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TEK 2236 100 MHZ OSCILLOSCOPE

THE ANSWER BY ANY MEASURE

100 MHz scope, counter, timer, multimeter: All one integrated system.

100 MHz dual time base scope. 3.5 ns risetime; sweeps from 0.5 s to 5 ns/div; alternate sweep; ±2% vertical/horizontal accuracy; vertical sensitivity to 2 mV/div @ 90 MHz.

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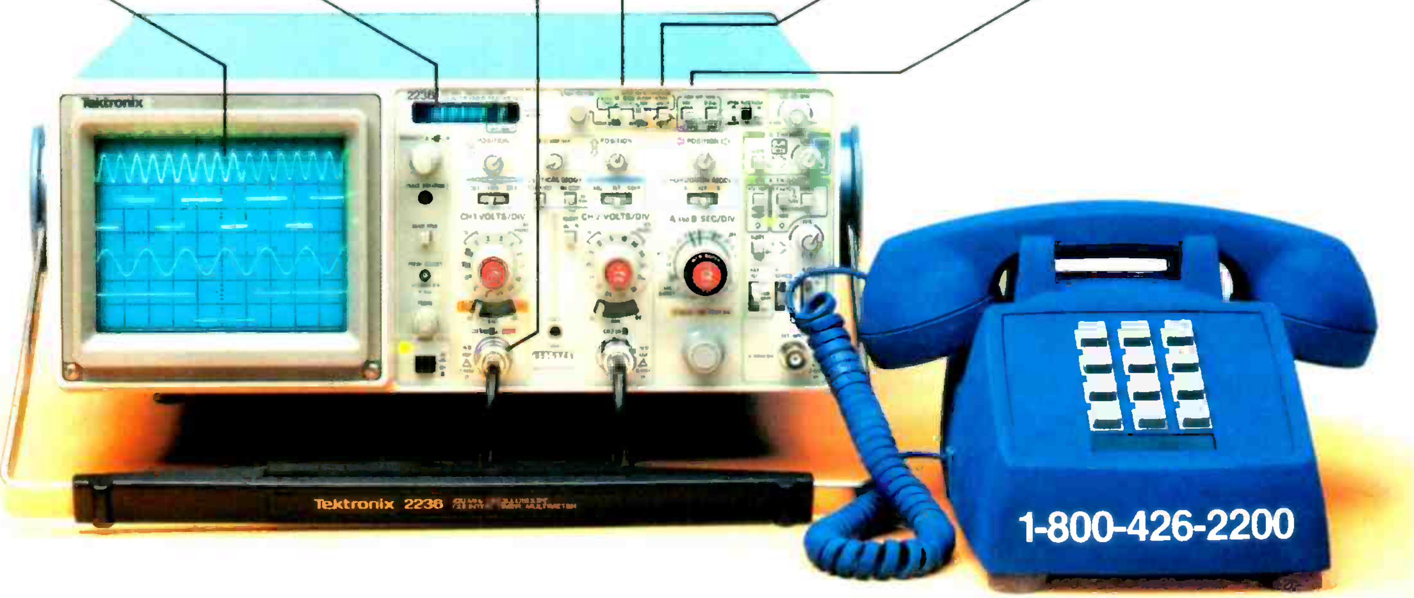

Now make measurements faster, easier, with greater accuracy and user confidence. The Tek 2236 makes gated counter measurements, temperature, time, frequency, resistance and voltage measurements pushbutton easy. You see results concurrently on the 9-digit numeric readout and CRT display.

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At just $2650,* the 2236 includes the industry's first 3-year warranty on all parts and labor, including the CRT.

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JULY '86

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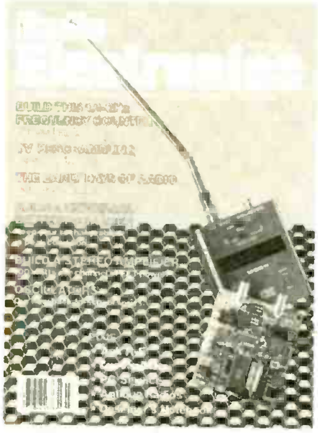

Who says that good test instruments have to be expensive? The subject of this month's cover can be built for under $60 if you're willing to overlook the case. But that low price doesn't mean low performance. For exmple, our counter features an accuracy of ±1 PPM ±1 count and a sensitivity better than 150 mV over the entire measurement range from 1 Hz to 1200 MHz. For more details and complete instructions on how to build the counter, turn to page 47.

NEXT MONTH

THE AUGUST ISSUE IS ON SALE JULY 1

BUILD AN INFRARED POWER SWITCH
Control your electrical appliances from your easy chair!

TV SIGNAL SCRAMBLING
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POCKET TV ROUNDUP
Set-by-set descriptions.

THE 4007
An indepth look at one of the most versatile CMOS IC's.

Radio-Electronics

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Advertising Sales Offices listed on page 112.

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-EA

List price $699.95/CE price $399.95/SPECIAL
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, F.B.I., Space Satellites, Police and Fire Departments, Drug Enforcement Agencies, Defense Department, Aeronautical AM band, Aero Navigation Band, Fish & Game, Immigration, Paramedics, Amateur Radio, Justice Department, State Department, plus thousands of other radio frequencies most scanners can't pick up. The *Regency* MX7000 is the perfect scanner for intelligence agencies that need to monitor the new 800 MHz. cellular telephone band. The MX7000, now at a special price from CE.

Regency® Z60-EA

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-EA

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-EA

List price $613.00/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 UHF version of the same radio called the RU150B covers 450-482 MHz. but the cost is $449.95. To get technician programming instructions, order a service manual from CE with your radio system.

NEW! Bearcat® 50XL-EA

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! Regency® XL156-EA

List price $239.95/CE price $129.95/SPECIAL
6-Band, 10 Channel • No-crystal Scanner
Search • Lockout • Priority • AC/DC
Bands: 30-50, 144-174, 440-512 MHz.
Cover your choice of over 15,000 frequencies on 10 channels at the touch of your finger. Display messages. External speaker jack. Telescoping antenna. External antenna jack. AC/DC.

NEW! Regency® R1060-EA

List price $149.95/CE price $92.95/SPECIAL
6-Band, 10 Channel • Crystalless • AC only
Bands: 30-50, 144-174, 440-512 MHz.
Now you can enjoy computerized scanner versatility at a price that's less than some crystal units. The *Regency* R1060 lets you in on all the action of police, fire, weather, and emergency calls. You'll even hear mobile telephones.

Bearcat® DX1000-EA

List price $649.95/CE price $349.95/SPECIAL
Frequency range: 10 KHz. to 30 MHz.
The *Bearcat* DX1000 shortwave radio makes tuning in London as easy as dialing a phone. It features PLL synthesized accuracy, two time zone 24-hour digital quartz clock and a built-in timer to wake you to your favorite shortwave station. It can be programmed to activate peripheral equipment like a tape recorder to record up to five different broadcasts, any frequency, any mode, while you are asleep or at work. It will receive AM, LSB, USB, CW and FM broadcasts.

There's never been an easier way to hear what the world has to say. With the *Bearcat* DX1000 shortwave receiver, you now have direct access to the world.

NEW! Regency® HX1200-EA

List price $369.95/CE price $214.95/SPECIAL
8-Band, 45 Channel • No Crystal scanner
Search • Lockout • Priority • Scan delay
Sidelit liquid crystal display • EAROM Memory
New Direct Channel Access Feature
Bands: 30-50, 118-136, 144-174, 406-420, 440-512 MHz.
The new handheld *Regency* HX1200 scanner is fully keyboard programmable for the ultimate in versatility. You can scan up to 45 channels at the same time including the AM aircraft band. The LCD display is even sidelit for night use. Order MA-256-EA rapid charge drop-in battery charger for $84.95 plus $3.00 shipping/handling. Includes wall charger, carrying case, belt clip, flexible antenna and nicad battery.

NEW! Bearcat® 100XL-EA

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-EA

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-EA

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-EA

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-EA Shortwave receiver	$179.95
RD95-EA *Uniden* Remote mount Radar Detector	$128.95
RD55-EA *Uniden* Visor mount Radar Detector	$98.95
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BC-WA-EA *Bearcat* Weather Alert™	$49.95
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PC22-EA *Uniden* remote mount CB transceiver	$99.95
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R1060-EA *Regency* 10 channel scanner **SALE**	$92.95
MX3000 EA *Regency* 30 channel scanner	$198.95
XL156-EA *Regency* 10 channel scanner **SALE**	$129.95
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RH250B EA *Regency* 10 ch 25 Watt VHF trans	$329 95
RH600B EA *Regency* 10 ch. 60 Watt VHF trans	$454.95
RU150B-EA *Regency* 10 channel UHF transceiver	$449.95
RPH410 EA 10 ch handheld no-crystal trans	$399 95
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CIE-EA Covert Intelligenct, Elect Eavesdropping	$14.95
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USATLM-EA Trunk lip mount VHF/UHF antenna	$35 00

Add $3.00 shipping for all accessories ordered at the same time.
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Add $7.00 shipping per scanner and $3.00 per antenna.

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WHAT'S NEWS

Science-research budgets holding up under cuts

Federal budgets for science and research are not fairing too badly, in spite of budget cutting for many services due to Gramm-Rudman and other factors, reports the Institute of Electrical and Electronics Engineers (IEEE).

Under the fiscal 1987 budget requests, says Dr. John McTague, acting science advisor to the President, the number of Department-of-Defense-sponsored engineering-research centers would increase from 23 to 35, and it is possible that the Departments of Agriculture and Energy may sponsor such centers in the future. The science and technology budgets of the Department of Defense also showed growth in 1986 over the previous fiscal year.

The National Science Foundation expects a nine percent budget increase in fiscal 1987—about $184 million. The National Aeronautics and Space Administration (NASA) is requesting 7.8 billion in fiscal 1987, roughly the same as in 1986. Only the Department of Energy's R&D activity would decrease in fiscal 1987, dropping from $4.87 billion to $4.5 billion.

Magnetic-resonance imaging solves mysteries of growth

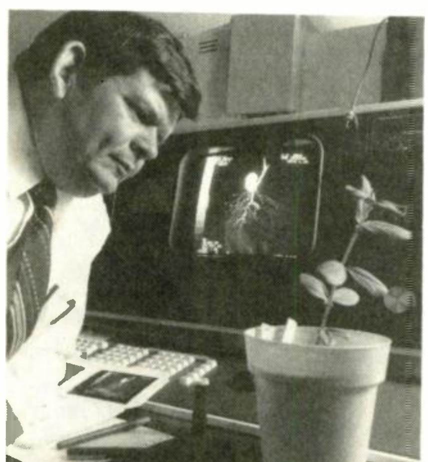
Scientists of the General Electric Co. and the U.S. Department of Agriculture have adapted the recently-discovered technology of magnetic-resonance imaging to help unravel the mysteries of plant growth.

In magnetic-resonance imaging, the object being studied is positioned in an extremely strong magnetic field and probed with high-frequency radio signals from a special type of antenna. Under the field's influence, those signals can excite atoms of selected substances in the object. Radiation from those atoms is picked up by another antenna and sent to a special-purpose computer that constructs a "map" showing the location and concentration of the excited atoms.

The scanner used for the plant studies uses a large, doughnut-shaped superconducting magnet capable of producing a field of 1.5 tesla—30,000 times the strength of the earth's field—within its 1-meter bore.

In this first application of magnetic-resonance imaging of intact root systems, the researchers used hydrogen imaging (looked at hydrogen atoms in the root system) to study water transport, root pathology, seed growth, and other factors.

Since magnetic-resonance imaging has no known effect on plants it can be used repeatedly to monitor plant development. It also opens the door to more accurate studies of plant responses to light, carbon-dioxide levels, and nutrients.



MAGNETIC-RESONANCE IMAGING, AN ADVANCED MEDICAL TECHNOLOGY, is being used by scientists of the General Electric company and the U.S. Department of Agriculture to unravel the mysteries of plant growth.

Electronics technicians honored by Reagan

Electronics technicians were honored nationally on March 4, 1986 with the inauguration of the first National Electronics Technicians Day. That special day recognized both the twentieth year of the certification program that is sponsored by the International society of Certified Electronics Technicians and the certification of the 20,000th electronics technician.

In his proclamation announcing National Electronics Technicians Day, President Ronald Reagan saluted the high standards of performance and excellence maintained by professional technicians and by ISCET in its 20 years of distinguished service to the electronics industry. He paid tribute to the vital part that electronics technicians play in helping to ensure our country's continued technological and economic leadership as a formidable international competitor. In extending his warm personal congratulations to technicians who have met the demanding criteria for certification, President Reagan recognized the individual skills, talent, and expertise that make electronics technicians one of our country's most important technological resources.

To make National Electronics Technicians Day an official commemorative holiday, persons involved in the electronics industry are asked to contact their senators and congressmen to request their support for House Joint Resolution 507 (HJRes507). **R-E**

VIDEO NEWS

DAVID LACHENBRUCH
CONTRIBUTING EDITOR

•**What kind of stereo?** Although broadcast stereo-sound TV is relatively new, the transmission of stereo audio with the video has long been an accepted practice—for example, in PBS simulcasts and on cable, with such services as MTV. Many cable-TV systems provide an FM-stereo service to their subscribers at a small additional monthly charge that includes FM channels in stereo plus stereo sound for such special cable channels as MTV, as well as special closed-circuit audio-only channels in some cases. With the advent of broadcast multichannel-TV-sound (MTS), cable systems have a new option—and new problems. Most cable systems are capable of passing along to their subscribers TV programs that are broadcast in the new stereo-sound system. The question now is whether they should also continue carrying the sound of such satellite-delivered cable programs as MTV and HBO as extra-cost FM channels or to use the standard MTS transmission systems; equipment is now available to let cable systems convert the sound of such programs to MTS.

When a consumer buys a stereo-TV set, he expects to be able to receive all stereo programs on it; in the case of simulcast programs on the FM band, for which cable systems usually add an extra charge, it creates ill will among cable subscribers when they buy "stereo-TV" receivers and can't receive cable stereo on them. As a result, HBO is currently urging its affiliated cable systems to add the standard MTS system, and to continue simulcasting as well, in order to gather the largest possible stereo audience. But MTV says it is making no recommendations and letting its affiliates use any stereo system they wish. Meanwhile, a new "super-stereo" system is being offered to cable companies. Called *Stereo-Track II*, the system is claimed to provide "digital quality sound," with 88–90-dB signal-to-noise ratios and 90-dB stereo separation. The audio is carried as two discrete tracks above and below the standard FM band, and the cable system provides special receiving equipment to its subscribers choosing to pay extra for the stereo-audio service.

• **Disc-continued.** The CED videodisc has reached the end of the road. RCA announced it is ending production of CED discs at its Indianapolis plant June 27 because of declining demand. The company announced the end of disc-player production in April 1984 and at that time said it would continue output of the discs for three years or as long as there was "reasonable demand." However, RCA now says the market for the discs has collapsed, with sales this year about five percent of the 1984 rate. CBS, the only other manufacturer of CED discs, ended production in the summer of 1984. RCA introduced the videodisc player in March 1981. RCA is being sold to General Electric, which once backed the competing VHD videodisc system developed by JVC. Disc players using that system are currently being produced in Japan, but have never been introduced in the U.S.

