a cabinet is a good clue that a radio wasn't originally a console radio. Converting those speaker cabinets to console radios surely didn't please the cabinet manufacturers, because the added shelves and other components did little for the cabinet's sound quality. If a back panel was present, it had to be removed to allow heat dissipation, and heat was something there was plenty of in early chassis with big tubes. Also, an AC-powered amplifier located close to a speaker often created hum that didn't exist when the speaker was mounted in the cabinet alone.

Baffle design

Sound waves emanating from the front of the speaker cone must be separated from the out-of-phase sound waves emanating from the rear. One fairly successful attempt to separate those sound waves looks like a speaker mounted on a paddle. The "paddle" is called a baffle board, and the assembly was designed to complement the furniture that was in style at that time (the late 1920's).

One baffle board, the 1928-ish *Musicone*, was made by Crosley. When first introduced, the *Musicone* sold for under $40.00 complete. That was quite a buy, when you consider that a magnetic speaker was included. The *Musicone* is an attractive piece of furniture with an ornate, scalloped, solid mahogany baffle, and a three-legged stand. Standing about 40 inches tall, the baffle of the *Musicone* can be adjusted from side to side to accommodate the listener's pleasure.

As with other components of developing radio, there was much controversy over which type of cabinet was best, and how components should be mounted inside it. Some designers thought that the speaker should be mounted in the top of the cabinet so that sound would be directed at the ears of the listeners in the room. Many readers have sent in photos of that type of antique radio, such as the Grigsby Grunow *Majestic;* some RCA models with a phono mounted over the speaker (from about 1933); some RCA Radiolas; the Stromberg-Carlson *Highboy*, and several Philco models, such as the nine-tube model *90B* shown in Fig. 2.

FIG. 2

It may have been a good idea to mount the speakers at ear height, but tuning some of those sets was difficult. You might have to get down on your knees to see the tuning dial, which sometimes was mounted a scant 14 inches above the floor.

So some people used the bottom part of the speaker cabinet as a baffle. The speaker faced downward, so sound came out of the bottom of the cabinet. That type of cabinet could be used only in rooms with heavily carpeted floors, because the echoes that result could degrade the sound quality.

The speaker-design wars ended in a compromise: Speakers were mounted in the bottom of the front panel facing forward. The difference in sound (from the upper position) wasn't noticeable, and the radio was much easier to tune when the dial was mounted above the speaker.

Early speaker cabinets often had thin supporting legs, but later the legged cabinets gave way to models that were enclosed almost all the way to the floor. The extra cabinet, besides conforming to more modern ideas about furniture design, gave the engineers new ways of reinforcing the bass notes. The extra length of the cabinet made it possible to delay the sound waves (by bouncing them around inside the cabinet) until they were in phase with the waves coming from the front of the cone.

Troubleshooting hints

It you have a cabinet with a "Labyrinth," you must remove a felt hood to get at the speaker. Be sure to replace the hood (behind the speaker) and all cabinet parts, or the sound will not be reproduced as the manufacturer intended. Also, speaker cabinets without backs should stand about six inches from a wall, or in a corner for best sound.

Most early cabinets were made of extremely heavy wood. The "Sonic Arc" baffle made by RCA required a heavy cabinet. So did their model that pumped bass tones through pipes and emitted them in phase through the bottom of the baseboard.

When you dismantle those cabinets to service the loudspeaker, don't destroy all the early engineers' hard work. Be sure to replace everything just as it was when you finish. Remember: that includes any sound-deadening material, and especially the heavy flat or curved backboards.

Haves and needs

We have one "have" this month, and a copule of "needs."

Tony Peterson (800 12th Ave. NE, Blaine, MN 55434) needs a 1939 Stromberg Carlson, 12-tube remote control unit.

John Kendall (301-877-3593) has a Jackson model *648* tube tester for antique tubes. George E. Kemmet (60-05 70th Ave., Ridgewood, NY 11385) needs someone to repair a Majestic Model *90*.

Help needed

I am compiling a list of useful reading material for inclusion in a future column. If you have a book, magazine, newsletter, catalog, reprint, or other source of information that you consider particularly useful, I'd appreciate it if you would let me know about it. Please include a sample issue, or complete publication data, including a source where it can be purchased by our readers. **R-E**

COMMUNICATIONS CORNER

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where on the screen.

If you think that a single character per line may not provide much information, bear in mind the fact that there are 30 usable fields per second. So in two seconds the system can transmit almost two complete lines of subtitles, which the microprocessor then integrates into a single display. Characters don't come up on the screen one at a time unless the captioning is being done in real time.

You might wonder whether the adapter can simply strip off the video information and display only text (in the manner of Teletext). A Teletext bulletin-board is, in fact, one of the options provided by the adapter's function selector. For example, the Teletext mode is used to piggyback news bulletins from the ABC network onto broadcasts, and real-time school news and notices on educational stations. **R-E**

MARKET CENTER

PLANS AND KITS

CATALOG: Hobby/broadcasting/1750 meters/ham/CB: transmitters, amplifiers, antennas, scramblers, bugging devices, more! **PANAXIS,** Box 130-F10, Paradise, CA 95969.

STEREO TV adapter kit Easily converts any TV/VCR to receive the new stereo TV sound. Contains all parts PCB and instructions to build a quality stereo decoder. For additional information send SASE to **SOKOLOWKSI,** Box 150, Elmont, NY 11003.

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CRYSTAL radio sets, plans, parts, kits, catalog $1.00. **MIDCO,** 660 North Dixie Highway, Hollywood, FL 33020.

BUILD this five digit panel meter and square wave generator including an ohms, capacitance and frequency meter. Detailed instructions $2.50. **BAGNALL ELECTRONICS,** 179 May, Fairfield, CT 06430.

VOICE disguisers! Telephone bugs! FM bugs! Other kits! Send stamped envelope: **XANDI,** Box 25647, Dept. 60C, Tempe, AZ 85282.

EPROM, EEPROM zapper kit. Stand alone, RS232, parallel. $5.00 plans, $99.00 kit, free literature. **MICRO KIT,** 6910 Patterson, Caledonia, MI 49316 (616) 791-9333.

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PROJECTION TV...Convert your TV to project 7 foot picture. Results comparable to $2,500 projectors. Total cost less then $30. Plans and 8" lens $21.95. Illustrated information **free. MACROCOMA-GB,** Washington Crossing, PA 18977. Credit card orders 24 hours (215) 736-3979.

MOBILE telephone using your 2-way radio, plans $9.95, with Pc/brds $24.95. Parts available. **CURRENT DEVELOPMENT CORP,** Box 384, Westmoreland, NY 13490.

TELEPHONE bug, FM room bug schematics with detailed construction procedures using Radio Shack's numbered parts. Both, $6.00. Receivers available. **SCHEFFIELD ELECTRONICS,** 7223 Stony Island, Chicago, IL 60649.

FLASH 6 bright LED's, random pattern. Round etched board plus schematics, $2.79 post-paid. **PARAWING,** PO Box 65, Menlo Park, CA 94026.

STRANGE stuff. Plans, kits, new items. Build satellite dish $69.00. Descramblers, bugs, adult toys. Informational photo package $3.00 refundable. **DIRIJO CORPORATION,** Box 212, Lowell, NC 28098.

FOR SALE

TUBES new, unused. Send self-addressed, stamped envelope for list. **FALA ELECTRONICS,** Box 1376-2, Milwaukee, WI 53201.

LINEAR parts, tubes, transistors —MRF454 $16.00, MRF455 $12.00, MRF477 $11.00, MRF492 $18.00. Catalog. **RFPC,** Box 700, San Marcos, CA 92069 (619)744-0728.

OLDTIME radio programs on high quality tapes. Comedy! Adventure! Music! Free catalog. **CARL F. FROELICH**, Heritage Farm, New Freedom, PA 17349.

TV tunable notch filters, free brochure. **D.K. VIDEO**, Box 63/6025, Margate, FL 33063 (305)752-9202.

TEST equipment, reconditioned. For sale. $1.25 for catalog. **WALTER'S**, 2697 Nickel, San Pablo, CA 94806 (415)724-0587.

LASERS and nightvision surplus components. Free catalog. **M.J. NEAL COMPANY**, 6672 Mallard Ct., Orient, OH 43146.

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CRYSTAL RADIO

continued from page 55

tinuity from the beginning of the coil to the end.

The coupling coil, L2, is wound in the same manner as the larger coils, but it's wound on a smaller (3¼-inch diameter) form, and is made up of 16 turns of 26-gauge DCC wire. The anchor spoke has a single mounting point, so that the coupling to L3 can be adjusting by pivoting L2 around that point.

Diode D1 can be just about any germanium diode. But if you want to keep your crystal radio authentic-looking, you should mount it in a case like the one shown in Fig 2. Such cases were commonly used to mount fixed-contact catwhisker detectors.

The variable capacitor is a 200-pF device. It won't be easy to find, so feel free to experiment with its value. Capacitors C1 and C3 are fixed-mica types.

Perhaps the most important part of building the receiver is putting up the antenna system. For good results, your antenna should be as long and as high as possible. If you can manage to put up a 75-foot long-wire antenna, great! Just remember: your ground system is also very important. A four-foot copper pipe or rod hammered into the earth can make a good ground. If you can't manage that, try your cold-water pipe.

The wooden base shown in the photographs is about 11 by 7 inches (it's ¾ inch thick). The edges are routed for a smooth appearance. Choose some type of hardwood, such as oak or maple for the base, and sand it well. Stain it according to taste, and then give it a couple of coats of satin-finish polyurethane. *(Sand very lightly)* between coats.

If you want to finish both sides of the breadboard base at the same time, then use four woodscrews as temporary feet. (Install them where you will be installing the rubber feet.) Finish the bottom of the breadboard first, and then turn it over and finish the top and the sides. The screws will keep the bottom of the board from touching anything else. Before you give the breadboard a second coat (which we do recommend), just be sure to let the first coat dry thoroughly. Then sand very lightly with super-fine-grit paper, and apply the second coat.

When your base is finished, it's time to start mounting parts. The parts on the prototype (and the available kit), including the coil taps, are mounted on small bakelite panels which are, in turn, mounted to the base. The main tuning capacitor, the headphone jack, and the antenna tap switch are mounted to the front panel, which is, in turn, mounted to the base using small "L" brackets.

Operating the receiver

Tuning your crystal set can be tricky business until you get used to it. The first step is to set the detector tap to the midway point, and to set the antenna tap switch, S1, to 0 (minimum inductance) and adjust L2 for maximum coupling to L3. When you plug in your high-impedance headphones, you'll hear one or more stations.

Tune to a station at the lower-frequency end of the band by adjusting the main tuning capacitor, C2, so that its plates are about 2/3 in mesh. Then reduce the coupling between L2 and L3, until you can barely hear the station. Advance the antenna tap switch until you reach the peak volume for that station. When that station is tuned, you can reduce the coupling further between L2 and L3. While that will reduce the volume, it will increase the receiver's selectivity, so you can tune in other stations on nearby frequencies.

Once you get used to tuning the radio, you can experiment with the detector tap. If you are in a strong-signal area, you can probably get by with decreased inductance of L3. That will increase the receiver's selectivity also. **R-E**

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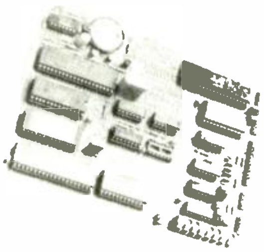

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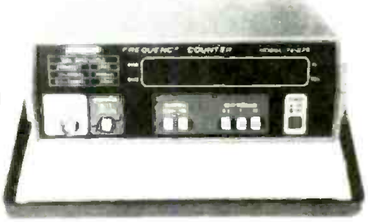

■ Eight digit LED display ■ Measurement range: 1Hz-120MHz ■ High input sensitivity of 20mV RMS. For detailed specifications call for a complete Tenma catalog.

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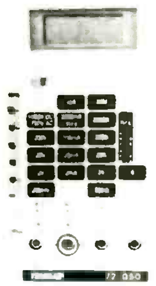
TENMA 0-18V 3A Power Supply

■ Regulated outputs — constant volt or constant current, both are continuously variable ■ Can be connected in series or parallel for more voltage or current output ■ Reverse polarity and overload protected ■ Isolated output. For detailed specifications call for a complete Tenma catalog.

#72-420
$99.50 (ea.) — 1 YEAR LIMITED WARRANTY

TENMA 3½ Digit LCD Multimeter



■ Measures resistance, AC-DC voltage and current ■ Diode and hFe transistor tests ■ Overload protection ■ 10Mohm input impedance ■ Carrying case included. For detailed specifications call for a complete Tenma catalog.

#72-050
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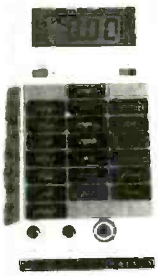
TENMA Digital LCR Meter



■ Measures inductance, capacitance and resistance ■ L = 1μH-200H, C = .1pF-200μF, R = .01ohm-20Mohm ■ Carrying case included. For detailed specifications call for a complete Tenma catalog.

#72-370
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TENMA Clamp-On/DMM

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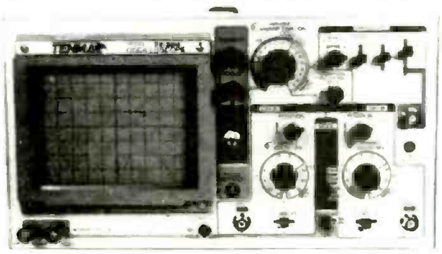
TENMA 20MHz Dual Trace Oscilloscope



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2114L-15	1024x4	(150ns)(LP)	1.95
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4164-150	65536x1	(150ns)(5v)	1.29
4164-120	65536x1	(120ns)(5v)	1.95
MCM6665	65536x1	(200ns)(5v)	1.95
TMS4164	65536x1	(150ns)(5v)	1.95
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41128-150	131072x1	(150ns)(5v)	5.95
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2732	4096x8	(450ns)(5V)	3.95
2732A	4096x8	(250ns)(5V)(21V PGM)	3.95
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27C64	8192x8	(250ns)(5V)(CMOS)	5.95
2764	8192x8	(450ns)(5V)	3.49
2764-250	8192x8	(250ns)(5V)	3.95
2764-200	8192x8	(200ns)(5V)	4.25
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27C256	32768x8	(250ns)(5V)(CMOS)	10.95
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5V=Single 5 Volt Supply 21V PGM=Program at 21 Volts

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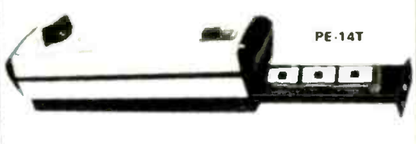

Model	Timer	Capacity Chip	Intensity (uW Cm²)	Unit Price
PE-14	NO	9	8,000	$83.00
PE-14T	YES	9	8,000	$119.00
PE-24T	YES	12	9,600	$175.00

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8224	2.25
8237	4.95
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8259-5	2.29
8272	4.95
8279	2.49
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Z80B-PIO	4.25
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1.0 MHz

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74LS01	.18	74LS166	.95
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74LS04	.16	74LS174	.39
74LS05	.18	74LS175	.39
74LS08	.18	74LS191	.49
74LS09	.18	74LS192	.69
74LS10	.16	74LS193	.69
74LS11	.22	74LS194	.69
74LS12	.22	74LS195	.69
74LS13	.26	74LS196	.59
74LS14	.39	74LS197	.59
74LS15	.26	74LS221	.59
74LS20	.17	74LS240	.69
74LS21	.22	74LS241	.69
74LS22	.22	74LS242	.69
74LS27	.23	74LS243	.69
74LS28	.26	74LS244	.69
74LS30	.17	74LS245	.79
74LS32	.18	74LS251	.49
74LS33	.28	74LS253	.49
74LS37	.26	74LS256	1.79
74LS38	.26	74LS257	.39
74LS42	.39	74LS258	.49
74LS47	.75	74LS259	1.29
74LS48	.85	74LS260	.49
74LS51	.17	74LS266	.39
74LS73	.29	74LS273	.79
74LS74	.24	74LS279	.39
74LS75	.29	74LS280	1.98
74LS76	.29	74LS283	.59
74LS83	.49	74LS290	.89
74LS85	.49	74LS293	.89
74LS86	.22	74LS299	1.49
74LS90	.39	74LS322	3.95
74LS92	.49	74LS323	2.49
74LS93	.39	74LS364	1.95
74LS95	.49	74LS365	.39
74LS107	.34	74LS367	.39
74LS109	.36	74LS368	.39
74LS112	.29	74LS373	.79
74LS122	.45	74LS374	.79
74LS123	.49	74LS375	.95
74LS124	2.75	74LS377	.79
74LS125	.39	74LS378	1.18
74LS126	.39	74LS390	1.19
74LS132	.39	74LS393	.79
74LS133	.49	74LS541	1.49
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74HCT08	.69	74HCT194	1.19
74HCT10	.69	74HCT240	2.19
74HCT11	.69	74HCT241	2.19
74HCT27	.69	74HCT244	2.19
74HCT30	.69	74HCT245	2.19
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74F08	.69	74F139	1.69	74F280	1.79
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4016	.29	4518	.85
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4024	.49	4529	2.95
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4035	.69	4553	5.79
4040	.69	4585	.75
4041	.75	4702	12.95
4042	.59	74C00	.29
4043	.85	74C14	.59
4044	.69	74C74	.59
4045	1.98	74C83	1.95
4046	.69	74C85	1.49
4047	.69	74C95	.99
4049	.29	74C150	5.75
4050	.29	74C151	2.25
4051	.69	74C161	.99
4052	.69	74C163	.99
4053	.69	74C164	1.39
4056	2.19	74C192	1.49
4060	.69	74C193	1.49
4066	.29	74C221	2.49
4069	.19	74C240	1.89
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4077	.29	74C374	1.99
4081	.22	74C905	10.95
4085	.79	74C911	8.95
4086	.89	74C917	12.95
4093	.49	74C922	4.49
4094	2.49	74C923	4.95
14411	9.95	74C926	7.95
14412	6.95	80C97	.95