• **Going up.** In most products, it's news when prices go down. In electronics, news is made when there's a price increase—and that's just what's happening now. A steady string of price reductions in color TV, almost since their introduction in the 1950's, has come to an end. And the even more dramatic decline in VCR prices is being reversed. Price increases so far have been relatively minor. Actually, color-TV prices have not so much risen as bottomed out. VCR prices, however, are up from the rock bottoms they reached late in 1985, with retail prices some $10 to $20 higher than at that point. The rise in VCR prices is due almost entirely to the increase in the value of the Japanese yen against the American dollar—by more than 25 percent since last September—which has caused price hikes in most Japanese products here. The yen/dollar relationship also has contributed to the rise in the cost of television sets made in Japan or using Japanese components. Another factor in the leveling-off of the downward TV price-spiral is the fact that most television manufacturers have been operating at a loss or sharply curtailed profits as a result of climbing costs in a hotly competitive market. **R-E**

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- ADJUSTABLE LF & HF RESPONSE
- COMPENSATION FOR MOST SCOPES

The Probe Master 2900 series oscilloscope probes combine the characteristics of high performance, and fast rise time pulse response, with a **slender design** to meet the needs of today's micro electronics. The **miniature tip** is ideal for accessing high density boards and hard to reach test points. By locating the high and low frequency compensation circuits in the BNC end of the cable, the design of the probe has become light weight and slender for easy handling.

Other features of the 2900 series probes include a replaceable probe tip, replaceable ground lead and a **Readout Actuator option** (RA).

The **Readout Actuator option** (permanently attached) is available on the 10x fixed attenualon probes only. This option provides the necessary resistor circuit to change the range factor on the model 465, 475, 485 and 7000 series Tektronix scopes.

The **Standard Accessories** included with each probe are the sprung hook, trimmer tool, BNC adapter, tip insulator, IC tip cover, spare probe tip, 6″ ground lead, and a handy storage pouch. The **Engineers Accessory Kit** ($12.00 option) includes a wire wrap adapter tip, wire wrap adapter ground lead, alligator tip, micro sprung hook, and a 12″ ground lead.

CHARACTERISTICS

MODEL	ATTENUATION	CABLE TERMINATION	BAND WIDTH (MHz)	RISE TIME (NS)	LOADING CAP. (PF)	*RES. (M-OHM)	DC MAX	PRICE
FIXED ATTENUATION								
2903	1X	STD	25	11	40	1	600V	$25.00
2960	10X	STD	60	5.8	16	10	500V	$30.00
2960 RA	10X	RA	60	5.8	16	10	500V	$40.00
2904	10X	STD	100	3.5	17	10	600V	$35.00
2904 RA	10X	RA	100	3.5	17	10	600V	$45.00
2905	10X	STD	250	1.5	17	10	600V	$45.00
2905 RA	10X	RA	250	1.5	17	10	600V	$55.00
2906	100X	STD	70	5.0	6	100	1.2KV	$55.00
SWITCHED			10X/1X	10X/1X	10X/1X	10X/1X		
2901	10X, 1X, GND	STD	100/5	3.5/70	17/100	10/1	600V	$39.00
2902	10X, 1X, GND	STD	250/5	1.5/70	17/100	10/1	600V	$49.00
1064	Engineers Accessory Kit							$12.00

- RA = Readout Actuator, STD = Standard BNC • Cable length 5½ ft.
- On switched probes, probe tip is grounded thru a 9 Meg OHM resistor, when switch is in the GND position • 10X compensation range, 15 to 50 PF

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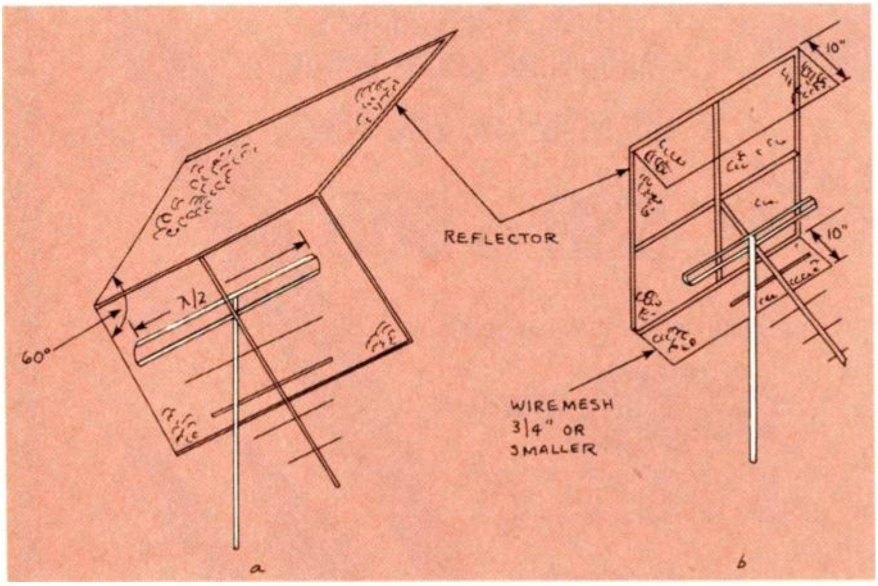

FIG. 1

POWER-LINE TV INTERFERENCE

My TV reception is being ruined by high voltage power transmission lines that run behind my apartment. My antenna is about eight to ten feet below, and 75 feet away from, those power lines. The interference is in the form of horizontal streaks and noise on channel 3, snow on channel 11, ghosts on channel 23, and extreme snow on channels 32 and 41. Sound is clear on all channels except 3. I've tried "ghost eliminators" and AC in-line filters without success. What can I do?—S. G., Elizabethtown, KY.

We're not sure that all of your problems, (ghosts, snow and noise) are caused by the power lines. We assume that all the stations you want to view are in the same general direction and that the power lines are *not* between the antenna and the desired signals. The snow indicates that your antenna is not pointed directly at the station, or that the station is located far away. The snow can probably be cleared up by installing an antenna rotator for accurate antenna orientation, and by installing a good all-channel booster for a boost in received signal strength.

In Fig. 1 are shown two ways we have found of reducing or eliminating power-line interference. In both cases, we use a high-gain antenna, but we replaced the single-element reflector with one that screens interference from behind and from above. In each case, the screen is as wide as the original reflector, and it extends approximately ¼ wavelength above and below the plane of the antenna.

We built ours from hard-drawn ¼-inch copper tubing used as the frame for the corner-reflector. We covered it with copper screen wire and soldered the mesh all around. The billboard-reflector was framed with ¼-inch bamboo salvaged from inexpensive fishing poles and covered with hardware cloth. The mesh should be three-quarter inch or smaller.

We found that the ratio of received signal to interference varied with antenna height. In fact, raising or lowering the antenna as little as three feet made an appreciable difference in the signal-to-interference ratio.

AIRCRAFT RADIO ON THE FM BAND

I live near a very active airport. FM reception is frequently marred by chatter from pilots in planes leaving or approaching the airport. Who should I complain to—the local airport authorities or the FCC?—H. McD., New Smyrna Beach, FL.

Neither; your complaint is invalid. The interference you are experiencing is due to an FM receiver with insufficient selectivity. Common FM receivers, which cover the 88- to 108-MHz band, have IF's of 10.7 MHz, so their local oscillators operate 10.7 MHz above the desired signal. To cover the broadcast band, that oscillator runs from 98.7 to 118.7 MHz. As you know, the 88- to 108-MHz band is assigned exclusively to FM broadcast stations, but, as you may not know, the 108- to 135-MHz band is allocated to aeronautical mobile services, including air traffic control.

So, if you are listening to an FM station on 100 MHz, the local oscillator is actually tuned to 110.7 MHz. Now suppose that a nearby plane is transmitting on 121.4 MHz. That signal is 10.7 MHz higher than the local oscillator signal, so it will also develop a 10.7-MHz IF signal. The signals developed by the FM broadcast station and the aircraft radio will both be amplified by the

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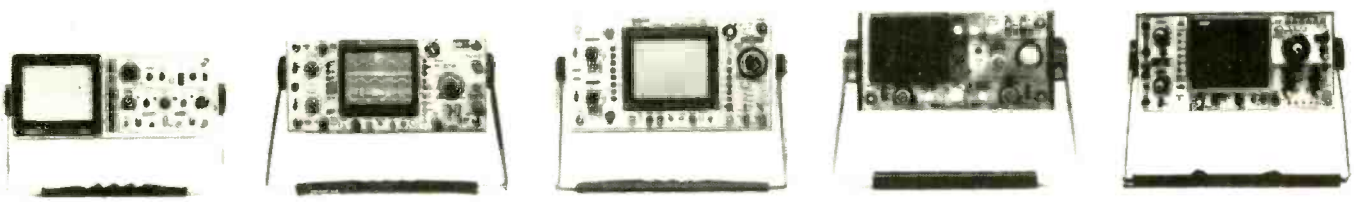

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IF amp and converted into interfering audio signals.

That type of interference is called "image" interference. It develops any time a receiver picks up a signal whose frequency is twice the frequency of the IF above the frequency of the desired station. To eliminate it you must increase the selectivity of your receiver by installing additional stages of preselection or image traps that discriminate against the unwanted signal.

AUDIO DISTORTION FILTER

I am in the process of designing a 10-watt power booster and distortion filter for my portable stereo system. I have the booster amplifier all laid out, but I don't know how to get rid of the distortion. At full output the portable has 10% total harmonic distortion, and that is quite high. Can you tell me how to reduce that interference to a tolerable level?—D. P., Los Altos, CA.

I don't know anything about your portable stereo, but I'll bet that the distortion you find objectionable is caused by overloading its small speakers. Unless you have "golden ears," 10% THD is not so bad when heard through good hi-fi speakers that are not being overdriven.

Be sure that you design your booster amplifier so that it can be driven to the desired output level by the portable stereo when it is just "loafing along." Then the setup should sound fine as long as you don't try to get every last watt out of the booster amp.

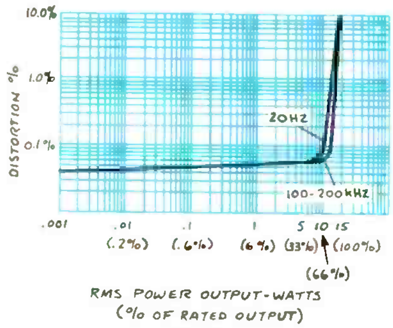

FIG. 2

Distortion curves for a typical 15-watt amplifier are shown in Fig. 2; as you can see, distortion increases drastically when you drive such an amplifier beyond about 66% of its rated output—in this case, about 10 watts. **R-E**

EDITORIAL

Guest Editorial—Scrambling: Another View.

Satellite television is a vital, billion-dollar industry, and one that is growing. Ill-conceived quips that dishes "are good only for scrambling eggs" reflect a total ignorance of reality—satellite technology is now the prime delivery system for TV signals.

Industry leaders, including satellite-dish-system manufacturers and cable-TV programmers and operators, must share the blame for consumer confusion about satellite-signal scrambling. Rather than treating each other with disdain and mistrust, home satellite-TV-system manufacturers and dealers, and cable-TV operators, should cooperate to provide consumers with the free choice in programming that they desire. Instead, many in both camps are in fantasy land, trying to wish each other out of existence.

The lack of hard information that has resulted from that has left the typical consumer totally baffled. To many, the clear and important distinction between legal home satellite-TV and illegal signal piracy has become blurred. Protecting their own special interests, some, knowing better, have told satellite-system buyers that there would be little scrambling. For the same reasons, others, knowing better, have claimed that with scrambling the sky will go dark. Shallow news reports in the media, often based on half-truths or presented by those not truly familiar with satellite and cable TV, have only compounded the confusion, endangering the livelihood of those who have put their faith in exciting new technologies.

Cable-TV programmers and operators, and satellite-dish and -receiver manufacturers are all part of one industry. It is called television: an educational, entertainment, and data-transfer medium that depends on satellite technology—whether signals eventually get to the home by dish, cable, or some other means. Encoding has and will not do anything to substantially change that. It is merely a means to ensure that all party's (programmers, cable operators, home-satellite-TV-system manufacturers and dealers, and home viewers) interests are protected.

Satellite TV, with signal encoding and all of the possibilities that that entails (direct pay-per-view, for instance), offers the greatest numbers of viewers the widest choice of programming options. For millions, it is the only alternative for those wishing to take advantage of what television has to offer.

Hans Giner
President
Luxor North America Corp.

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LETTERS

MODEL AIRCRAFT FREQUENCIES

I noted your response to B. G. of Evergreen Park, IL in the "Ask-RE" department, **Radio-Electronics**, April 1986, page 14. I wonder if he gave you enough information. Would your answer have been the same if you had known that the channel separation is 40 kHz? Channel 42 is 40 kHz below and channel 46 is 40 kHz above his frequency. In 1991, the odd-numbered channels will come into use and separation will decrease to 20 kHz. Those model-aircraft frequencies are in the 72-MHz region, along with many commercial services.

One solution to his problem is to use a down-converter working through an automobile radio to get selectivity. I designed one, added an RF preamp, and got a 0.25-microvolt receiver that tunes the band—not really a simple project, but not too complex.

I have two suggestion for B. G. He could replace the motor in a servo with a small speaker, and with his receiver on and his transmitter off, he would hear if there were another transmitter on his frequency. Second, he should inquire at his hobby shop about local clubs affiliated with the Academy of Model Aeronautics, 1810 Samuel Morse Drive, Reston, VA 22090. Or he could write directly to them for information. Safety procedures used by those clubs are designed to avoid simultaneous channel usage.

Here are a few suggestions for **Radio-Electronics.** I think it is time that you did a comprehensive article on radio-controlled model aircraft. The impact of solid-state

continued on page 20

NEW!

Satellite Communications Training from NRI!

Move into commercial satellite communications and home satellite TV with NRI's latest training breakthrough!

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Back in 1964, great excitement surrounded the launching of Syncom 2, the true forerunner of today's satellites. But not even the most hopeful of scientists believed that in less than 25 years, communications satellites would have such a tremendous impact on the professional and personal lives of millions of people around the globe.

Today, thanks to the rapid development of satellite technology, a call to Paris is as clear and as easy to make as a call to your next door neighbor... executives from multi-national corporations and even small businesses use video conferencing to "meet" without leaving their offices... simultaneously a billion people witness a single event (a soccer game, an inauguration, a benefit rock concert)... global weather maps transmitted from satellites allow meteorologists to forecast weather trends weeks in advance... and scientists now explore and investigate the mysteries of outer space without leaving their labs.

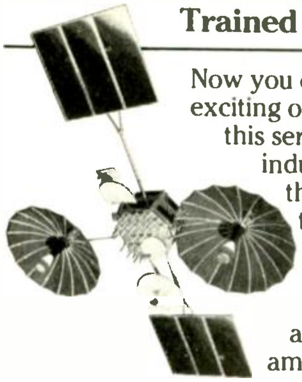
And, not surprisingly, these amazing applications of satellite technology have opened up exciting new opportunities for the technician trained to install, maintain, troubleshoot and repair satellite communications equipment.

Home Satellite TV Is Just at the Start of Its Explosive Future

You've seen them in suburban backyards and alongside country farmhouses. Home satellite TV systems are springing up all across the country.

Already there are over a million TVRO (Television Receive-Only) systems in place in the U.S. alone, and experts predict that by 1990, a remarkable 60% of U.S. homes will have a satellite dish. Contributing to the field's phenomenal growth are the support of the FCC and Congress, steady improvement in product quality, the development of smaller dishes, and a growing consumer enthusiasm for satellite TV.

New Jobs, New Careers for the Trained Technician



Now you can take advantage of the exciting opportunities opening up in this service- and support-intensive industry. NRI's new breakthrough training prepares you to fill the increasing need for technicians to install, adjust, and repair earth station equipment, such as dishes, antennas, receivers, and amplifiers.