7400/9000

7400	.19	74147	2.49
7402	.19	74148	1.20
7404	.19	74150	1.35
7406	.29	74151	.55
7407	.29	74153	.55
7408	.24	74154	1.49
7410	.19	74155	.75
7411	.25	74157	.55
7414	.49	74159	1.65
7416	.25	74161	.69
7417	.25	74163	.69
7420	.19	74164	.85
7423	.29	74165	.85
7430	.19	74166	1.00
7432	.29	74175	.89
7438	.29	74177	.75
7442	.49	74178	1.15
7445	.69	74181	2.25
7447	.89	74182	.75
7470	.35	74184	2.00
7473	.34	74191	1.15
7474	.33	74192	.79
7475	.45	74194	.85
7476	.35	74196	.79
7483	.50	74197	.75
7485	.59	74199	1.35
7486	.35	74221	1.35
7489	2.15	74246	1.35
7490	.39	74247	1.25
7492	.50	74248	1.85
7493	.35	74249	1.95
7495	.55	74251	.75
7497	2.75	74265	1.35
74100	2.29	74273	1.95
74121	.29	74278	3.11
74123	.49	74367	.65
74125	.45	74368	.65
74141	.65	9368	3.95
74143	5.95	9602	1.50
74144	2.95	9637	2.95
74145	.60	96S02	1.95

74S00

74S00	.29	74S163	1.29
74S02	.29	74S168	3.95
74S03	.29	74S174	.79
74S04	.29	74S175	.79
74S05	.29	74S188	1.95
74S08	.35	74S189	1.95
74S10	.29	74S195	1.49
74S15	.49	74S196	2.49
74S30	.29	74S197	2.95
74S32	.35	74S226	3.99
74S37	.69	74S240	1.49
74S38	.69	74S241	1.49
74S74	.49	74S244	1.49
74S85	.95	74S257	.79
74S86	.35	74S253	.79
74S112	.50	74S258	.95
74S124	2.75	74S280	1.95
74S138	.79	74S287	1.69
74S140	.55	74S288	1.69
74S151	.79	74S299	2.95
74S153	.79	74S373	1.69
74S157	.79	74S374	1.69
74S158	.95	74S471	4.95
74S161	1.29	74S571	2.95

VOLTAGE REGULATORS

TO-220 CASE

7805T	.49	7905T	.59
7808T	.49	7908T	.59
7812T	.49	7912T	.59
7815T	.49	7915T	.59

TO-3 CASE

7805K	1.59	7905K	1.69
7812K	1.39	7912K	1.49

TO-92 CASE

78L05	.49	79L05	.69
78L12	.49	79L12	1.49

OTHER VOLTAGE REGS

LM323K	5V 3A	TO-3	4.79
LM328K	Adj. 5A	TO-3	3.95
78H05K	5V 5A	TO-3	7.95
78H12K	12V 5A	TO-3	8.95
78P05K	5V 10A	TO-3	14.95

LINEAR

TL066	.99	LM733	.98
TL071	.69	LM741	.29
TL072	1.09	LM747	.69
TL074	1.95	LM748	.59
TL081	.59	MC1330	1.69
TL082	.99	MC1350	1.19
TL084	1.49	MC1372	6.95
LM301	.34	LM1414	1.59
LM309K	1.25	LM1458	.49
LM311	.59	LM1488	.49
LM311H	.89	LM1489	.49
LM317K	3.49	LM1496	.85
LM317T	.95	LM1812	8.25
LM318	1.49	LM1889	1.95
LM319	1.25	ULN2003	.79
LM320	see 7900	XR2206	3.95
LM322	1.95	XR2211	2.95
LM323K	4.79	XR2240	1.95
LM324	.49	MPQ2907	1.95
LM331	3.95	LM2917	1.95
LM334	1.19	CA3046	.89
LM335	1.79	CA3081	.99
LM336	1.75	CA3082	.99
LM337K	3.95	CA3086	.80
LM338K	6.95	CA3089	1.95
LM339	.59	CA3130E	.99
LM340	see 7800	CA3146	1.29
LM350T	4.60	CA3160	1.19
LF353	.59	MC3470	1.95
LF356	.99	MC3480	8.95
LF357	.99	MC3487	2.95
LM358	.59	LM3900	.49
LM380	.89	LM3909	.98
LM383	1.95	LM3911	2.25
LM386	.89	LM3914	2.39
LM393	.45	MC4024	3.49
LM394H	5.95	MC4044	3.99
TL494	4.20	RC4136	1.25
TL497	3.25	RC4558	.69
NE555	.29	LM13600	1.49
NE556	.49	75107	1.49
NE558	1.29	75110	1.95
NE564	1.95	75150	1.95
LM565	.95	75154	1.95
LM566	1.49	75188	1.25
LM567	.79	75189	1.25
NE570	2.95	75451	.39
NE590	2.50	75452	.39
NE592	.98	75453	.39
LM710	.75	75477	1.29
LM723	.49	75492	.79

H=TO-5 CAN, K=TO-3, T=TO-220

DATA ACQ / INTERFACE

DATA ACQ		INTERFACE	
ADC0800	15.55	8T26	1.29
ADC0804	3.49	8T28	1.29
ADC0809	4.49	8T95	.89
ADC0816	14.95	8T96	.89
ADC0817	9.95	8T97	.59
ADC0831	8.95	8T98	.89
DAC0800	4.49	DM8131	2.95
DAC0806	1.95	DP8304	2.29
DAC0808	2.95	DS8833	2.25
DAC1020	8.25	DS8835	1.99
DAC1022	5.95	DS8836	.99
MC1408L8	2.95	DS8837	1.65

IC SOCKETS

	1-99	100-up
8 PIN ST	.11	.10
14 PIN ST	.11	.09
16 PIN ST	.12	.10
18 PIN ST	.15	.13
20 PIN ST	.18	.15
22 PIN ST	.15	.12
24 PIN ST	.20	.15
28 PIN ST	.22	.16
40 PIN ST	.30	.22
64 PIN ST	1.35	1.19
ST=SOLDERTAIL		
8 PIN WW	.59	.59
14 PIN WW	.59	.52
16 PIN WW	.59	.58
18 PIN WW	.99	.90
20 PIN WW	1.09	.98
22 PIN WW	1.39	1.28
24 PIN WW	1.49	1.35
28 PIN WW	1.69	1.49
40 PIN WW	1.99	1.80
WW=WIREWRAP		
16 PIN ZIF	4.95	CALL
24 PIN ZIF	5.95	CALL
28 PIN ZIF	6.95	CALL
40 PIN ZIF	9.95	CALL

ZIF=TEXTOOL (ZERO INSERTION FORCE)

EDGECARD CONNECTORS

100 PIN ST	S-100	.125	3.95
100 PIN WW	S-100	.125	4.95
62 PIN ST	IBM PC	.100	1.95
50 PIN ST	APPLE	.100	2.95
44 PIN ST	STD	.156	1.95
44 PIN WW	STD	.156	4.95

36 PIN CENTRONICS

MALE

IDCEN36	RIBBON CABLE	6.95
CEN36	SOLDER CUP	4.95

FEMALE

IDCEN36F	RIBBON CABLE	7.95
CEN36PC	RT ANGLE PC MOUNT	4.95

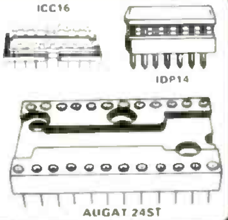
INTERSIL

ICL7106	9.95
ICL7107	12.95
ICL7660	2.95
ICL8038	4.95
ICM7207A	5.95
ICM7208	15.95

DIP CONNECTORS

DESCRIPTION	ORDER BY	CONTACTS 8	14	16	18	20	22	24	28	40
HIGH RELIABILITY TOOLED ST IC SOCKETS	AUGATxxST	.62	.79	.89	1.09	1.29	1.39	1.49	1.69	2.49
HIGH RELIABILITY TOOLED WW IC SOCKETS	AUGATxxWW	1.30	1.80	2.10	2.40	2.50	2.90	3.15	3.70	5.40
COMPONENT CARRIES (DIP HEADERS)	ICCxx	.49	.59	.69	.99	.99	.99	.99	1.09	1.49
RIBBON CABLE DIP PLUGS (IDC)	IDPxx	...	.95	.95	...	...	...	1.75	...	2.95