As an NRI-trained technician, you can concentrate your efforts on consumer-oriented TVRO equipment. Or you can use your NRI training to build a career servicing larger commercial or military equipment used both to transmit and receive voice, data, and video signals. You'll also find opportunities in sales and system consulting, a role some expect to increase tenfold within the next five years on both the corporate and consumer levels.

NRI Brings Satellite Technology Down to Earth

Only NRI has the resources and the skills necessary to transform today's most sophisticated technology into understandable, step-by-step training.

NRI's new course in Satellite Communications gets you in on the ground floor of this booming technology. You are thoroughly trained in the necessary basic electronics, fundamental communications principles, and television transmission and operation.

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The Wilson TVRO system included in your course comes complete with 5′ parabolic dish antenna system, low-noise amplifier (LNA), down converter, receiver, low-loss coaxial cable, and even a permanent polar mount.

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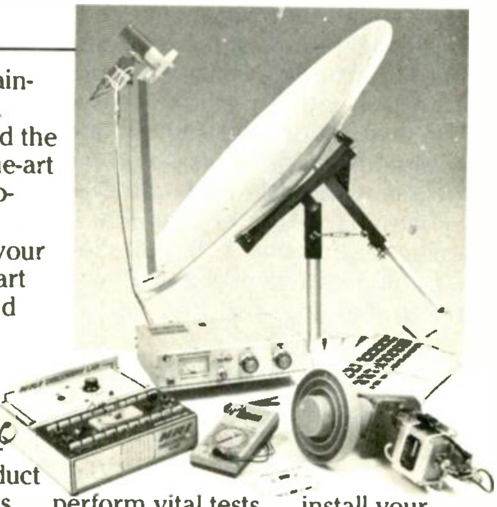

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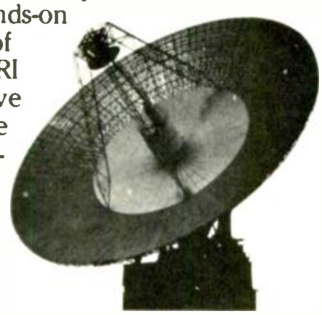

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technology on the hobby has been incredible. Some very sophisticated equipment is now in use at surprisingly modest prices, compared to 10 or 15 years ago. Besides AM pulse-width modulation, we now have FSK (they call it FM); and pulse-code modulation is coming into use with systems of up to 7 or 8 channels. Most equipment is Japanese, but one U.S. supplier, ACE R/C in Higgensville, MO offers equipment in kit form.

C. R. AHERN
President,
District of Columbia Radio Club

SECRETS

I couldn't help but be angered at the lament in one of your product-review columns that schematics were not given out freely for new products—especially in "enthusiast type" equipment.

Perhaps the design of an elegant, manufacturable, and cost-effective product seems a minor exercise to that writer, but in fact it is not. Often, the only way a small company can prevent or at least slow down larger companies with volume advantage (or the Japanese) from sliding in and seizing a market is to keep as many circuit details as secret as possible for as long as possible.

That way, at least, you have a chance of selling enough of the product to recover development costs before someone else muscles in. And never mind "proprietary" circuits; the protection provided is negligible. A small company can be destroyed before the court gets around to looking at your case. A large company can patent a product before a ruling is reached, and you are left up the creek without a paddle.

NAME WITHHELD

OOOOPS!

I have received some letters from **Radio-Electronics** readers in regard to my article on the TV Stereo Adapter that appeared in the March 1986 issue. Those letters complained that the Adapter does not operate.

Reviewing the schematic presented, I understood the reason for the complaints: there is an omission in the schematic. Pin 1 of the MC1310 IC should be connected to +12 volts. Without that connection, the Adapter certainly will not operate.

STEVE SOKOLOWSKI

RELAYS IN ROBOTICS

I enjoy your magazine, but one thing that bothers me is the use of electromechanical relays, especially in robotics projects. For example, in "Building Your Own Robot," (**Radio-Electronics**, March 1986) Mark Robillard states: "First of all, you're going to need relays if your motors are small DC types." He goes on to say that transistors sometimes don't provide full power.

My objection is that, with MOSFETS having R_{DS}'s of 0.05Ω and less commonly available, why use a relay? It's best these days to reduce the number of unreliable mechanical parts as much as possible. I have worked with relay sys-

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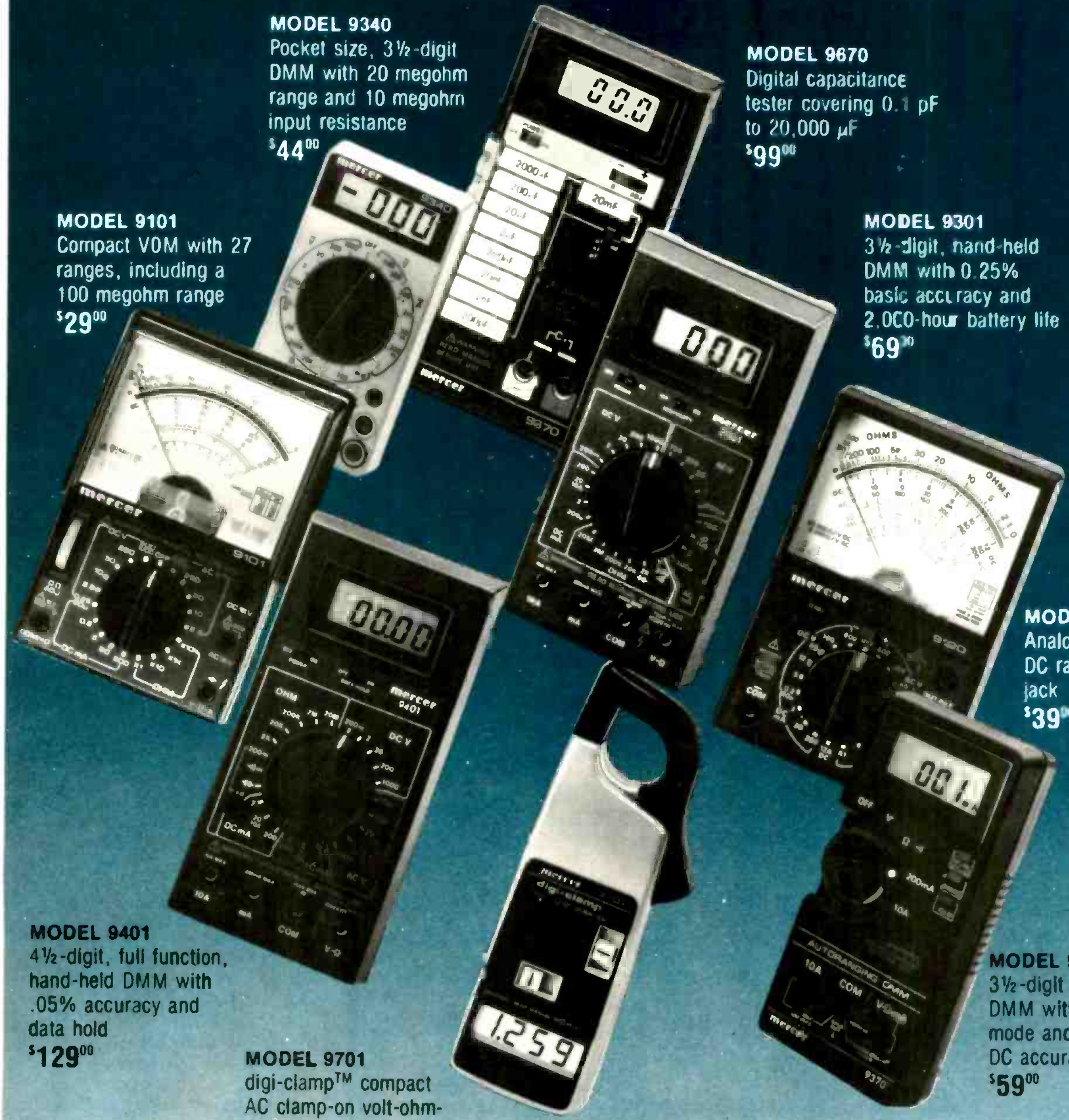

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CIRCLE 177 ON FREE INFORMATION CARD

tems, and, believe me, they waste power and they are prone to failure with age. They are also slow and they induce transients. Their only redeeming feature is that they provide simultaneous multiple-contact closure. But even that can be circumvented by using logic and semiconductor devices.

You fellows who write for the magazines: Please try to dump the old mechanics and keep it state-of-the-art.

Let me repeat that I enjoy your magazine and hope that you won't succumb to computer mania. Not that computers aren't wonderful, but a steady diet of them bores me. Let's face it: If you can't interface them with the real world, then they are limited.

As far as I am concerned, you are the last remaining good electronics magazine.

CLYDE H. HYDE
Tenino, WA

HELP NEEDED

Help! I need an operator/service manual for the Leader *LBO-511* single trace oscilloscope. Can you give me an address so that I can obtain that manual? Thanks.

PETER A. MELVILLE
Mt. Sterling, KY

Leader Instruments Corp. is located at 380 Oser Ave., Hauppage, NY 11788.

INFORMATION NEEDED

I recently acquired an Astrocom/Marlux Solid State Tape Deck. It is a rugged, 3-motor deck, the model *407*, made in Japan. It is a ¼-track reversible reel-to-reel deck.

Unfortunately, it is in need of some minor repairs, and I have no information or schematic. If any of your readers could help me out, I would be glad to pay a reasonable compensation for their time.

ROLF K. TAHLOR
2692 Mayfield Road, apt. 2
Cleveland Hts, OH 44106
(216) 321-8716

SERVICE AND INFO NEEDED

I have an Akai model *X-IV* tape recorder and I need service information, or at least a schematic. The Akai Company's response to my request for a manual was that they no longer have any information. Sams lists it in their T-111 manual, but that manual is no longer available. Therefore, I will appreciate any information your readers could provide.

E. W. HOFFHINE
P.O. Box 252
Kihei, HI 96753

RESTORING AN OLD MARCONI

I am trying to restore an old Marconi TV set (TV 500 chassis) to its original working condition, but I am unable to find a schematic or repair manual from the usual sources. The chassis appears to have a problem in the horizontal phase detector circuit, which is a type I have not encountered before. I would appreciate any help you or your readers could give me in locating information about that chassis.

P.G. DODD
18 Lakeland Cres.,
Scarborough, Ontario,
Canada M1G 2L3

EQUIPMENT REPORTS

Radio-Shack Telephone Tester

Now anyone can troubleshoot a telephone.

CIRCLE 5 ON FREE INFORMATION CARD

IN THE "GOOD OLD DAYS" (BEFORE THE breakup of AT&T), getting your telephone fixed was easy. All you needed to do was call the phone company and they would come out and give you a new one. There were no extra charges, no questions to answer, and no arguments.

Now it's like playing a game of Truth or Consequences. First, you've got to figure out if it's the phone itself that's broken, or whether the problem is in the telephone line. Quess wrong and you could add a hefty, needless bill to your woes. That's because your friendly neighborhood telephone company now regards the telephone instrument itself as an alien object—they won't touch it with a ten foot pole. If they make a service call and determine that the problem is not in their lines, the only thing they are now responsible for, they'll bid you adieu, after they advise you that the bill is in the mail. Assuming that you own your own phone, as many of us now do, getting the phone fixed is your headache.

One way to cure that headache is with Radio-Shack's (Ft. Worth, TX 76102) aptly named *Telephone Tester* (catalog number 43-114). One of Radio-Shack's newest products, that microprocessor-controlled unit makes troubleshooting a telephone so easy even a child could do it.

By the numbers

The unit is capable of testing either pulse- or tone-dialed telephones. It can also be used to test answering machines, and cordless telephones.

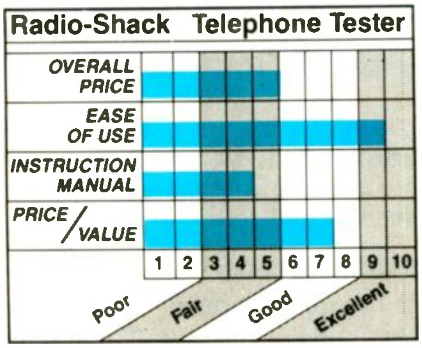
The tester, as supplied, is designed for use with single-line telephones. It can be adapted for use with two-line telephones via a two-line coupler. An appropriate coupler is available from Radio-Shack (catalog number 279-401).

The layout of the *Telephone Tester* is reminiscent of the self-service TV- and radio-tube testers that used to be all over the place; they are still around, but now you might have to search a bit more. All instructions are printed in a flow-chart-like format on the unit's front panel. By following the steps in sequence, the user is able to test for most common telephone and answering machine malfunctions, including defective plugs and cords, in a systematic manner.

The unit is entirely self-contained; there are no probes, accessories, etc. required. Sockets are provided on the tester for the telephone itself, and for the line and handset cords. There are also two AC outlets for telephones or answering machines that require an outside source of power.

Results of all tests are conveyed via two LED's using a simple pass-fail system. In addition a small readout is used to display further information in two of the tests: In the cord test, it is used to display the number of conductors in the cable; in the dial test, it is used to verify the number dialed. Tests are selected using a row of pushbuttons; which test has been selected is indicated by a lighted LED.

In all, the unit is capable of testing nine different parameters. It has both LONG LOOP and SHORT LOOP modes that simulate connections to distant and nearby Central Offices.



The CORD TEST checks the number of conductors in the handset or line cord, and verifies the condition of either cord, including plugs.

When the handset is off-hook, the telephone company's Central Office should see a DC resistance of between 57 and 600 ohms. The function of the unit's LOOP TEST is to verify that parameter.

The DIAL TEST checks for correct dialing. Each digit output by the phone is displayed on the readout for verification. That test will work for both pulse- and tone-dialed telephones.

The TRANSMIT TEST and the RECEIVE TEST check the functioning of the telephone microphone and earpiece, respectively. In the TRANSMIT TEST, if everything is functioning normally, the PASS LED flickers in response to the output of the microphone. In the RECEIVE TEST, the user listens at the earpiece for a tone that is output by the tester.

The unit will also test ringer operation at low and high voltages, simulating distant and nearby Central Offices, and it will test telephone answering machines.

Limitations

The tester is not without its limitations. First of all, its troubleshooting capabilities are quite basic. It will tell you that the telephone is defective, and will more-or-less tell you which functions have failed, but that's all. Pinpointing the fault any further must be done using appropriate equipment and standard troubleshooting techniques. Also, the tester will not test electronic key systems or PABX key sets reliably.

The manual is pretty much what you would expect from Radio-Shack—operating instructions, some specifications, and a schematic, but little else. As to the schematic, in our copy of the manual, the hand-lettering was exceptionally difficult to read; in some cases the printing was so blurred that figuring out a part number or value was reduced to educated guesswork. (A note indicated that the schematic was subject to change and advised contacting Radio-Shack for the latest schematic and parts.) The operating instructions were a fleshed out version of the front-panel instructions.

Obviously, the tester is not something that's a must for every workbench. But without a doubt, it is a unit that will find plenty of use in the appropriate application. The tester would perhaps be at its best on a counter in a telephone store, were customers could troubleshoot their own telephones with ease. It's professional, yet, non-threatening layout and sturdy grey-steel case seem to indicate that the tester will lend itself particularly well to such an application. In service departments, the tester could be used to do initial troubleshooting, and final check-out. Since the work could be done by a non-technical individual, expensive bench time could be saved.