FOR ORDERING INSTRUCTIONS SEE D-SUBMINIATURE BELOW



DIODES/OPTO/TRANSISTORS

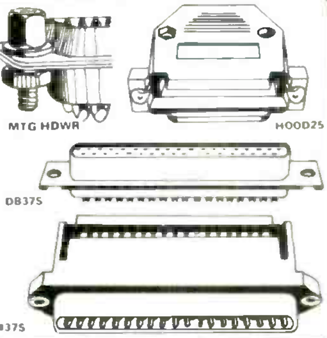
1N751	.25	4N26	.69
1N759	.25	4N27	.69
1N4148	25/1.00	4N28	.69
1N4004	10/1.00	4N33	.89
1N5402	.25	4N37	1.19
KBP04	.55	MCT-2	.59
KBL8A	.95	MCT-6	1.29
MDA990-2	.35	TIL-111	.99
N2222	.25	2N3906	.10
PN2222	.10	2N4401	.25
2N2905	.50	2N4402	.25
2N2907	.25	2N4403	.25
2N3055	.79	2N6045	1.75
2N3904	.10	TIP31	.49

D-SUBMINIATURE

DESCRIPTION		ORDER BY	CONTACTS 9	15	19	25	37	50
SOLDER CUP	MALE	DBxxP	.82	.90	1.25	1.25	1.80	3.48
	FEMALE	DBxxS	.95	1.15	1.50	1.50	2.35	4.32
RIGHT ANGLE PC SOLDER	MALE	DBxxPR	1.20	1.49	...	1.95	2.65	...
	FEMALE	DBxxSR	1.25	1.55	...	2.00	2.79	...
WIRE WRAP	MALE	DBxxPWW	1.69	2.56	...	3.89	5.60	...
	FEMALE	DBxxSWW	2.76	4.27	...	6.84	9.95	...
IDC RIBBON CABLE	MALE	IDBxxP	2.70	2.95	...	3.98	5.70	...
	FEMALE	IDBxxS	2.92	3.20	...	4.33	6.76	...
HOODS	METAL	MHOODxx	1.25	1.25	1.30	1.30	...	...
	GREY	HOODxx	.65	.65	...	.65	.75	.95

ORDERING INSTRUCTIONS: INSERT THE NUMBER OF CONTACTS IN THE POSITION MARKED "xx" OF THE "ORDER BY" PART NUMBER LISTED.
EXAMPLE: A 15 PIN RIGHT ANGLE MALE PC SOLDER WOULD BE DB15PR

MOUNTING HARDWARE $1.00



LED DISPLAYS

FND-357(359)	COM CATHODE	.362"	1.25
FND-500(503)	COM CATHODE	.5"	1.49
FND-507(510)	COM ANODE	.5"	1.49
MAN-72	COM ANODE	.3"	.99
MAN-74	COM CATHODE	.3"	.99
MAN-8940	COM CATHODE	.8"	1.99
TIL-313	COM CATHODE	.3"	.45
HP5082-7760	COM CATHODE	.43"	1.29
TIL-311	4x7 HEX W/LOGIC	.270"	9.95
HP5082-7340	4x7 HEX W/LOGIC	.290"	7.95

DIFFUSED LEDS

		1-99	100-UP
JUMBO RED	T1¾	.10	.09
JUMBO GREEN	T1¾	.14	.12
JUMBO YELLOW	T1¾	.14	.12
MOUNTING HDW	T1¾	.10	.09
MINI RED	T1	.10	.09

SWITCHES

SPDT	MINI-TOGGLE ON-ON	1.25
DPDT	MINI-TOGGLE ON-ON	1.50
DPDT	MINI-TOGGLE ON-OFF-ON	1.75
SPST	MINI-PUSHBUTTON N.O.	.39
SPST	MINI-PUSHBUTTON N.C.	.39
SPST	TOGGLE ON-OFF	.49
BCD OUTPUT 10 POSITION 6 PIN DIP		1.95

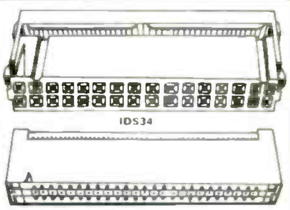
DIP SWITCHES

4 POSITION	.85	7 POSITION	.95
5 POSITION	.90	8 POSITION	.95
6 POSITION	.90	10 POSITION	1.29

IDC CONNECTORS

DESCRIPTION	ORDER BY	CONTACTS 10	20	26	34	40	50
SOLDER HEADER	IDHxxS	.82	1.29	1.68	2.20	2.58	3.24
RIGHT ANGLE SOLDER HEADER	IDHxxSR	.85	1.35	1.76	2.31	2.72	3.39
WW HEADER	IDHxxW	1.86	2.98	3.84	4.50	5.28	6.63
RIGHT ANGLE WW HEADER	IDHxxWR	2.05	3.28	4.22	4.45	4.80	7.30
RIBBON HEADER SOCKET	IDSxx	.79	.99	1.39	1.59	1.99	2.25
RIBBON HEADER	IDMxx	...	5.50	6.25	7.00	7.50	8.50
RIBBON EDGE CARD	IDExx	1.75	2.25	2.65	2.75	3.80	3.95

FOR ORDERING INSTRUCTIONS SEE D-SUBMINIATURE ABOVE



RIBBON CABLE

CONTACTS	SINGLE COLOR 1'	SINGLE COLOR 10'	COLOR CODED 1'	COLOR CODED 10'
10	.18	1.60	.30	2.75
16	.28	2.50	.48	4.40
20	.36	3.20	.60	5.50
25	.45	4.00	.75	6.85
26	.46	4.10	.78	7.15
34	.61	5.40	1.07	9.35
40	.72	6.40	1.20	11.00
50	.89	7.50	1.50	13.25

HARD TO FIND "SNAPABLE" HEADERS

CAN BE SNAPPED APART TO MAKE ANY SIZE HEADER. ALL WITH .1" CENTERS

1x40	STRAIGHT LEAD	.99
1x40	RIGHT ANGLE	1.49
2x40	STRAIGHT LEAD	2.49
2x40	RIGHT ANGLE	2.99

SHORTING BLOCKS

GOLD CONTACTS SPACED AT .1" CENTERS

5/$1.00

Dear Mr. Rose:

I feel compelled to commend you and your people for the pleasant, polite, willingness to help and professional attitude you have displayed. In these times it is indeed refreshing to deal with a company whose staff consists of people of this caliber. My friends and associates will most certainly be doing business with you again.

Sincerely, Nicholas Chabra

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- LIGHT PEN INTERFACE

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FULL ONE YEAR WARRANTY

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- .31mm DOT, 25MHz
- 16 COLORS OUT OF 64
- TEXT SWITCH GREEN AMBER

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BOTH FOR $699!

SPECIALS END 10/31/86

PAGE WIRE WRAP WIRE

PRECUT ASSORTMENT IN ASSORTED COLORS $27.50

100ea: 5.5", 6.0", 6.5", 7.0"
250ea: 2.5", 4.5", 5.0"
500ea: 3.0", 3.5", 4.0"

SPOOLS

100 feet	$4.30	250 feet	$7.25
500 feet	$13.25	1000 feet	$21.95

Please specify color: Blue, Black, Yellow or Red

WIRE WRAP PROTOTYPE CARDS

FR-4 EPOXY GLASS LAMINATE WITH GOLD-PLATED EDGE-CARD FINGERS

IBM-PR2

IBM

BOTH CARDS HAVE SILK SCREENED LEGENDS AND INCLUDES MOUNTING BRACKET

IBM-PR1	WITH +5V AND GROUND PLANE	$27.95
IBM-PR2	AS ABOVE WITH DECODING LAYOUT	$29.95

S-100

P100-1	BARE - NO FOIL PADS	$15.15
P100-2	HORIZONTAL BUS	$21.80
P100-3	VERTICAL BUS	$21.80
P100-4	SINGLE FOIL PADS PER HOLE	$22.75

APPLE

P500-1	BARE - NO FOIL PADS	$15.15
P500-3	HORIZONTAL BUS	$22.75
P500-4	SINGLE FOIL PADS PER HOLE	$21.80
7060-45	FOR APPLE IIe AUX SLOT	$30.00

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- 6 AMP 120/240 VOLT

6 FOOT LINE CORDS

LC-2	2 CONDUCTOR	39
LC-3	3 CONDUCTOR	99
LC-HP	3 CONDUCTOR W/ STD FEMALE SOCKET	1.49

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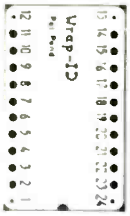
3.15" SQ	ROTRON	14.95
3.63" SQ	ETRI	14.95
3.18" SQ	MASUSHITA	16.95

SOCKET-WRAP I.D.™

- SLIPS OVER WIRE WRAP PINS
- IDENTIFIES PIN NUMBERS ON WRAP SIDE OF BOARD
- CAN WRITE ON PLASTIC, SUCH AS IC #

PINS	PART#	PCK. OF	PRICE
8	IDWRAP 08	10	1.95
14	IDWRAP 14	10	1.95
16	IDWRAP 16	10	1.95
18	IDWRAP 18	5	1.95
20	IDWRAP 20	5	1.95
22	IDWRAP 22	5	1.95
24	IDWRAP 24	5	1.95
28	IDWRAP 28	5	1.95
40	IDWRAP 40	5	1.95

PLEASE ORDER BY NUMBER OF PACKAGES (PCK. OF)



ID WRAP 24

FRAME STYLE TRANSFORMERS

12.6V AC CT	2 AMP	5.95
12.6V AC CT	4 AMP	7.95
12.6V AC CT	8 AMP	10.95
25.2V AC CT	2 AMP	7.95

25 PIN D-SUB GENDER CHANGERS

$7.95

SWITCHING POWER SUPPLIES

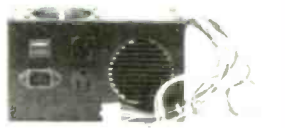
PS-IBM $69.95

- FOR IBM PC-XT COMPATIBLE
- 135 WATTS
- +5V @ 15A, +12V @ 4.2A, -5V @ .5A, -12V @ .5A
- ONE YEAR WARRANTY

PS-IBM

PS-IBM-150 $79.95

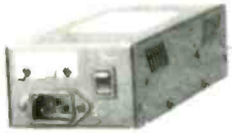
- FOR IBM PC-XT COMPATIBLE
- 150 WATTS
- +12V @ 5.2A, +5V @ 16A, -12V @ .5A, -5V @ .5A
- ONE YEAR WARRANTY



PS-130

PS-130 $99.95

- 130 WATTS
- SWITCH ON REAR
- FOR USE IN OTHER IBM TYPE MACHINES
- 90 DAY WARRANTY



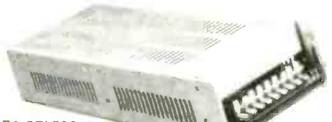
PS-A

PS-A $49.95

- USE TO POWER APPLE TYPE SYSTEMS, 79.5 WATTS
- +5V @ 7A, +12V @ 3A, -5V @ .5A, -12V @ .5A
- APPLE POWER CONNECTOR

PS-SPL200 $49.95

- +5V @ 25A, +12V @ 3.5A, -5V @ 1A, -12V @ 1A
- UL APPROVED
- ALUMINUM ENCLOSURE



PS-SPL200

CAPACITORS

TANTALUM

1.0µf	15V	.35	.47µf	35V	.45
6.8	15V	.70	1.0	35V	.45
10	15V	.80	2.2	35V	.65
22	15V	1.35	4.7	35V	.85
.22	35V	.40	10	35V	1.00

DISC

10pf	50V	.05	680	50V	.05
22	50V	.05	.001µf	50V	.05
27	50V	.05	.0022	50V	.05
33	50V	.05	.005	50V	.05
47	50V	.05	.01	50V	.07
68	50V	.05	.02	50V	.07
100	50V	.05	.05	50V	.07
220	50V	.05	.1	12V	.10
560	50V	.05	.1	50V	.12

MONOLITHIC

.01µf	50V	.14	.1µf	50V	.18
.047µf	50V	.15	.47µf	50V	.25

ELECTROLYTIC

RADIAL			AXIAL		
1µf	25V	.14	1µf	50V	.14
2.2	35V	.15	10	50V	.16
4.7	50V	.15	22	16V	.14
10	50V	.15	47	50V	.20
47	35V	.18	100	35V	.25
100	16V	.18	220	25V	.30
220	35V	.20	470	50V	.50
470	25V	.30	1000	16V	.60
2200	16V	.70	2200	16V	.70
4700	25V	1.45	4700	16V	1.25

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- COMPACT—NO DRAWER
- THIN METAL SHUTTER PREVENTS UV LIGHT FROM ESCAPING

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10 PCS	same value	.05	100 PCS	same value	.02
50 PCS	same value	.025	1000 PCS	same value	.015

RESISTOR NETWORKS

SIP	10 PIN	9 RESISTOR	.69
SIP	8 PIN	7 RESISTOR	.59
DIP	16 PIN	8 RESISTOR	1.09
DIP	16 PIN	15 RESISTOR	1.09
DIP	14 PIN	7 RESISTOR	.99
DIP	14 PIN	13 RESISTOR	.99

SPECIALS ON BYPASS CAPACITORS

.01 µf CERAMIC DISC	100/$5.00
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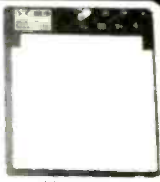
WBU-D	.38 x 6.50"	1	100	---	---	---	2.95
WBU-T	1.38 x 6.50"	---	---	1	630	---	6.95
WBU-204-3	3.94 x 8.45"	1	100	2	1260	2	17.95
WBU-204	5.13 x 8.45"	4	400	2	1260	3	24.95
WBU-206	6.88 x 9.06"	5	500	3	1890	4	29.95
WBU-208	8.25 x 9.45"	7	700	4	2520	4	39.95



WBU-208

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3 VOLT BATTERY	$3.95
BATTERY HOLDER	$1.49

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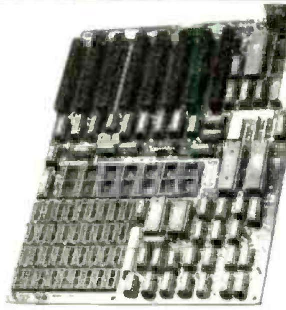

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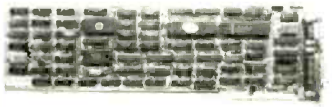

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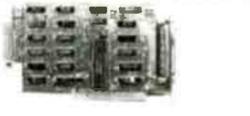

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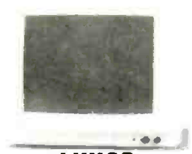

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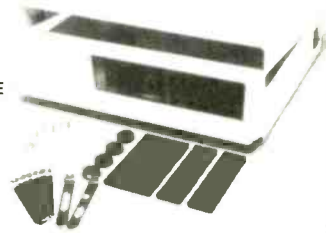

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SN7442N	.45	SN74175N	.59
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SN7474N	.35	SN74273N	1.95
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74LS02	.19	74LS166	.89
74LS04	.25	74LS173	.49
74LS05	.25	74LS174	.39
74LS06	.99	74LS175	.39
74LS07	.99	74LS189	3.95
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74LS14	.39	74LS221	.59
74LS27	.25	74LS240	.69
74LS30	.19	74LS243	.69
74LS32	.25	74LS244	.69
74LS42	.39	74LS245	.79
74LS47	.89	74LS259	1.19
74LS73	.35	74LS273	.79
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74LS90	.39	74LS368	.39
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74F04	.65	74F157	1.29
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74F10	.59	74F240	2.49
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CD4013	.35	CD4093	.39
CD4016	.29	CD4094	1.49
CD4017	.49	CD40103	2.95
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CD4020	.59	CD4510	.69
CD4024	.49	CD4511	.69
CD4027	.39	CD4515	1.39
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CD4040	.65	CD4520	.79
CD4049	.29	CD4522	.79
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TMS4416-12	16,384 x 4	(120ns)	4.95
MM5280	4096 x 1	(200ns) 2107	1.95
8118	16,384 x 1	(120ns)	.69
41256-150	262,144 x 1	(150ns)	2.95
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2102	1024 x 1	(350ns)	.89
2102-2L	1024 x 1	(250ns) LP (91L02)	1.49
2114N	1024 x 4	(450ns)	.99
2114N-L	1024 x 4	(450ns) LP	1.09
2114N-2	1024 x 4	(200ns)	1.05
2114N-2L	1024 x 4	(200ns) LP	1.49
21C14	1024 x 4	(200ns) (CMOS)	.49
2149	1024 x 4	(45ns)	4.95
5101	256 x 4	(450ns) CMOS	3.95
HM6116P-3	2048 x 8	(150ns) CMOS	1.45
HM6116LP-3	2048 x 8	(150ns) LP CMOS	1.49
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HM6264LP-12	8192 x 8	(120ns) LP CMOS	3.95
HM6264P-15	8192 x 8	(150ns) CMOS	3.29
HM6264LP-15	8192 x 8	(150ns) LP CMOS	3.49
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TMS2532	4096 x 8	(450ns) 25V	5.95
TMS2564	8192 x 8	(450ns) 25V	8.95
2708	1024 x 8	(450ns)	3.49
TMS2716	2048 x 8	(450ns) 3 voltage	9.95
2716	2048 x 8	(450ns)	3.25
2716-1	2048 x 8	(350ns) 25V	4.95
27C16	2048 x 8	CMOS	6.49
2732	4096 x 8	(450ns)	3.75
2732A-20	4096 x 8	(200ns) 21V	3.95
2732A-25	4096 x 8	(250ns) 21V	3.49
2732A-45	4096 x 8	(450ns) 21V	3.29
27C32	4096 x 8	CMOS	6.49
2758	1024 x 8	(450ns) Single +5V	2.95
2764-20	8192 x 8	(200ns) 21V	3.95
2764-25	8192 x 8	(250ns) 21V	3.49
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27C64	8192 x 8	CMOS 21V	4.95
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27128A-25	16,384 x 8	(250ns) 12.5V	4.95
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27C256-25	32,768 x 8	(250ns) 256K (CMOS) (12.5V)	8.95
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68764	8192 x 8	(450ns) 25V	15.95
68766	8192 x 8	(350ns) 25V	16.95
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74S471	256 x 8	PROM T.S.	4.95
82S123	32 x 8	PROM T.S.	2.95