The *Telephone Tester*, which is covered by a one-year limited warranty, is available at Radio-Shack stores. It sells for $299.95. **R-E**

continued on page 26

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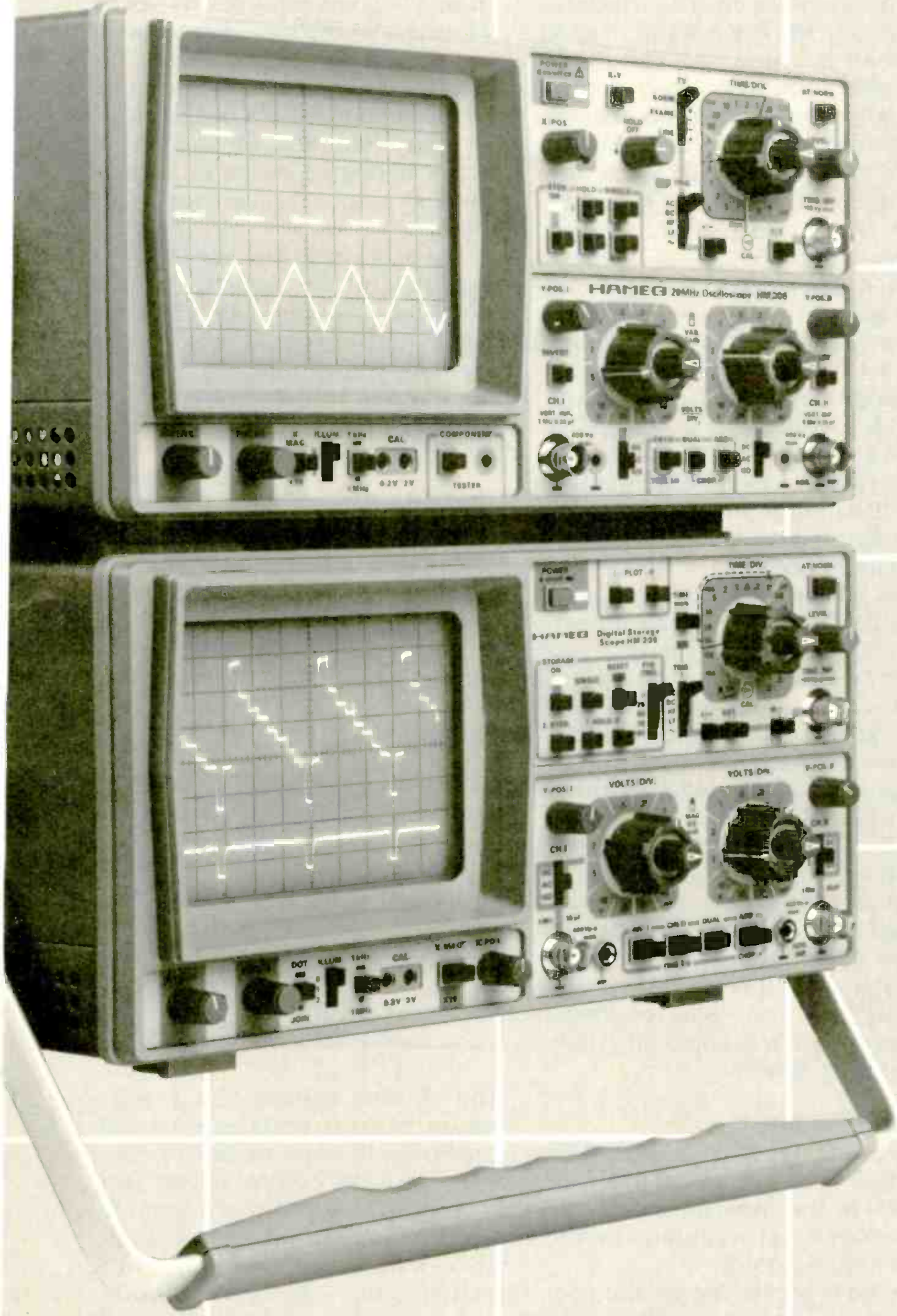

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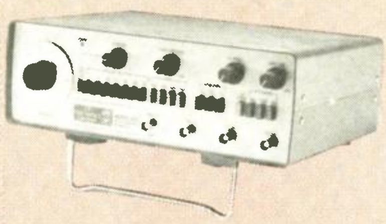
OK INDUSTRIES MODEL 205 FUNCTION GENERATOR

A 5-MHz, no-nonsense function generator.



CIRCLE 6 ON FREE INFORMATION CARD

AS YOUR TEST AND MEASUREMENT needs become more sophisticated, one instrument you're sure to need is a function generator that offers sinewave, squarewave, and triangle wave outputs. We recently examined one such instrument, the model *205* from the Electronics Division of OK Industries Inc. (3455 Conner Street, Bronx, NY 10475).

We'll start our description of the *205* with its physical characteristics. It measures about 12×4×9 inches and weighs 7½ pounds thanks, in part, to a well shielded steel housing. All circuitry and switches, with the exception of front-panel potentiometers and BNC input and output jacks, are mounted on a single well laid-out circuit board.

The *205* has a frequency range of 0.005 Hz to 5 MHz in seven overlapping ranges. The output frequency is chosen by using a vernier dial (calibrated from 0.005 to 5) and a group of pushbutton MULTIPLIER switches that are arranged in decade multiples from 1 to 1 million.

Although the *205* does not offer an internal sweep generator, it does provide a SWEEP IN jack that allows the generator's frequency to be controlled by an external voltage. The sweep input sensitivity is 0 to 4 volts for 1000:1 sweep, and a maximum allowable input of ± 10 volts.

Operating modes

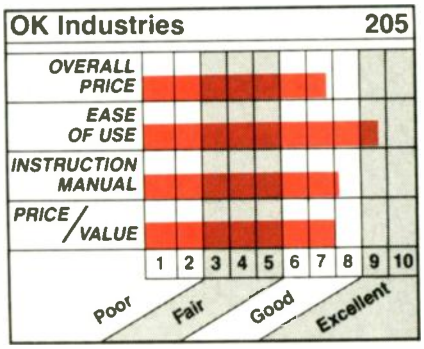
The *205* has 3 basic operating modes: free-run, triggered, and gated. In the free-run mode, the generator runs continuously at the selected frequency.

In the triggered mode, the generator outputs one complete cycle of the selected signal after it receives a trigger. That trigger signal can vary from DC to 5 MHz and from TTL-compatible levels up to 20 volts. Alternatively, the MANUAL button can be used to trigger the generator. The phase of the output signal can be selected by the START/STOP PHASE control, which offers a full ±90-degree range of adjustment at output frequencies up to 500 kHz.

The gated mode is similar to the triggered mode except that the output runs for the duration of the gate signal (instead of only one cycle). As you would expect, the starting and stopping phase at the output can be set by the START/STOP PHASE control.

Outputs

The model *205* has two outputs jacks: TTL OUT and 50Ω OUT. The TTL output is at a fixed amplitude level at the frequency and symmetry of the main (50-ohm) output. It has a fan-out of 20 standard TTL loads.



The 50-ohm output has a maximum output voltage (into 50 ohms) of 10 volts peak-to-peak. The AMPLITUDE control allows you to vary the output more than 20 dB. Additional attenuation is available from three pushbutton switches (0, −20, and −40 dB), and a DC OFFSET control is featured to further tailor the output signal to suit your needs.

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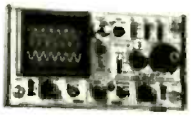

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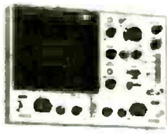

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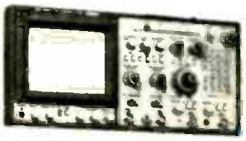

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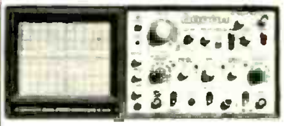

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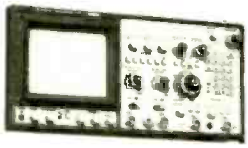

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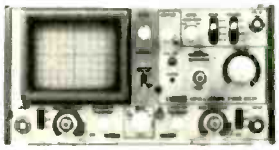

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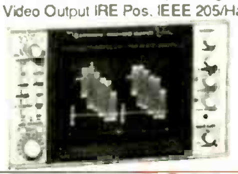
Waveform Monitor/2Loop-through Inputs/AC-DC Input Coupling/ Video Output IRE Pos. IEEE 205/Half-rack Width/6"CRT



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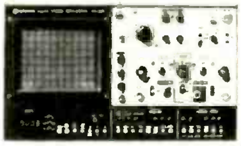

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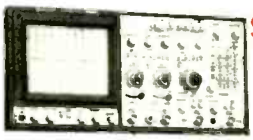

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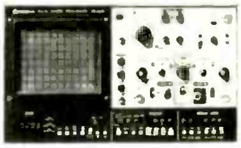

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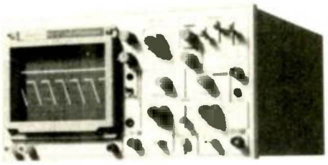

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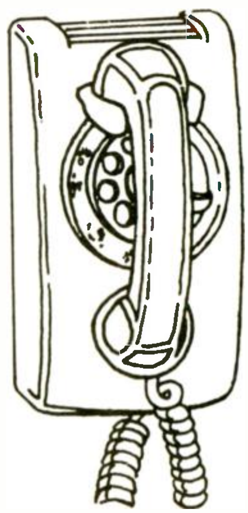

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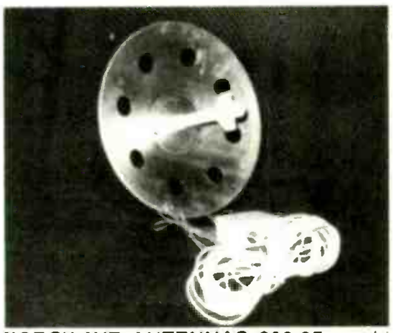

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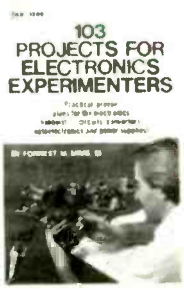

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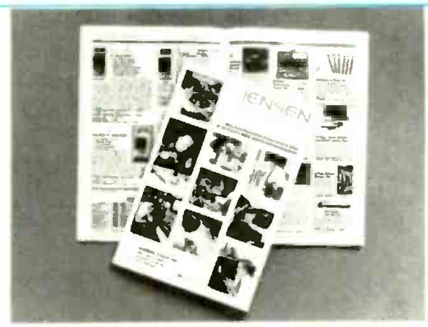

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EQUIPMENT REPORT

continued from page 26

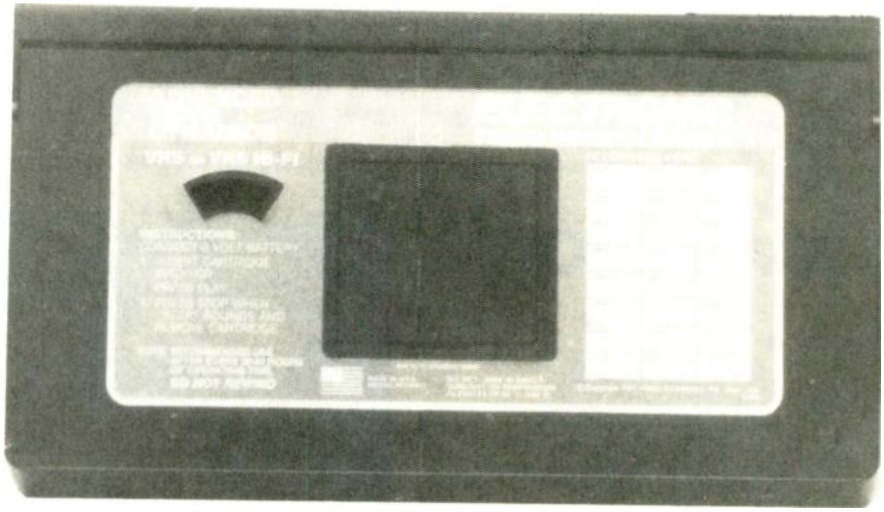
A SYMMETERY control can be used to vary the duty cycle of the output. So, for example, you can produce sawtooth waveforms from the triangle output or you can produce pulse waveforms from the squarewave output in the symmetery mode.

The instruction manual for the *205* should be adequate for most users. It includes a list of specifications, instructions on how to change the operating voltage from 110 volts to 220 volts, and basic operating information. It also includes a nomograph that can be used to determine the output frequency based on the vernier setting and the externally applied sweep voltage.

We would have liked the manual to include calibration instructions, especially since the circuit board has more than thirty trimmer potentiometers. However, a service manual (which we did not see) is available separately.

The model *205* seems like a rugged unit that offers the most-often-needed features in an attractive package. It is priced at $545. **R-E**

NEW PRODUCTS



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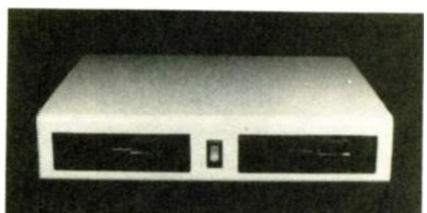
VIDEO HEAD CLEANER, the model *CJ-58*, is an electronic head cleaner that doesn't require the user to estimate either the length of the cleaning cycle or the amount of fluid to supply. The device automatically calculates both items.

The automatic dispensing system in the cartridge also makes the product easy to use—no spraying, swabbing, or pouring the cleaning fluid; no other paraphernalia to keep track of. The user inserts the cartridge into the VCR and presses the PLAY button. It takes about 15 seconds to clean the video heads and other components thoroughly; then the cartridge stops and emits a beep. The user then presses the STOP button and removes the cartridge.

The head cleaner lasts for about 25–30 cleanings. It comes complete with a 9-volt alkaline battery and has a suggested retail price of $18.95.—**Video Dynamics, Inc.,** 6525 Oxford Street, St. Louis Park, MN 55426.

DISK SYSTEM, *the EquiDisk +*, is a subsystem for the Apple *II+* and *IIe* that increases data storage to 737 kilobytes on each 5.25-inch floppy disk and allows CP/M users to access foreign formats.



CIRCLE 22 ON FREE INFORMATION CARD

The *EquiDisk +* is a complete package. It includes an *EquiDisk +* controller card, software, and instruction manual, plus two (or optionally one) disk drives. Thee half-height, high-capacity disk drives are enclosed in a slimline case that fits neatly between the computer console and the

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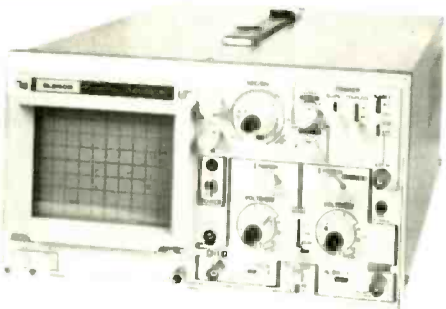
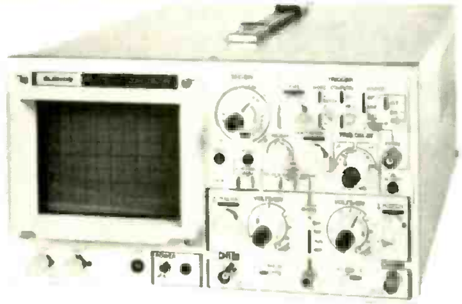


20 MHz DUAL TRACE OSCILLOSCOPE
$336 MO-1251



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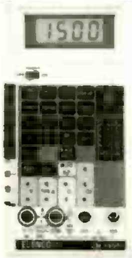

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Reads Volts, Ohms, Current, Capacitors Transistors & Diodes

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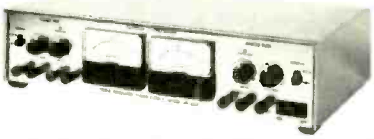
5V	3A	.10V	.005V
-5V	.4A	.05V	.005V

Triple Power Supply XP-660



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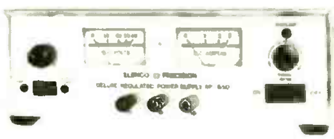

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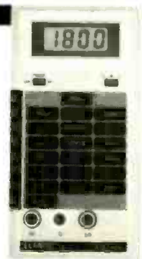

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monitor. The case, with built-in surge suppressor, is equipped with three AC outlets, and allows the user to control power to the computer, monitor, and printer with the unit's front-mounted ON/OFF switch.