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Part No.	1-9	10-99	100-up
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24 pin LP	.31	.30	.29
28 pin LP	.39	.37	.35
40 pin LP	.49	.46	.43

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Part No.	1-9	10-99	100-up
8 pin WW	.55	.49	.45
14 pin WW	.69	.65	.59
16 pin WW	.75	.69	.65
24 pin WW	1.19	1.09	.99
28 pin WW	1.39	1.29	1.19
40 pin WW	1.79	1.69	1.59

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The MM5321 is a TV camera sync generator designed to supply the basic sync functions for either color or monochrome 525 line/60Hz interlaced and camera video recorder applications. COLOR BURST GATE & SYNC ALLOW STABLE COLOR OPERATION

MM5321 . . . . $9.95

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DT1050 — **Applications: Teaching aids, appliances, clocks, automotive, telecommunications, language translations, etc.** The DT1050 is a standard DIGITALKER kit encoded with 137 separate and useful words, 2 tones, and 5 different silence durations. The words and tones have been assigned discrete addresses, making it possible to output single words or words concatenated into phrases or even sentences. The "voice" output of the DT1050 is a highly intelligible male voice. **The DT1050 consists of a Speech Processor Chip, MM54104 (40-pin) and two (2) Speech ROMs MM52164SSR1 and MM52164SSR2 (24-pin) along with a Master Word list and a recommended schematic diagram on the application sheet.**

Part No.	Description	Price
DT1050	Digitalker™	$24.95
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DT1057 - Expands the DT1050 vocabulary from 137 words to over 250 words. Includes two (2) ROMs and specs.

DT1057 . . . . $11.95

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7106CPL	8.95	7211MIPL (Micro)	8.49
7106EV/Kit	46.95	7217IJL	10.95
7107CPL	8.95	7217AIPI	8.95
7107EV/Kit	46.95	7224IPL	10.95
7207AIPD	5.95	7226AEV/Kit	99.95

74HC HI-SPEED CMOS

74HC00	.35	74HC175	.89
74HC02	.39	74HC221	1.95
74HC04	.39	74HC240	1.39
74HC08	.39	74HC244	1.49
74HC10	.39	74HC245	1.59
74HC14	.59	74HC253	.79
74HC30	.39	74HC259	1.19
74HC32	.45	74HC273	1.79
74HC74	.45	74HC373	1.49
74HC75	.69	74HC374	1.49
74HC76	.69	74HC393	1.19
74HC85	1.19	74HC595	1.95
74HC86	.59	74HC688	1.95
74HC123	1.19	74HC4040	1.19
74HC125	.99	74HC4049	.79
74HC132	.79	74HC4050	.79
74HC138	.79	74HC4060	1.19
74HC139	.79	74HC4511	1.95
74HC154	1.95	74HC4514	2.95
74HC163	.89	74HC4538	1.95
74HC174	.89	74HC4543	2.95

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74C00	.29	74C174	.89
74C02	.29	74C175	.89
74C04	.25	74C221	1.19
74C08	.35	74C240	1.59
74C10	.29	74C244	1.59
74C14	.49	74C373	1.95
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74C85	1.19	74C915	1.19
74C86	.29	74C920	9.95
74C89	3.95	74C921	9.95
74C90	.89	74C922	3.95
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DS0026CN	1.69	LM399H	3.95
TL074CN	.79	TL497ACN	2.19
TL084CN	1.09	NE540H (C540H)	2.95
LM307CN	.45	NE555V	.29
LM309K	1.25	XR-L555	.69
LM311CN	.45	LM556N	.59
LM317T	.99	NE558N	1.19
LM318CN	1.19	LM565N	.99
LM319N	1.19	LM567V	.89
LM320K-5	1.35	NE592N	.89
LM320T-5	.59	LM741CN	.29
LM323K	4.49	LM747N	.59
LM324N	.39	LM1458CN	.49
LM338K	3.95	LM1488N	.69
LM339N	.49	LM1489N	.69
LM340K-5	1.35	LM1496N	.99
LM340K-12	1.35	LM1871N	1.95
LM340K-15	1.35	LM1872N	2.49
LM340T-5	.49	LM1896N	1.59
LM340T-12	.49	ULN2003A	.99
LM340T-15	.49	XR2206	3.95
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LF356N	.89	LM3905CN	1.19
LM358N	.49	LM3909N	.89
LM360N	2.19	LM3914N	1.95
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The JE232CM allows connection of standard serial RS232 printers, modems, etc. to your VIC-20, C-64 (excluding the SX-64 Portable), and C-128. A 4-pole switch allows the inversion of the 4 control lines. Complete installation and operation instructions included.
· Plugs into User Port · Provides Standard RS232 signal levels · Uses 6 signals (Transmit, Receive, Clear to Send, Request to Send, Data Terminal Ready, Data Set Ready)

JE232CM. $39.95

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MW350 (For VIC-20, C-64 & C-128). $54.95

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All kits come complete with documentation

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TRS-80 COLOR AND COLOR II

TRS-64K-2. . . . . $11.95
New models only —
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Expands Model 4 from 16K-64K or Model 4P from 64K-128K
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TANDY 200

M200R. . . . . $74.95 ea. or 2 for $129.95
Tandy Model 200 Expansion

UV-EPROM ERASER

Erases all EPROMs. Erases up to 8 chips within 21 minutes (1 chip in 15 minutes). Maintains constant exposure distance of 1". Special conductive foam liner eliminates static build-up. Built-in safety lock to prevent UV exposure. Compact - 9.00"L x 3.70"W x 2.60"H. Complete with holding tray for 8 chips.

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UVS-11EL Replacement Bulb. . . . $17.95

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30003	National Linear Data Book (82)	$14.95
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30013	Zilog Data Book (85)	$14.95
30032	National Linear Supplement (84)	$ 6.95
210830	Intel Memory Handbook (86)	$17.95
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Howard Industries (4.68" sq. 60 cfm)
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EG&G Rotron (3.125" square 20 cfm)

NEW! 13" Color Composite Monitor

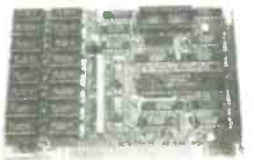
for VIC-20 and C-64
Also compatible with other computers with composite output (i.e. Apple II, II+, *IIe**)

Ideal for color graphics and games
· Resolution 260H x 300V · Recommended Display Character Number 960 Characters (40 Characters x 24 Rows on 5 x 7 Dot Matrix) · CRT 13" diagonal · Size 14.6 W x 13.5 H x 15.5 D · Weight 25.3 lbs

CMON. . . . . $129.95 each or 2 for $219.95
RCA-3-DIN (Universal Computer to Monitor Cables for Atari, Commodore & TI). . . . $3.49

NEW PRODUCTS!

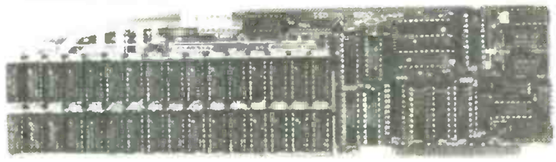
ZUCKERBOARD Expansion Memory Half Card and Clock/Calendar for the Tandy 1000



The Zuckerboard Expansion Memory Board allows you to expand the memory of your Tandy 1000 (128K Model) as much as 640K! 256K DRAM chips increase your computer's memory by either 256K or 512K, bringing your total system memory up to either 384K or 640K. The memory board also includes a DMA controller chip. Optional clock/calendar plugs directly onto the memory board. Manual included.

TAN-Clock	Clock/Calendar Option (only)	$ 39.95
TAN-EM256K	Includes 256K RAM	$ 99.95
TAN-EM512K	Includes 512K RAM	$139.95

BIG BOARD 1MBYTE RAM CARD for Apple II, II+ and *IIe**



Introducing a third generation memory card that gives you both great expandability and great versatility at an extraordinary price. **Versatility to users** means that BIG BOARD is compatible with software written for the Synetix SSD (Flashcard) as well as for Jameco's JE868 128K RAM Card. Big Board makes available 426K of worksheet space, using the program THE Spreadsheet Version 2.0. It is compatible with PLUSWORKS XM for running Appleworks on the Apple II. Versatility also means that BIG BOARD comes complete with RAMDISK software for DOS 3.3, ProDOS, Pascal 1.2 and CP/M for Microsoft's Softcard. A separate driver is available for the AppliCard (StarCard).

BIG BOARD-256K	256K RAM	$199.95
BIG BOARD-512K	512K RAM	$249.95
BIG BOARD-1M	1Meg RAM	$299.95

External Power Supply for the Commodore 64

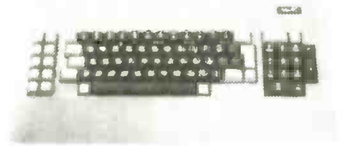
1 Yr. Warranty!

· Input 117VAC @ 60Hz · Output 5VDC @ 3 Amps, 10VAC @ 250mA · Short circuit protected and current limited · Transient spike suppression on 2 auxiliary 110VAC sockets · Switch on front serves as power switch for the computer and other peripherals · RFI/EMI filtered · Adjustable linear regulator · Has less than 50mV ripple rms at full load · 5 Amp primary fuse · Two conductor with ground line · Color brown · Size: 7½"D x 5½"W x 2½"H · Weight: 5 lbs

CPS-10. . . . . . . $39.95

IBM® COMPATIBLE ACCESSORIES

83-KEY KEYBOARD



· Identical layout as original IBM PC Keyboard · Highly desirable case with palm rest · Complete with cable and data · JUST PLUG IN!

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IBM-MCC	Monochrome Card	$ 79.95
IBM-PS	Power Supply	$ 79.95
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IBM-MB	Motherboard	$139.95

Regular List $674.58

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IBM-EGA	Enhd. Graphics 256K RAM	$299.95
IBM-20MBK	20MB Hard Disk Drive	$499.95

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NEW! Universal 64K/256K Printer Buffer NEW!

The **UBUFFER Universal Printer Buffer** is a hi speed data buffer that accepts data at a high rate and then outputs this data to your printer. You save valuable computer time. The UBUFFER can be connected to practically any computer or printer. There are four possible combinations: 1) Serial to Serial, 2) Serial to Parallel, 3) Parallel to Parallel, 4) Parallel to Serial. Manual included. Size: 9-1/3"L x 4"W x 1½"H

UBUFFER-64K . . . $199.95
UBUFFER-256K . . $229.95

IBM Compatible! DISK DRIVES

Documentation Included

FD55B	Teac 5¼" DS ½-Height	$119.95
SA455	Shugart 5¼" DS ½-Height	$119.95
TM100-2	Tandon 5¼" DS Full-Height	$109.95

JMR 5¼" DISK DRIVE ENCLOSURES

Complete with power supply, switch, power cord, fuseholder and connectors.

DDE-1FH. $69.95
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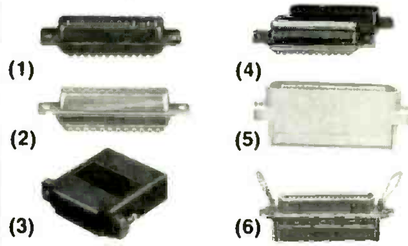
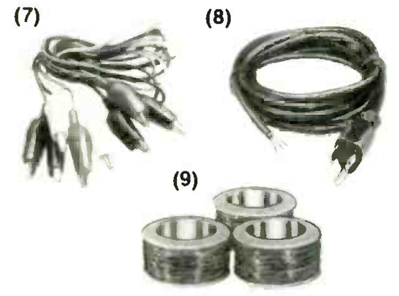


25-Position Solder-Type D-Subs.

Fig.	Type	Cat. No.	Each
1	Male	276-1547	1.99
2	Female	276-1548	2.99
3	Hood	276-1549	1.99

(4) NEW! Multipurpose Hood. Use as standard hood or build a custom gender-changer. #276-1520 .... 1.79
(5) 36-Position Male Printer Connector. For fast repairs or extension cables. #276-1533 .... 5.99
(6) NEW! 36-Position Female Printer Connector. Great for printer cable extensions. #276-1523 .... 5.99

Hookup to Value!



(7) Set of 4 Test Cables. 30" long. With insulated clip at each end. #278-001 .... 3.49
(8) 6-Ft. AC Line Cord With Three-Prong Plug. 18-gauge conductors handle up to 10 amps at 125 VAC. SVT jacket. UL listed. #278-1258 .. 2.99
(9) Magnet Wire. 3-spool set is ideal for winding coils. Includes 40-ft. of 22-gauge, 75-ft. of 26-ga., 200-ft. of 30-ga. #278-1345 .... 4.49

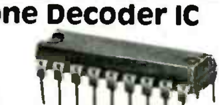
Voice Synthesizer Team

Add Voice to Your Computer

(10) SPO256-AL2 Speech Synthesizer. MOS/LSI device with a built-in program is easy to interface with most micros. 28-pin DIP and complete data. #276-1784 .... 12.95
(11) CTS256-AL2 Text-to-Speech IC. 8-bit processor translates ASCII into control data for the chip above. 40-pin DIP and data. #276-1786 .... 16.95

Touch-Tone Decoder IC

NEW!



DTMF Receiver in One 18-Pin DIP

SSI 202. Ideal for ham radio autopatching, repeater, link and remote-station control. Features single analog input and eight built-in switched-capacitor filters—no input filtering is required. Provides selectable hexadecimal or binary coded 2 of 8 output. Clocked by low-cost colorburst crystal (RS #272-1310, not incl.). 5 VDC, single supply. With data and circuit examples. #276-1303 .... 12.95

Biggest & Brightest LEDs

(12) Super-Bright Red LED. Breakthrough! Outputs 300 mcd at 20 mA yet runs cool. #276-066,99¢
(13) NEW! Jumbo Red LED. Two LED elements connected cathode-to-cathode in a huge 10 mm housing. Three-lead pinout lets you use separate current limiting resistors. Really big! #276-065,1.19

Top-Quality Memory

Manufacturer's Best—Why Settle for Less?

(14) 4164 64K Dynamic RAM. 150 ns access. Add reliable memory today. #276-2506 .... 3.95
(15) NEW! TMS 4256 256K Dynamic RAM. 150 ns access. #276-1252 .... 6.95
(16) NEW! MSM 2764RS 64K EPROM. UV erasable, 250 ns access. #276-1251 .... 6.95

Melody Synthesizer

NEW!

Preprogrammed With 12 Popular Tunes

UMC 3482. Ideal for musical doorbells, telephone music-on-hold, game and novelty applications. Tunes include Happy Birthday, Oh My Darling Clementine, London Bridge is Falling Down, Home Sweet Home, Row-Row-Row Your Boat. 16-pin DIP with data and circuit examples. #276-1797 ... 2.99

Hi-Q Ceramic Capacitors

Low As **39¢** Pkg. of 2

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5	50	272-120	39
47	50	272-121	39
100	50	272-123	39
220	50	272-124	39
470	50	272-125	39

µF	WVDC	Cat. No.	2-Pack
.001	500	272-126	49
.0047	500	272-130	49
.01	500	272-131	49
.047	50	272-134	49
.1	50	272-135	49

Unusual Buzzers

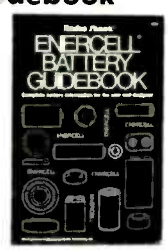
NEW!

(17) Electronic Chime. Melody-synthesizing IC and speaker combo produce a pleasant "ding-dong" sound. Operates 6 to 18 VDC. 5" leads. #273-071 .... 6.95
(18) NEW! Tri-Sound Siren. You've never heard a buzzer like this! Contains an IC, driver circuit and 8-ohm speaker in a compact 1¼ x 1[13]/16" case. Three distinctive sounds. 3 VDC. #273-072 .... 5.95

Battery Guidebook

1.99

Helps You Select The Right Battery



Learn how batteries work, how to recharge and test them, and how to choose the best values. Includes complete technical data on every type of Radio Shack ENERCELL® batteries. 160 pages. #62-1396

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Digital Logic Probe

NEW!

The fast way to test TTL, LS and CMOS digital circuits. Color-coded LEDs indicate high, low or pulsed logic states (up to 10 MHz). Simultaneous tone output frees your eyes for faster testing. 36" leads with clips provide power from circuit under test. With instructions. #22-303 .... 16.95

Digital Logic Pulser

NEW!

Together, the pulser and probe make an effective diagnostic team for testing today's digital circuits. Produces single 5 µs pulse or a continuous 5 Hz pulse train at the push of a button. Overload protected. With instructions. #22-304 ... 17.95

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SALE! Save $3

Reg. 10.95

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Includes Probes and Owner's Manual

Rugged, easy to use, and 27% off if you hurry! Perfect for beginners and a great second meter for car or toolbox. Features "off" position to protect movement during transit, 8 ranges. Measures to 1000 volts AC/DC. DC current to 150 mA. Resistance to 100,000 ohms. 2000 ohms per volt. Requires "AA" battery. #22-212

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Build a vintage radio with this unique kit!