The *EquiDisk+* is priced at $679.00 for the two-drive system, $579.00 for the one-drive system.—**H&M Disk Drive Services, Inc.,** 1101 East Pacifico Avenue, Anaheim, CA 92805.

DC POWER SUPPLY, the model *1630*, features regulated outputs for volts and amperes; built-in metering; two current ranges for full or half output; a pre-regulator to limit internal dissipation; an isolated output so either polarity may be floated or grounded; and reverse-polarity protection. It is a 0–30 volt, 3-ampere device with low ripple.

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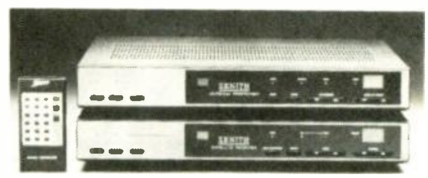
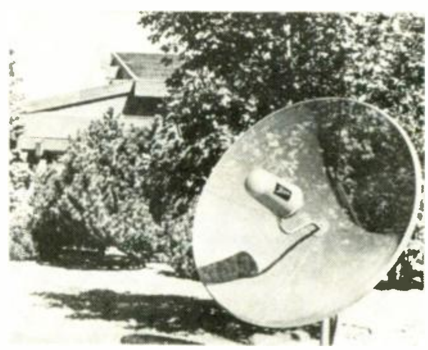
The model *1630* has fully adjustable current limiting (from 5% to 100% of maximum output current) that protects both the circuit under test and the power supply. It can be hooked up in series or in parallel with another model *1630* for 0–30 volt, 6-ampere or 0–60-volt, 3-ampere operation. It is designed for use in service shops, engineering labs, production testing, school labs, and by hobbyists. The model *1630* is priced at $225.00, and comes with test leads, spare fuse, schematic and parts list, and a complete instruction manual.—**B&K Precision, Dynascan Corporation,** 6460 West Cortland Street, Chicago, IL 60635.

HOME SATELLITE RECEIVER, the *Zenith Home Satellite Receiving System*, is available with a 10-, 8-, or 6-foot-diameter perforated dish; the full system includes a microprocessor-based receiver with *Space Command* remote control and an electronic antenna positioner.

The design of the perforated aluminum dish provides high gain and interference rejection—important when receiving signals from satellites that are more than 22,300 miles away and spaced together closely. To receive signals from different satellites, the system features a motorized actuator that moves the antenna. Also mounted on the antenna is an LNB (low-noise block downconverter) and feed assembly for optimum reception.

Indoors, the system is built around a satellite receiver that can feed up to 24 channels through to a television set or videocassette recorder. The Space Command remote control operates channel selection and audio tuning, and can be used to change antenna positions. Because information is programmed (during installation) into a non-volatile memory inside the antenna positioner, the unit will retain programmed information during a power loss.





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The *Zenith Home Satellite Receiving System* has a range of prices from $1495 for a 6-foot manual system to $2549.00 for a 10-foot motorized system, plus installation.—**Zenith Electronics Corporation,** 1000 Milwaukee Avenue, Glenview, IL 60025. **R-E**

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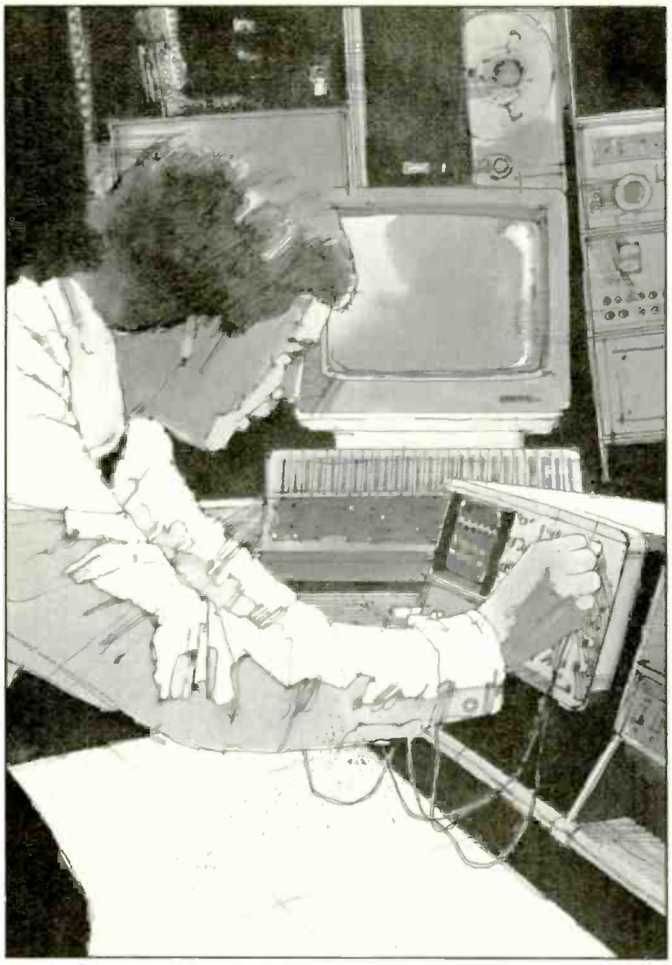
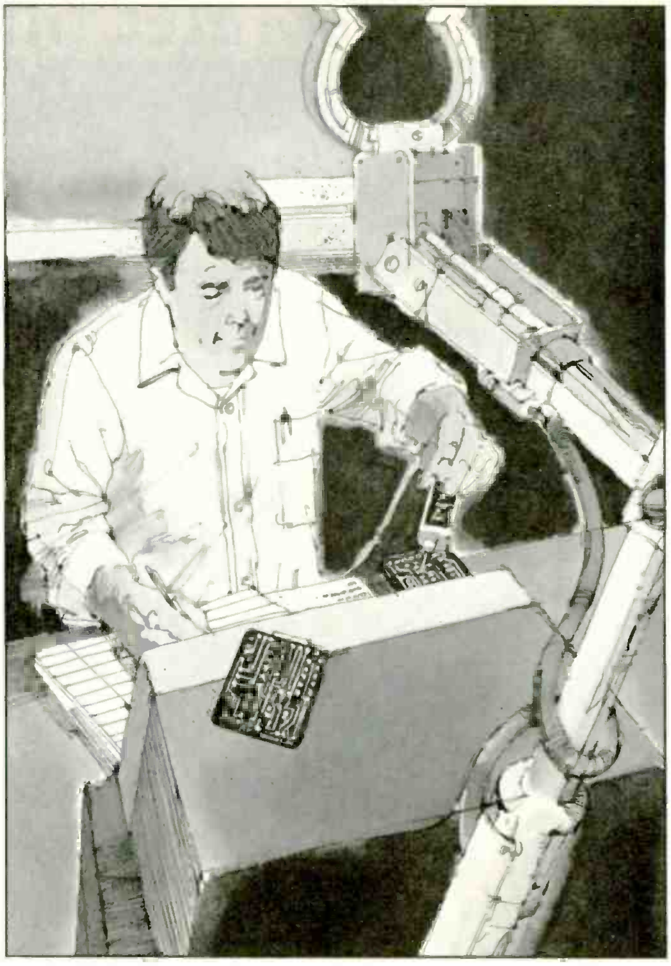
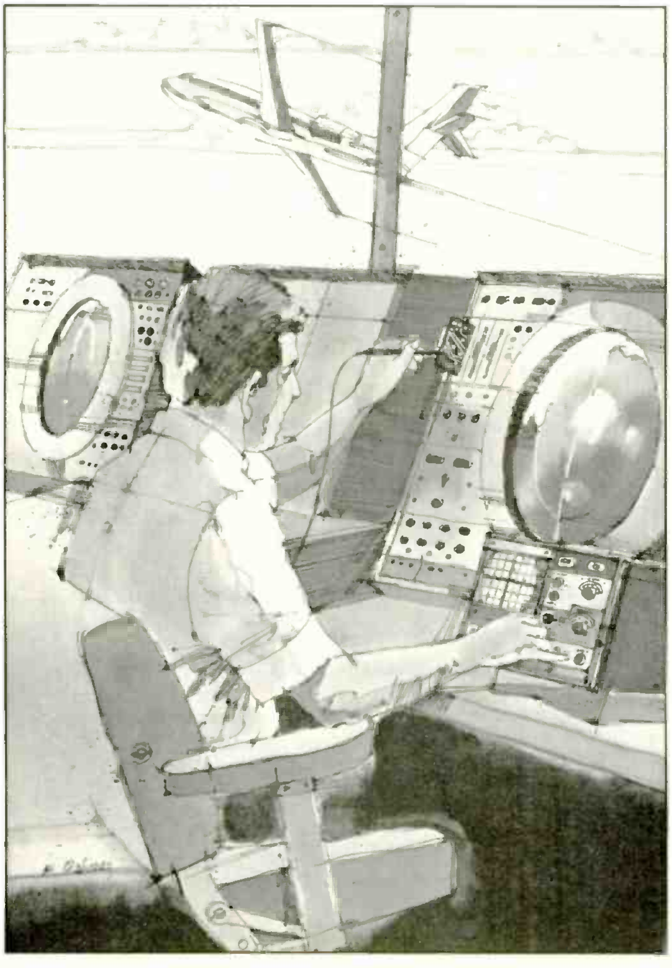
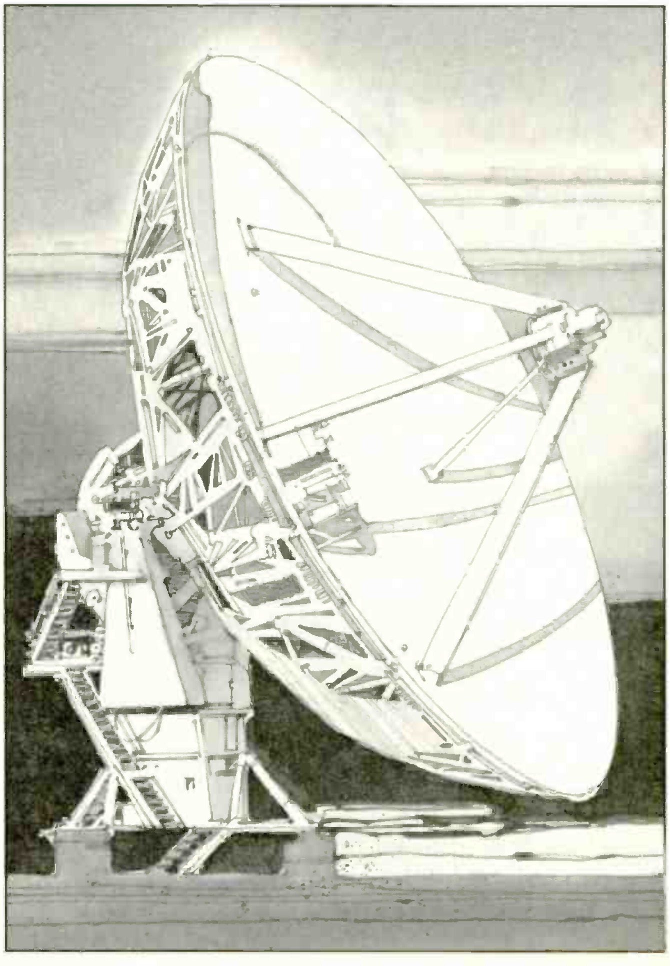





THE CONCEPT BEHIND POCKET-TV IS NOT NEW; ITS origins can be traced to the science-fiction pulps and comic strips of the first part of this century and beyond. Science fiction became science fact in January, 1977 when Sir Clive Sinclair, that English genius of micro-miniaturization, introduced and sold the *Microvision* "pocket" TV through his company, which was called Sinclair Radionics at that time. The *Microvision* was a black-and-white TV set; it used a CRT with a 2-inch (diagonal measure) screen. Despite having some interesting features, that set's price (about $300) and size (pocket*book* size would have been more accurate) contributed to its eventual demise.

The reasons behind both the high cost and the relatively large size of the *Microvision* could be traced to the CRT (specifically, its manufacturing costs and long neck). Realizing that, Sinclair launched research aimed at producing a "flat" CRT. His efforts, and those of his competitors, have led to the birth of a whole new branch of consumer electronics—pocket-TV sets.

This report

As we stated, Sinclair is not the only player in this field. In developing products, various manufacturers have embraced new technologies, and have added color as well. Sony's *Watchman* line, originally offered in 1982, recently passed the one-million-unit production mark.

In this report we will look at 24 pocket-TV sets that are either available now or about to be introduced. For quick reference, the features of each set are summarized in Table 1. More details on each set

Pocket Television Receivers

Here's a no-punches-pulled look at pocket TV, one of the hottest segments of the consumer-electronics market.

FRED BLECHMAN

can, of course, be found in the text.

In preparing this report, most of the TV sets discussed were actually tested, and comments on their performance are provided. Untested sets are noted as such. Any available or supplied accessories are also listed.

Note that the performance judgments were relative to other pocket-TV sets. (The sound from all of the sets was poor compared to a regular TV set.)

LCD displays

In developing their tiny TV sets, manufacturers have taken two basic approaches. One is to use tiny CRT's. Those CRT's are identical to the ones found in your home TV set, except they are *significantly* smaller. The other approach has been to turn to a new display technology, at least as far as TV is concerned—the LCD (*L*iquid *C*rystal *D*isplay).

CRT technology has been used for decades to produce a bright, clear picture. The CRT, however, is not without its faults. It is expensive to produce; it uses a lot of energy, and it requires high voltages to operate.

In the early 1970's, LCD's made their initial appearance in digital watches. Those displays were cheap and easy to manufacture, and used little power. By the early 1980's, more complicated LCD's began to appear; among other things, they were used as the display screens for pocket videogames.

LCD research has progressed to the point now where those devices are practical for use in TV receivers. To date, perhaps the most sophisticated of the displays are the ones found in some Epson and Seiko models, including the Epson *Elf*. Those displays make use of TFT (*T*hin-*F*ilm *T*ransistor) technology.

EPSON *ELF*

The Epson *Elf*, the product of a five-year research effort by the research and development group of Suwa Seikosha that serves Epson and other companies within the Hattori Seiko conglomerate, was developed to overcome certain limitations of the CRT. For one thing, the relatively high power consumption, bulk, and weight of CRT's make them difficult to use in truly portable TV's. And CRT's are poor performers in bright sunlight.