From his hideaway home high in Australia's Blue Mountains, vintage radio enthusiast David Whitby has painstakingly hand-crafted these kits from original designs. Using authentic components (a limited supply discovered recently in an old warehouse), Mr. Whitby has created a kit that is not only entertaining & educational, but, as a genuine piece of radio history, can actually appreciate in value! This model, the Varometer Super Crystal Set, is based upon circuitry first used over 60 years ago in naval & other applications where maximum performance was necessary. It uses no power source other than received RF energy from the antenna/earth system which powers the headphones. The design is enhanced by its cove-routed wooden baseboard and gold-type lettered bakelite panel which carries the aerial tap switch (also vintage), dial, & headphone jack socket. But remember, due to the limited stock of components, production of these kits is strictly limited, so order now!

Varometer Super Crystal Radio Kit — $79.95 Cat K-9002

1940 Vintage Headphones

These rugged, yet sensitive phones are the perfect mate for your antique radio. Manufactured in 1940 by the Standard Telephone Company.

$19.95 Cat C-4001

Short Wave Antenna Kit

Expert design, complete with instruction & ready to assemble. No soldering required.

$11.95 Cat K-3490

Fabulous Foxhunting with the DSE RDF kit!

Locate the source of any transmission with this sophisticated radio direction finder from DSE. Similar commercial units may cost hundreds of dollars, but you can build this one yourself and spend the difference on antennas (not included). Complete with detailed construction manual & all hardware for both fixed & mobile installation. Requires only an alligator clip lead & screwdriver to adjust for operation.

Features: 32 unit LED compass ● Electronic Antenna Switching Unit (ASU) ● Stable digital circuitry ● Adjustable internal monitor speaker ● Internal alignment reference ● Self-aligning commutating filters ● 170° calibration
Specifications: 12V operation ● 50-500 MHz Freq. range ● Accurate ± 5.6°

$99.95 Cat K-6345

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CLOSEOUT!

SAVE 35%

VK Powermaster

This power supply for RF linear amplifiers features a completely discrete design - no IC's are used! The ingenious design by Rex Callaghan also boasts instantaneous short circuit protection with no loss of power or performance!

was $79.95 — $49.95 Cat K-3448

SPECIFICATIONS
● 18V, 14A continuous, 25A intermittent (with M-2010 transformer) ● Aluminum case

Transformer (Cat M-2010) $39.95

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Featured in August Radio-Electronics

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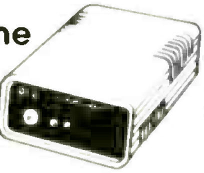

Transmitter WITH CASE (Includes parts) — $7.95 Cat K-3429

Receiver WITH CASE (Includes screen front rear panel, all parts and hardware) — $32 Cat K-3428

NEW from the WOZ

Make life a little easier

with TYRŌN Remote Control Power Booster

Now you can control your home electronics from anywhere in the room - without line of sight or aiming! This unique device (developed by ex-Apple ace Steve Wozniak) attaches quickly & easily to your existing infra-red remote (without tools!). Operates a year or more on a 9V alkaline battery (included).

$29.95 Cat Y-6002

Have you seen the many marvelous DSE kits featured in recent issues of R-E?

January 1986	Australis I Satellite Receiver (No modulator included)	Cat K-6316	$89.95
February 1986	Build a Music Synthesizer	Cat K-2669	$19.95
March 1986	Build a Walkman Amplifier	Cat K-2667	$14.95
April 1986	Build a Teletext Decoder (Cover Story)	Cat K-6315	$199.00
May 1986	Teletext Decoder (Part 2)		
June 1986	Hi-Performance Stereo Amp	Cat K-3516	$299.00
July 1986	Hi-Performance Amp (Part 2)		
August 1986	Hi-Performance Amp (Part 3)		
	Build a Remote Power Switch	Cat K-3428	$32.00
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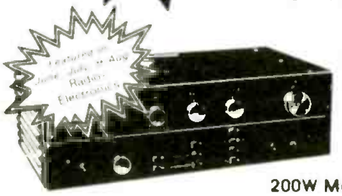
Dear Enthusiast: We also carry parts for many of the other fine build-it-yourself projects in *Radio-Electronics*. Try us!



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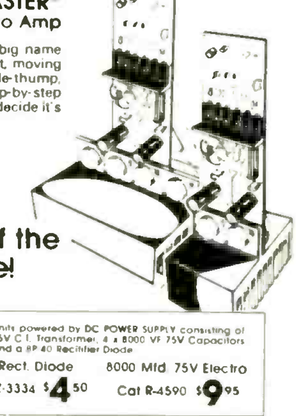
PLAYMASTER® 200W Mosfet Stereo Amp

Feature for feature, dollar for dollar, this kit outperforms the big name competition! Electronic input circuitry handles moving magnet, moving coil, CD, hi-fi, VCR, cassette, tuner, & more. Soft-touch controls, de-thump, and toroidal transformers are only a few of its many features. Step-by-step instructions make it easy to build (but if, after examination, you decide it's beyond your abilities, just return the kit intact for full refund!).

$299 Cat K-3516



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BP-40 Rect. Diode	8000 Mfd. 75V Electro
Cat Z-3334 $4.50	Cat R-4590 $9.95

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Commodore Model # 1520
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SOLID STATE BUZZER

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6 vdc
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± 12 Vdc or 24Vdc POWER SUPPLY

DELTRON MODEL QD12/15-1.7
Dual plus and minus 12Vdc open frame power supply. Can be used as 24Vdc @ 1.5 amp. INPUT either 115 Vac or 230 Vac. Fully regulated computer grade supply. 7" x 4 1/2" x 2 3/4"
$12.50 each 10 for $110.00

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solder lug style 10 for $11.00
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$2.00 ea PC style 10 for $18.00
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$2.50 ea PC style 10 for $22.00
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PC style $3.00 each
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PC style $4.50 each

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2N706	4 for $1.00
2N2222A	3 for $1.00
PN2222A	4 for $1.00
2N2904	3 for $1.00
2N2905	3 for $1.00
MJ2955	$1.50
2N3055	$1.00
PMD 10K40	$1.00
TIP 121	75¢
TIP 125	75¢

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120 volt primaries

5.6 volts @ 750 ma	$3.00
6 volts @ 150 ma	$1.25
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24 V.C.T. @ 1 amp	$4.85
24 V.C.T. @ 2 amp	$6.75
24 V.C.T. @ 3 amp	$9.50
24 V.C.T. @ 4 amp	$11.00
36 V.C.T. @ 135 ma	$3.00

WALL TRANSFORMERS

all plug directly into 120 vac outlet

4 VDC @ 70 ma.	$2.00
6 VAC @ 500 ma.	$3.50
6 VDC @ 750 ma.	$4.50
9 VDC @ 500 ma.	$5.00
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18 VAC @ 18 VA and 8.5 VAC @ 1.28 VA	$3.50
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MULTI-VOLTAGE @ 500 ma. 3, 4 1/2, 6, 7 1/2, 9 or 12 VDC	$7.50

MINI-BOX

Pomona # 2104
$1.00 EACH
Heavy-duty black phenolic project box with cover and screws. 2 3/4 X 1 1/2 X 1 1/2

FUSES

3AG (AGC) SIZE
1, 1 1/2, 2, 2 1/2, 3, 4, 5, 6 AMP
GMA SIZE
1, 2, 3, 4, 5 AMP
5 of any ONE amperage 75¢

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1 AMP 50 VOLT DIODES
1N4001 TAPE AND REEL
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10 AMP SOLID STATE
CONTROL 3 - 32 vdc
LOAD 140 vac 10 amp
SIZE 2 1/4 x 1 3/4 x 1
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Fujitsu # FBR211NED005M20
High sensitivity
COIL 120 ohms
CONTACTS 1 amp
Mounts in 14 pin DIP socket
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Aromat # RSE-6V
Super Small S.P.D.T. relay
GOld colbalt contacts rated 1 amp @ 30 vdc. Highly sensitive TTL direct drive possible. 120 ohm coil
Operate from 4.3 - 6 vdc
COIL 120 ohms $1.50 each
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CONTACTS: S.P.N.C. 10 amp @ 120 vac
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CAT# PPC-170
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Full range speaker
8 oz magnet
4 diagonal mounting centers
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ALL ARE RATED 5 AMPS @ 125 VAC

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10 for $9.00
100 for $80.00

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PC style non-threaded bushing
75¢ each
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Compact, well-regulated switching power supply designed to power Texas Instruments computer equipment.
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NEW stereo cassette player with auto reverse. 12 Vdc neg. ground with pre-amp output. Designed for underdash use in 1980 Datsuns.
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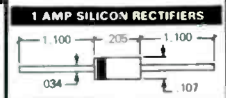

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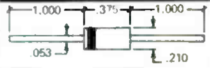

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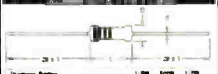

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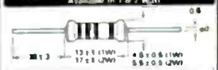

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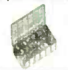

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Mfr — Power Systems PS1554
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