TABLE 1—COMPARISON CHART

MANUFACTURER OR SOURCE	MODEL	PRICE	SIZE (IN.) WIDE	SIZE (IN.) HIGH	SIZE (IN.) DEEP	RADIO AM	RADIO FM	RADIO FM STEREO	SCREEN CHARACTERISTICS COLOR	SIZE (DIAG IN)	TYPE	PIXELS HORIZ	PIXELS VERT.	PIXELS TOTAL	CLARITY	CONTRAST	ADJUSTMENTS V HOLD	CONTRAST	BRIGHTNESS	COLOR	TINT	BATTERIES ALKALINE	LIFE (HRS)	RECHARGEABLE	TUNING SLIDE RULE	DRUM	AUTOMATIC	SPEAKER SIZE (DIAG IN)	LOCATION	SOUND	I/O JACKS VIDEO	AUDIO	ANTENNA	EXT POWER	EARPHONE	COMPUTER MONITOR VIDEO IN 32 COLUMN	VIDEO IN 80 COLUMN	ANT. IN 32 COLUMN	ANT. IN 80 COLUMN	UHF CONV. 32 COLUMN	UHF CONV. 80 COLUMN	ACCESSORIES BUILT-IN STAND	EARPHONE	HAND STRAP	CASE	AC ADAPTER	CAR CORD	BACKLIGHT	WIRE ANTENNA	BATTERIES	PATCHCORD	MAGNIFIER	REMARKS
Casio, Inc 5 Gardner Road Fairfield, NJ 07006	TV-21	$99	4⅝	2½	13/16					2	LCD	139	110	15290	F	P			.			2 AA	4 1				.	2	2	P			3		.	X	X	X	X	X	X	4	.					O	3	✓			C
	TV-60	$130	4 9/16	2 7/16	1	.	.			2	LCD	139	110	15290	?	?			✓			2 AA	4 1		5		✓	2	2	?			3		✓	?	?	?	?	?	?	4	✓					O	3	✓			A C
	TV-1000	$299	6 5/16	3¼	1⅜				.	2 6	LCD	144 × 3	108	46656	G	F			✓	✓	.	5 AA	4 1	O				1 5	F 6	✓	✓	.	✓	.	.	X	X	X	X	X	X	.	.	✓	.	O	O	✓ 7		.	O		C
	TV-5000	$350	8¼	4⅜	13/16	.		.	.	2 6	LCD	144 × 3	108	46656	?	?			✓	.	.	5 AA	?	?	.			1 9	F 6	?	✓	.	.	.	.	?	?	?	?	?	?	?	✓	.		O	O	✓ 7		✓	O		A
Consumer Electronics Group Citizen Watch Co. of America, Inc. 1200 Wall St. West Lyndhurst, NJ 07071	03TA	$149	5¼	3	⅞	✓				2.7	LCD	148	122	18056	F	P			✓			4 AAA	10	O		✓		1	T 6	F	✓		✓	✓	✓	X	X	X	X	X	X	4	✓	✓	✓	✓	O	O	✓	✓			B 8
	05TA	$250	7	4¼	1				✓	2.7	LCD	?	?	35200	F	F			✓	✓	✓	5 AA	10 9	O	✓			1.2	F 6	G	✓	✓		✓	✓	X	X	X	X	X	X	✓	✓	✓	✓	O	O	7	✓	✓			D
	06TA	$100	4¾	2⅞	.8					2 5	LCD 10	160	150	24000	?	? 10			✓			4 AAA	12 11	O	✓			1	T 6	?				✓	✓	?	?	?	?	?	?	4	✓		✓	O	O	O		✓			A
	08TA	$160	5¾	3¼	1			✓		3.5	LCD 10	320	150	48000	?	? 10			✓			4 AAA	10 11		✓			1.1	T 6	?	✓	✓		✓	✓	?	?	?	?	?	?	4	12	✓	✓	O	O	O		✓			A

Epson America, Inc 2780 Lomita Blvd Torrance, CA 90505	ELF ET-20	$199	2¾	4½	1 3/16					2	LCD 13	240	220	52800	G	G			✓			2 AA	10		✓			1	B 6	F			✓		✓	X	X	X	X	F	X	✓	✓	✓	✓			14	✓				E
	ELF ET-12	$350	6⅛	3¼	1¼				✓	2	LCD 13	240	220	52800	G	G			✓	✓	✓	5 AA	5 15	O	✓			1 4	F 6	G	✓	✓		✓	✓	P	X	X	X	P	X	✓	✓	✓	✓	O	O	✓ 7				O	
Magnavox NAP Consumer Electronics Corp. Interstate 40 & Strawplains Pike Knoxville, TN 37914-1810	BF 3900BK	$160	3	6½	1½					2	CRT	N/A	N/A	N/A	?	?	✓	✓				4 AA	3	O	✓			1 4	F 6	?				✓	✓	?	?	?	?	?	?	✓		✓	✓	O	O	14					A
	BF 3901BK	$220	3⅛	6¾	1⅝	✓		✓		2	CRT	N/A	N/A	N/A	E	E	✓	✓				4 AA	3 16	O	✓			1 4	F 6	G	✓			✓	✓	E	F	X	X	E	F	✓	17	✓	✓	O	O	14			O		F
Panasonic Company One Panasonic Way Secaucus, NJ 07094	TR-1030P	$180	3⅛	1½	6					1 5	CRT	N/A	N/A	N/A	E	E		✓	✓			4 AA	4 5	18		✓		1 4	T 6	G				✓	✓	X	X	X	X	G	P	✓	✓	✓		✓	✓	14		18		✓	G H
	CT-101	$450	4⅛	1⅛	7¼				✓	1 5	CRT	?	?	?	E	E	✓	✓	✓	✓	✓	8 AA	3	18	19			1 2	F 6	G	✓	✓	✓	✓	✓	X	X	X	X	X	X	✓	✓	✓		✓	✓	14		18	✓	✓	
Radio-Shack, Div of Tandy Corp. 1700 One Tandy Center Fort Worth, TX 76102	POCKET-VISION -2 (16-152)	$100	4⅝	2½	1 3/16					2	LCD	139	110	15290	F	P			✓			2 AA	4 1				✓	2	2	P			3		✓	X	X	X	X	X	X	4	✓		✓			✓	3				
	POCKET-VISION -3 (16-153)	$160	5¼	3	⅞					2.7	LCD 10	148	122	18056	?	?			✓			4 AAA	10			✓		1	T 6	?			✓	✓	✓	?	?	?	?	?	?	4	✓	✓	✓	O	O	✓	✓				A
	POCKET-VISION -20 (16-154)	$300	6 5/16	3¼	1⅜				✓	2.6	LCD	144 × 3	108	46656	?	?			✓	✓	✓	5 AA	4 1	O			✓	1.5	F 6	?	✓	✓	✓	✓	✓	?	?	?	?	?	?	✓	✓	✓	✓	O	O	✓ 7	✓		O		A I
Consumer Electronics Division Hattori Corp of America 1330 W Walnut Parkway Compton, CA 90220	SEIKO LDV012	$199	2¾	4½	1 3/16					2	LCD 13	240	220	52800	G	G			✓			2 AA	10		✓			1	B 6	F			✓		✓	X	X	X	X	F	X		✓	✓	✓			14	✓	✓			
	SEIKO LDV202	$349	3¼	6	1⅛				✓	2	LCD 13	240	220	52800	G	G			✓	✓	✓	4 AA	5	O	✓			1 2	F 6	F			✓	✓	✓	X	X	F	X	F	X	20	✓	✓	✓	O	O	7	O	✓			J
Sinclair Research Limited One Sinclair Plaza Nashua, NH 03061	FTV2	$100	5½	3½	1¼					2	CRT	N/A	N/A	N/A	G	E						21	15		✓			0.7	S 6	P			2	✓	✓	X	X	X	X	F	X	✓	✓		✓	22	22	14		21			
Sony Consumer Products Co Sony Drive, Park Ridge, NJ 07656	FD-2A	$180	2½	6⅛	1⅝					2	CRT	N/A	N/A	N/A	E	E		✓	✓			4 AA	5 23		✓			1 2	F 6	F			✓	✓	✓	X	X	E	F	E	F	✓	O	✓	✓	O	O	14		✓		O	K L
	FD-30A	$240	3⅛	6¼	1⅛	✓		✓		2	CRT	N/A	N/A	N/A	E	E	✓	✓				4 AA	3 16	O	✓			1 4	F 6	G	✓			✓	✓	E	F	X	X	E	F	✓	17	✓	✓	O	O	14		✓	O	O	
	FD-40A	$200	4¼	8 5/16	2 9/16					4	CRT	N/A	N/A	N/A	E	E	✓	✓	✓			4 C	5	O	✓			2	F 6	G	✓	✓	✓	✓	✓	E	G	G	F	G	F	N/R	O	✓	✓	O	O	14		✓	O		M
Zenith Electronics Corp. 1000 Milwaukee Ave. Glenview, IL 60025	BT 044S	$199	4¾	8 5/16	2 9/16					4	CRT	N/A	N/A	N/A	G	G	✓	✓	✓			4 C	5		✓			2	F 6	G	✓	✓	✓	✓	✓	G	P	G	P	G	P	N/R	✓	✓	O	✓	O	14			O		

LEGEND:
? = "Unknown" or "Not tested", ✓ = "Yes" or "Included", E = Excellent, G = Good, F = Fair, P = Poor,
X = Not usable, N/A = Not applicable, N/R = Not required O = Optional

REMARKS:
A Not tested B Discontinued, but may still be available at retailers C Seek tuning D Fancy book-like case E High-resolution, reflective LCD F Sunhood G Dual earphone jacks H AC adapter uses non-standard plug. I Antenna included J Removable LCD alarm clock K TV-Audio-only capability L Magnifier with sunshade included. M Optional car antenna available

NOTES:
1 2 hours with backlight 2 Earphone only 3 Earphone wire is antenna 4 Mirror provides viewing angle 5 Radio only 6 For speaker location: F = Front, T = Top, B = Back, S = Side 7 Fluorescent backlight built in 8 Slide controls for volume and brightness 9 3 hours with backlight 10 Manufacturer claims 5:1 contrast using black matrix LCD 11 6 hours with backlight 12 Stereo headphones included 13 TFT (Thin-film-tyansistor) technology 14 Backlight not required 15 2.5 hours with backlight 16 28 hours radio only 17 Stereo headset included 18 Rechargeable battery pack included 19 On-screen tuning bar indicator 20 Viewing screen tilts upward 21 Polaroid P-500 lithium battery included 22 Available from Radio Shack. See text 23 35 hours TV sound only

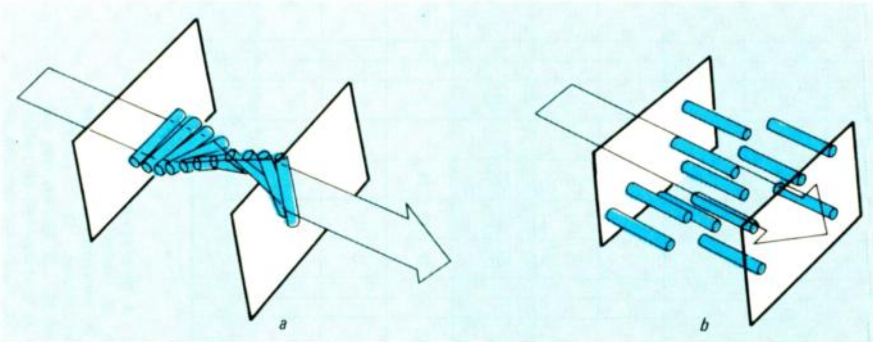


FIG. 1—IN THE ABSENCE of an electric field, liquid-crystal molecules twist the light 90°, allowing it to pass through the display (*a*). When an electric field is present, that twisting does not take place and the light is absorbed by the top polarizer (*b*).

By contrast, the circuitry required with LCD's is compact and lightweight. Therefore, the *Elf* and similar units easily can be held in the palm of the hand. Moreover, the low power consumption of an LCD eases the drain on the unit's batteries. Because the electrodes in a liquid crystal display can be made of transparent materials, the screen can be lit from behind (backlighted) with ambient light or from a built-in source.

In developing the Epson liquid-crystal color TV, Suwa Seikosha's scientists and engineers had to overcome some formidable obstacles. For one thing, the liquid crystals commonly used in watch and calculator displays respond slowly to electrical signals. That is unacceptable for video displays, where the liquid crystals must be turned on and off many times a second. Also, most liquid-crystal displays are low in contrast and limited to black images on a light background.

To solve the problems of slow response times and low contrast, Suwa Seikosha's research team turned to TFT's to turn on and off each of the 52,800 pixels in the *Elf* display. The transistors, deposited on a glass substrate, are made of polycrystalline silicon, a material known for its stability and reliability.

To understand how the TFT's improve performance, it is necessary to know a little about how liquid-crystal displays operate. In the type of LCD used in watches, calculators, and the Epson *Elf*, liquid-crystal material, which is composed of long, organic molecules, is sandwiched between two polarizers; for our discussion, let's designate those the top and bottom polarizers. The polarizers are placed in the display so that their transmission axes are separated by 90 degrees. When no electric field is present, the liquid crystal molecules have their long axes parallel to the top and bottom polarizers and the in-between layers gradually twist through the 90 degrees between top and bottom. Light entering through the bottom polarizer gradually gets twisted through a 90-degree angle by the liquid-crystal layers and exits through the top polarizer as shown in Fig 1-*a*. A person viewing the display sees a light spot.

In the presence of an electric field, however, the molecules stand up on their ends, parallel to the direction of the field. In that state, they can no longer rotate light. Therefore, light entering the bottom does not get twisted; instead it gets absorbed by the top polarizer as shown in Fig. 1-*b*. To a person viewing the display, that spot appears dark.

To create the hundreds or thousands of pixels needed to form an image in a complex liquid-crystal display suitable for use as a video screen, the earlier (and still widely used) approach is "multiplexing." In multiplexing, rows of electrodes are deposited on one side of the liquid-crystal layer, and columns of electrodes are deposited on the other side. The pixels are created at the junctions of rows and columns.

To simulate the scanning processes of a CRT, electric pulses are fed to the row electodes in succession; during that interval, all of the column electrodes are pulsed simultaneously. Whenever the voltage at a row-column junction exceeds a threshold value, the liquid crystals respond. In that way, every field of a standard TV signal can be displayed.

Multiplexing has its problems, however. Because many rows must be addressed in a short time by a single electric pulse, the time-weighted average on/off ratio of black to white is very low, and that results in poor contrast.

Those problems were solved by resorting to an approach called *active-matrix addressing*. In that system, the 240 row and 220 column electrodes of the display are deposited on a single glass substrate. On the opposite side of the display is a common electrode. The TFT's, placed at each row and column junction, are turned on whenever a pixel is to be activated. Driver circuitry controls which pixels are activated at what times.

With the TFT's, each pixel receives the full voltage needed to turn it on, not a time-weighted average, as in multiplexed devices. The result is a very high on/off ratio and good contrast.

Color is added through the use of thousands of microscopic red, blue, and green primary-color filters; one filter is placed over each pixel electrode. When a red spot is to be created, the TFT's at the blue and green filters in the appropriate region are turned on, blocking out light there and letting light through only the red filters. If blue is desired, the red and green TFT's are turned on. If green is to be displayed, the red and blue TFT's are activated.

PANASONIC *CT-101*

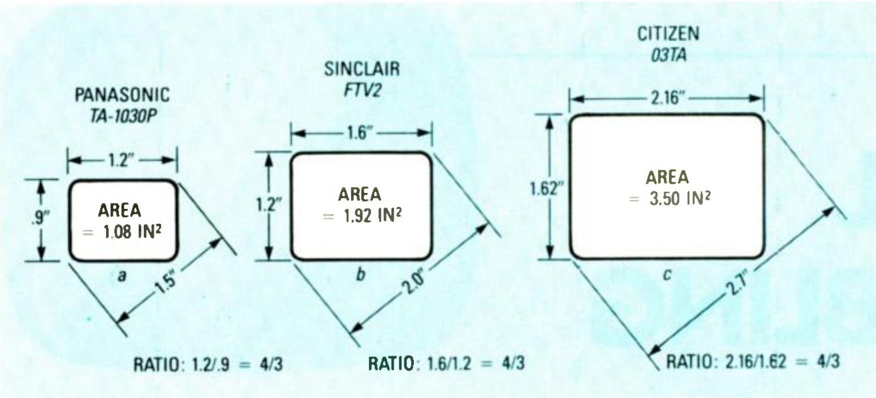


FIG. 2—DIAGONAL MEASURE versus viewing area for three popular pocket-TV sets. The Panasonic *TA-1030P* is shown in *a*, the Sinclair *FTV2* is shown in *b*, and the Citizen *03TA* is shown in *c*.

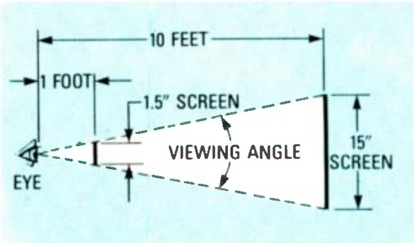


FIG. 3—A 1.5-INCH SCREEN, viewed at a distance of 1 foot, will yield the same viewing angle as a 15-inch screen viewed at a distance of 10 feet.

Other shades are created by turning on various mixtures of the primary-color pixels. If all the TFT's in a region are turned on, no light gets through and the image appears black. If none of them are turned on, all the primary colors get through and the image appears white.

Charting the sets

While the meaning of many of the entries in Table 1, our comparison chart, are obvious, some require further explanation. So, before discussing the individual TV sets, we'll first explain each of the chart headings. The notes and the remarks at the end of the chart provide much additional information.

Manufacturer or source: Most pocket TV sets are still relatively hard to find in local retail stores. Large electronics stores that carry many brands of TV and video equipment are the most likely sources. If you can't find a set you are interested in locally, you may wish to write the manufacturer for assistance. Also, some luxury catalogs, such as those available from Markline and The Sharper Image, frequently offer pocket-TV sets.

Model: It's not unusual for some pocket TV sets to look alike and yet be different in performance. Some are made by one manufacturer for another, but specifications may not be the same although appearance is identical. For example, the Citizen *03TA* and the Radio Shack *Pocketvision-3* look almost identical, but use a different screen technology and include different accessories. Therefore, when shopping with our chart, look for specific model numbers.

Price: The prices shown are the manufacturer's suggested retail prices in effect at the time this article was compiled. As with most other types of consumer-electronics products, substantial discounts are usually available, either from dealers or from mail-order houses.

Size: The dimensions, given in inches, are approximate, and may not include minor protrusions such as switches or retracted antennas. The intention is to give you an idea of relative size. The designations of wide, high, and deep are made with the assumption that the user is looking at the surface of the unit that contains the viewing screen.

Screen characteristics: Some sets offer color but, with the exception of the Panasonic *CT-101*, you'll be disappointed if you expect picture quality that rivals your home color-TV set. That's because all of the color sets, except the *CT-101*, use an LCD instead of a CRT. While some LCD sets are surprisingly good, most have a way to go before they will equal the performance of conventional CRT's

The screen sizes are given in inches measured diagonally, as is the convention with TV-screen specifications. However, that can be very deceptive when dealing with small-size sets. For example, the 1.5-inch Panasonic sets have a viewing area that is only about 50% of a 2-inch screen (that's probably why both Panasonic sets come with magnifiers). Figure 2 shows how diagonal measure relates to viewing area for three popular screen sizes. Note that the TV-standard 4:3 aspect ratio is maintained for all sets.

That is not to say that a 1.5-inch screen is too small. It depends upon how far it is from your eye. Figure 3 shows that a 1.5-inch diagonal screen one foot from your eye subtends the same viewing angle as a 13-inch diagonal television screen 10 feet away.

Probably the most important screen characteristic in determining the acceptability of the picture is the type of display. Subjectively speaking, a black-and-white CRT offers the highest levels of resolution and contrast. On the other hand, LCD screens, with their limited pixel counts and often poor contrast ratios, are the worst performers.

The clarity and contrast rating provided in the table are strictly the author's judgements, and are based on his comparisons between sets.

Adjustments: The trend by manufacturers in recent years has been to delete some of the traditional user controls from their TV sets. Among the controls that have slowly begun to disappear are vertical hold, contrast, and brightness. One reason for that is that modern integrated circuitry can control many of those parameters automatically, thereby eliminating the need for user overide. Another is cost. The elimination of seldom-used controls does make the set a little less formidable to operate, but it also reduces your control over what you watch.

Speaker: If you don't expect much in the way of good sound from these sets, you won't be disappointed. Speaker location plays a role in the sound quality, with the worst performing units being those with the speakers mounted at the rear. Further, some sets are barely audible at maximum volume in noisy surroundings, such as a fast-food restaurant. Earphones are provided or available with all units, if you can tolerate typical earphone quality. The best sound was provided with the stereo earphones included with the Sony *FD-30A* and the Magnavox *BF3901BK*. Where quality ratings are provided (only on those sets tested), the rating was relative to other pocket TV's.

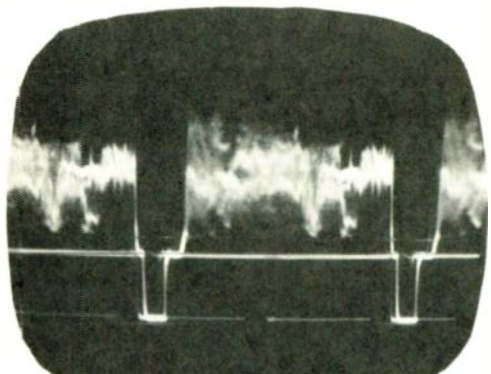
Computer monitor: Because of those TV set's small size, their use as a computer monitor is obviously marginal. However, the set's ability to display a 32- or 80-column computer screen is useful as a benchmark in determining its resolution capabilities. For all sets, the computer signal was coupled via a UHF modulator (channel 15) with a stub antenna. Where available, displays coupled via a video or external-antenna input were also evaluated.

Accessories: The large range of included and optional items are shown in this section of the chart. Most are self-explanatory, but further information can be found in the discussion of each individual set.

Next time

Of course, there's a lot more to be said for the various TV's than can be summarized in a chart. Next time, we'll provide in-depth, no-punches-pulled evaluations of many of the pocket-TV set currently available. If you are contemplating purchasing one of those sets, it is a round-up you won't want to miss. **R-E**

TV SIGNAL DESCRAMBLING



Learn all about what might be the ultimate scrambling system in this month's article.

WILLIAM SHEETS and RUDOLF F. GRAF

Part 2 LAST TIME WE LOOKED at several of the simpler scrambling techniques that are currently in use. All of those rendered the picture unwatchable by either reversing the video polarity or altering the sync in such a way that the receiver's sync circuitry could not lock onto the video signal.

However, all the methods discussed thus far have one major fault: They are "static." By that we mean two different things. First of all, the scrambling algorithm does not change over time. Once the scrambling technique has been determined, it is relatively simple to come up with a circuit that will unlock it. Further, nothing has been done to alter the order in which the video information is transmitted. The video signal is still transmitted line by line, frame by frame, in the same order as it was scanned. The audio is usually unaltered, though it may be hidden on a subcarrier.

Let's expand on that a bit. The static scrambling systems used on most pay-TV and cable-TV systems are not difficult to decode because of the following:

- There is a horizontal sync pulse (or hole) every 63.5 microseconds, and a new field every 16.68 milliseconds.
- The video signal at every instant has a fixed relationship with the scene that was scanned to produce that picture.
- All necessary decoding or unscrambling information is present in the video signal, or on another frequency or channel in a cable pay-TV system.
- Changes in picture content between adjacent frames is generally insignificant.

Thus, if the sync pulses were stripped from a video signal (currently a very popular scrambling technique), the resulting signal would drop to zero at regular intervals. Those regions of zero signal, or "holes," would occur at the points where the sync pulses would be found normally. As we've previously seen, it is a simple matter to restore the normal sync pulses using a locally generated sync signal.

Over the next few months, **Radio-Electronics** will be presenting a series of articles describing the techniques used by pay-TV and cable companies to scramble their signals. While specific circuits for specific scrambling systems will be discussed, they are presented for *informational and experimental purposes only*. Therefore, parts lists, parts suppliers, and additional technical support *will not be available* for those circuits.

Scrambling the picture

Here's a thought to ponder for a moment: All of the previously discussed "scrambling" techniques in fact *do not scramble the picture*. All they do is disrupt the normal video waveform in such a way that a conventional TV receiver can not reproduce a watchable image.

But what if we could actually *scramble* the picture? Normally, a scene is scanned by the video camera and broken up into pixels. Those pixels are transmitted to the receiver one by one. At the receiver, the pixels are reassembled in the order in which they are received to recreate the original picture.

However, in theory there is no reason to scan the picture elements in any particular order. The picture could be thought of as a jigsaw puzzle, with each piece represented by a pixel. The puzzle could be put together in any order without affecting the final image that results. In a conventional TV system, scanning is done from left to right and top to bottom, but that is not the only scan sequence that is possible.

What would happen if we reversed the scan process? That would cause the TV picture to be inverted top to bottom, left to right. A quick "descrambler" for that would be to turn the TV set upside down.

But suppose we began the scan at the midline of the picture. Then the bottom half would appear above the top half and things would appear to be cut in two. By now you of course realize where we're heading. We could cut the picture into four strips and scan them in 2, 4, 3, 1 order. The result would be a nearly unrecognizable picture.

Continuing on, suppose we scanned the 262½ lines per field in any random order. The resulting picture would be unrecognizable—like an unassembled jigsaw puzzle.

Finally, we could break up each line into random segments and scan them in random sequence in each line. All the pixels would still be there, but the picture would look like nothing more than colorful confetti. It would be as if someone tore the picture into tiny pieces and threw it on the floor.

Of course, there is a significant difference between what is theoretically possible and what is practical. For instance, at the receiving end, conventional, magnetic-deflection CRT's are simply incapable of displaying a picture generated by complex scanning satisfactorily. Further, the sweep circuitry in conventional TV receivers is not capable of generating the type of high-speed, high-precision waveforms needed to properly drive the CRT. It is, of course, possible to redesign the sync circuits and the CRT so they are capable of providing the appropriate drive signals; but the TV set that would result would be prohibitively expensive.

Introducing digital scrambling

There is, however, another approach—use digital technology. Thanks to modern VLSI techniques, the cost of a digital scrambling system is rapidly becoming affordable. Let's see what's involved.

It is a relatively simple task to represent the luminance and chrominance information of each pixel in digital form. Each pixel could, for example, be represented by sixteen different luminance levels and sixteen different chrominance levels. If that were done, any pixel could be described by one of the 256 possible combinations that would result. Further, if our digital system used 8-bit "words," any pixel could be completely described by one byte of data.

A standard TV set, one with a bandwidth of 3.5- to 4-MHz, has a resolution of about 250 vertical lines. That translates to a resolution of 250 pixels per line. (On a 25-inch set, which would have a screen width of about 20 inches, such resolution would allow you to see details that were as small as about 1/10 inch.) Thus, all of the information contained in a line could be stored in a 256-byte memory.

If we wished, even more video information could be stored easily. For instance, each field has 262.5 lines. However, only 249.5 to 241.5 lines are actually displayed; the rest are lost to vertical retrace. That means that a complete field of video can be stored in a 256 × 256 = 64K memory.

Of course, once that data is stored, we will need to retrieve that data at a fairly high rate if a usable video image is to be displayed. For instance, if we are storing our data by field, remember that 60 such fields are displayed per second. Thus our access rate must be 60 × 64K = 3.84 megabytes per second. Those of you familiar with the capabilities of current digital technology will realize that the hardware needed to implement such a system is available, but not inexpensive.

Now the fun begins. Once the data is safely in memory, there are few rules to restrict the order in which that data is retrieved. Thus, the order of the pixels within a line may be scrambled (called line dicing), the order of the lines in a field may be scrambled (called line shuffling), or both.

Let's expand on that thought. The pixels of video data stored in memory could be thought of as pieces of a jigsaw puzzle stored in a box. If we could assign a numerical code to each piece, and if we had a map or chart showing where each piece should be placed, the puzzle could be assembled without wondering where each piece fits or having to figure out what part of the picture it represents.

That code could be assigned in one of several ways. One would be to break up each line into eight segments. Using a binary numbering scheme, the segments would be numbered from 000 at the extreme left to 111 at the extreme right. The ordering of the line could then be altered during transmission. At the receiver end, the segments would be placed in memory in the order in which they are received.

The proper sequence of segments could be relayed to the receiver in many ways. For instance, it could be hidden in the horizontal blanking interval, put on a subcarrier, etc. Once the receiver has the proper segment sequence, it is easy enough to pull the stored segments out of memory in the proper order.

What makes such a scrambling system so hard to break is that the encoding can be changed at any time. Each line could be scrambled in a different manner. Or all the lines in one field or frame could be scrambled in one way and all the lines in the next field or frame in another.

If line shuffling is used, the lines can be sent to the receiver in any order. If that is done, the decoding algorithm can be sent prior to each field during the vertical blanking interval. For maximum security both line dicing and line shuffling can be used with changing algorithms.

To give you a better idea of the level of security that those systems could provide, let's stop and consider the number of possible combinations of segments that line dicing and line shuffling can give us. If we were to dice a line into 8 segments, there would be 8! (read 8 factorial) possible combinations. For those unfamiliar with factorial computations, $8! = 8 \times 7 \times 6 \times 5 \times 4 \times 3 \times 2 \times 1 = 40{,}320$.

Now consider the number of lines in a field—rounding down, there are 262. If all of the lines in a field were shuffled, there would be 262! different possible combinations. (If you don't mind, we'll leave the actual computation as an exercise for an adventurous reader.) And that's just for one field; there are some 60 such fields per second, 3,600 per minute, and 108,000 per half hour. Add a constantly changing algorithm and *addressability* into the equation and you have a video "pirate's" nightmare.

For those unfamiliar with the concept, addressability allows you to send certain signals—such as descrambling algorithms—only to those decoders that have been registered as belonging to paying subscribers. Addressable decoders are now being used by many of this country's largest pay-TV distributors.

A block diagram of a system capable of carrying out the scrambling we've just described is shown in Fig. 1. In that system data stored in memory is first read out, then incoming data is read in. The result is a delay of one field (or line or frame, depending on the system). Because of the times involved (remember, 60 fields are displayed per second), the effect

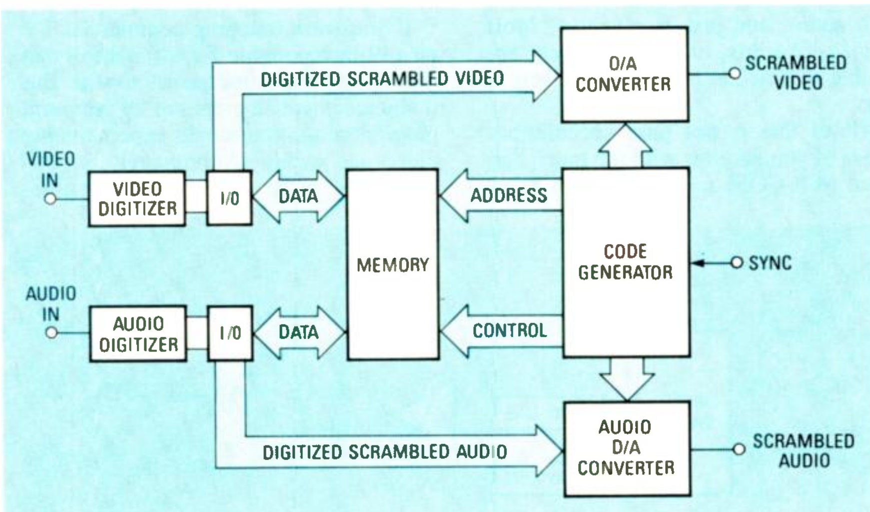


FIG. 1—A DIGITAL-SCRAMBLING SYSTEM is shown here in block diagram form. An unauthorized viewer would find that descrambling that signal is a near impossible task.

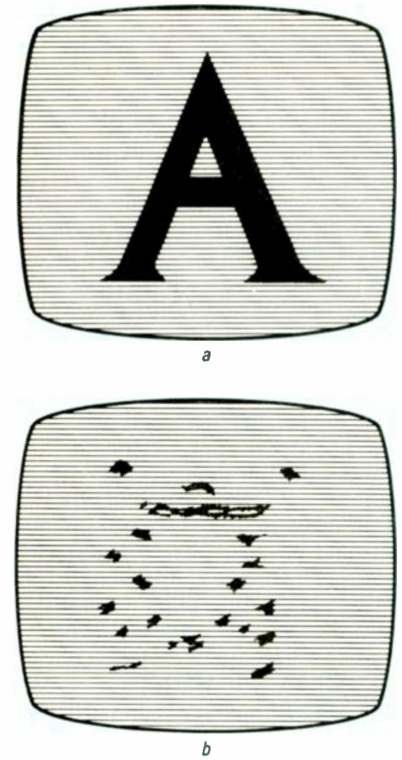


FIG. 2—IF A DIGITAL-scrambling technique such as line shuffling were used, a normal video image (*a*) would be reduced to colorful confetti (*b*).

of that delay is nonexistent. Of course, the data is read in in the sequence in which it is received, but is read out in the order determined by the code generator. The code generator establishes the order of the scrambling under direction of the "sync" signal. Note that that sync signal is the scrambling algorithm that we spoke about previously. The result is that a normal picture, like the one shown in Fig. 2-*a* will become completely scrambled, like the one shown in Fig. 2-*b*.

As indicated in Fig. 1, there is no reason that digital scrambling need be limited to just video. In fact, the task is much easier with audio, and just as effective. Most movies, concerts, etc., are not very enjoyable if they can't be heard as well as seen.

All of this is not pure speculation. Those of you familiar with the much heralded M/A-COM *Linkabit* system know that the age of affordable digital scrambling has arrived. That system is used by HBO and other satellite programmers to limit access to their uplinked signals. The video scrambling method used by M/A-COM is rather primitive, and easily unlocked. The audio is another matter. It is scrambled using a sophisticated digital technique, one that makes use of a constantly changing algorithm and the addressability of the *Linkabit* decoders. Breaking that system should prove to be a formidable task.

Another scrambling method

Before we leave the area of theory, let's look at one more possible approach to scrambling the video. That system introduces a switchable time delay that alters the spatial relationship between successive horizontal lines.

A block diagram of the system is shown in Fig. 3. As you can see in that figure, the technique makes use of one or more delay lines. That allows for various amounts of delay, or no delay at all, to be selected for each horizontal line. The result is that a normal signal, like the one shown in Fig. 4-*a*, becomes one with severe ghosting and distortion, like the one shown in Fig. 4-*b*.

Scrambling and picture quality

One consideration with any scrambling system is how it affects the quality of the picture seen by paying subscribers. Gated sync and sinewave, and related methods, introduce deliberate interference into the video signal. While decoders do a good job of removing the interference, they are not perfect. There is always some residual video noise or interference left over. On a good quality, large-screen receiver or video monitor the effect is noticeable and may be objectionable. Further, with the use of audio subcarriers, the bandwidth of the audio that is received is somewhat reduced, resulting in less than optimum audio quality.

If you were watching commercial TV on a 19-inch portable TV set, none of that may be of great consequence to you. But if you are paying a premium for premium programming, you would expect quality video and audio. Unfortunately, scrambling may make that expectation unrealistic. It is something that should be considered when deciding whether or not you wish to receive a scrambled premium system.

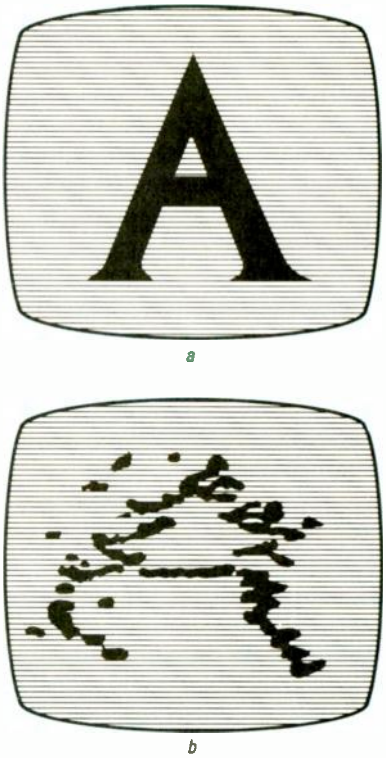


FIG. 4—DELAYING THE VIDEO INFORMATION can turn a normal video image (*a*) into one with severe distortion and ghosting (*b*).

However, digital scrambling may affect video quality in a very different way. Higher resolution, reduced video noise, and reduced interference problems are just some of the improvements possible with digital-TV technology. That's why digital TV is currently such a hot topic.

All of those advantages could also be passed on to the viewer of a digital-scrambling system, especially if the video were viewed on a high-quality, high-resolution monitor. Just as the order of assembly does not affect the way a completed jigsaw puzzle appears, the scrambling/descrambling process would have no detrimental effect on the way the displayed video would appear. In fact, one proponent of a digital video-scrambling system claims that the improvement in the signal-to-noise ratio over that of the baseband video would be about 2 dB.

Next time

So far we've seen some of the many different ways that programmers could scramble their signals to prevent access by unauthorized viewers. And we've examined those systems at the block-diagram level. But what about the circuitry necessary to implement those scrambling/descrambling systems? That's our topic for next time. **R-E**

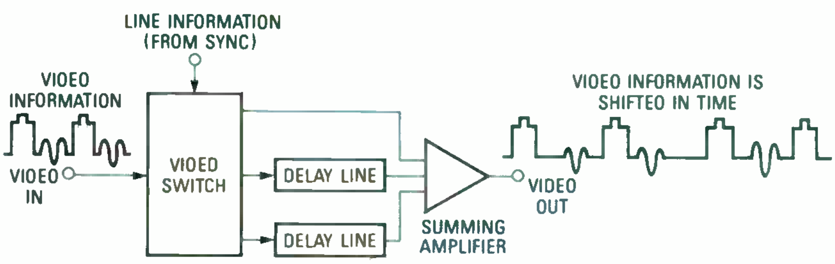
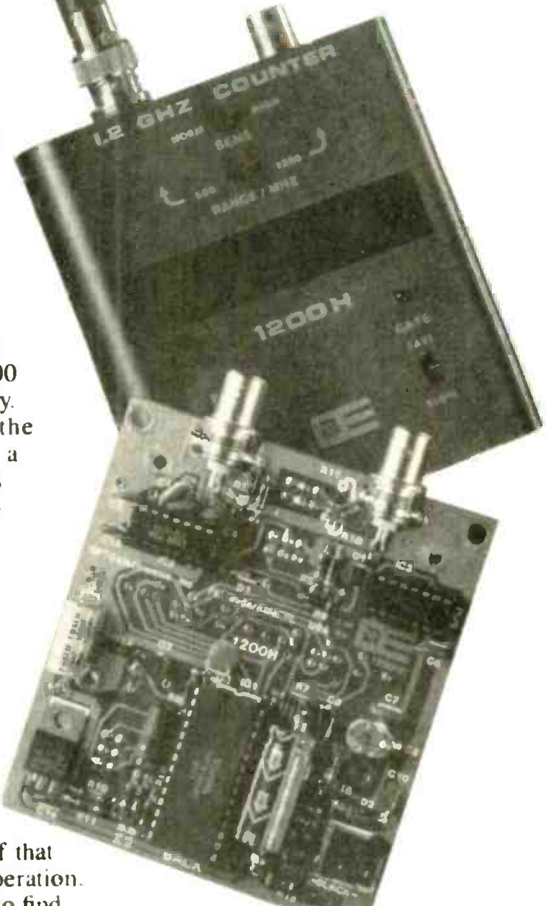


FIG. 3—IN THIS ANALOG scrambling system, adding varying amounts of delay to the video will result in spatial displacement of the horizontal lines. The result is a video image with severe distortion.

1.2 GHz FREQUENCY COUNTER

Who says a frequency counter must be big and expensive? Our little counter can measure signals into the gigahertz range, and it can be built for under $60!

FRED HUFFT



THE PRICES OF VARIOUS TYPES OF TEST instruments have been dropping like ducks in a shooting gallery the past few years. The latest victim is the frequency counter. When digital frequency counters first appeared in the early 1950's they were very large, very expensive, and, by today's standards, very limited. However, inexpensive LSI frequency-counter IC's and high-speed ECL prescalers have been developed in the past few years.

Those IC's allow us to offer you a high-performance, hand-held frequency counter for under $60. It can measure the frequency of signals ranging from 1 Hz to 1200 MHz, and it has sensitivity under 25 mV throughout most of its useful range. In fact, using a 19-inch telescopic antenna, we can measure the output of a 1/10-watt, 146-MHz handie-talkie that is located more than 20 feet away! Our frequency counter has many other features rivalling units selling for several times its price. Complete specifications are shown in Table 1.

Design Philosophy

Our main design objectives were to produce a 1-GHz counter with good sensitivity, and with minimal size and cost. To meet those objectives we selected two key parts: Intersil's LSI frequency counter, the 7216D (IC1 in Fig. 1), and RCA's ECL prescaler, the CA3179 (IC2).

The Intersil IC was chosen because it contains all the circuitry necessary to count, generate gate signals, latch data, and drive a multiplexed LED display. It also has an MIP (*M*easurement *I*n *P*rogress) output, and control inputs for decimal-point placement and gate time.

The second key part is the RCA CA3179 amplifier/prescaler. It is an ECL part with an exceptional bandwidth of 1200 MHz and with excellent sensitivity. As you can see in Fig. 2, the CA3179's 500-MHz input has a sensitivity of about 10 mV rms above 100 MHz. Below that frequency, sensitivity is inversely related to frequency, rising to 125 mV at frequencies below about 2 MHz. As you can see in Fig. 3, the CA3179's 1200-MHz input is about 25 mV over the 300–1000-MHz range.

The CA3179 requires a single five-volt supply, and it runs barely warm to the touch. That makes it the only IC of its kind we know of that does not run hot in normal operation. Last, it is inexpensive and easy to find.

A few other inexpensive components round out our frequency counter. Refer-

TABLE 1—FREQUENCY COUNTER SPECIFICATIONS

Range	1–1200 MHz
Gate time (fast)	0.25 second
(slow)	2.5 seconds
Resolution	100 Hz (fast gate time) 1000 Hz (slow gate time)
Display	Eight 0.28-inch high, 7-segment LED displays, common-cathode. Decimal point indicates MHz. Leading zero blanking.
Sensitivity (1–10 MHz)	100–150 mV rms
(10–1000 MHz)	1–35 mV rms
(1–1.2 GHz)	10–150 mV rms
Accuracy	±1 PPM RTXO timebase, ±1 count in LSD
Timebase aging	0.1 PPM/month
Input impedance	50 ohms
Gate LED	Illuminates during count
Input connectors	2 BNC female jacks
Input power	9–14 VDC, 150 mA, internally regulated
Optional battery pack	Six AA Ni-Cd cells (7.2 volts)
AC adapter and battery charger	9 VDC, 300–500 ma
Input power connector	⅛-inch jack, center positive
Case	0.060-inch anodized aluminum
Size	3.9 × 3.5 × 1.5 (inches)
Weight	8.5 oz, 13 oz with battery pack

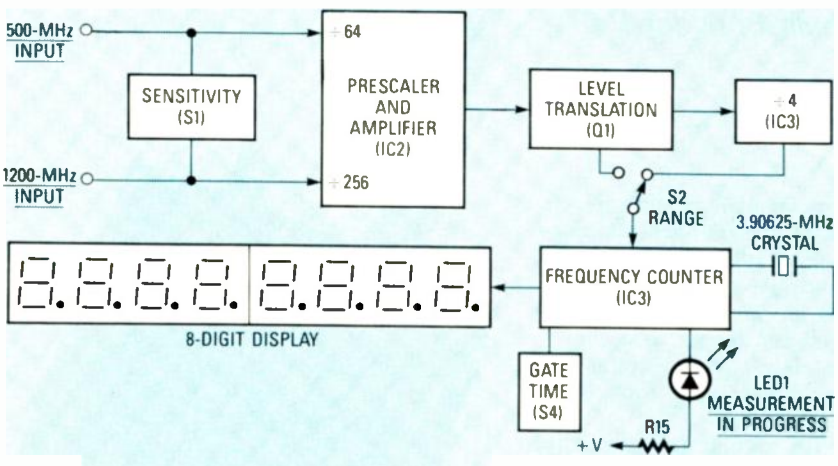


FIG. 1—BLOCK DIAGRAM OF THE FREQUENCY COUNTER reveals that only three IC's and a few discrete components are needed to produce a high-performance 1-GHz counter.

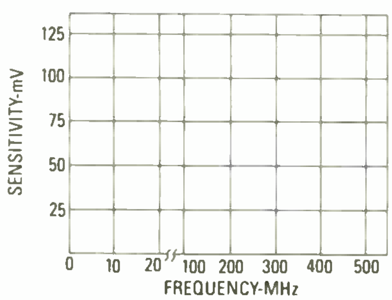


FIG. 2—RMS SINEWAVE SENSITIVITY of the CA3179's 500-MHz input is a flat 15 mV from 100 to 450 MHz.

ring back to Fig. 1, the output of the prescaler is fed through a level translator and then to two "D" flip-flops configured as a divide-by-four counter. We use a 74LS74 dual-D flip-flip because it is inexpensive and readily available, and because it uses little power. RANGE switch S2 allows you to select either the divide-by-four output or the direct output from the prescaler. Your chosen signal is then passed on to IC1, which processes it for output on the LED displays, two four-digit, common-cathode, multiplexed displays with 0.28-inch high digits.

The circuit is powered by an external AC adapter or an optional built-in Ni-Cd battery pack (which is trickled charged by the adapter). Separate switches are

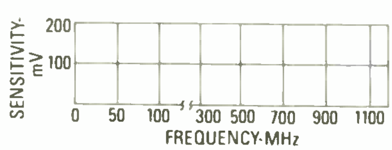


FIG. 3—RMS SINEWAVE SENSITIVITY of the CA3179's 1200-MHz input is a fairly flat 25 mV from 300 to 950 MHz.

provided to control SENSITIVITY (S1) and GATE TIME (S4).

Circuit Description

Referring now to the complete circuit diagram in Fig. 4, you can see that the output of the CA3179 is fed through the D1/Q1 circuit. Those components serve to boost the 1-volt output of the CA3179 to a standard TTL level. Then, depending on the position of RANGE switch S2-b, the signal is passed directly to the 7216, or through the divide-by-four circuit built from the two "D" flip-flops in IC3.

The other half of the RANGE switch (S2-a) controls the voltage at pin 3 of the CA3179. When pin 3 is high, the signal applied to pin 9 is fed through an extra internal divide-by-four stage before it is amplified and output on pins 4 and 5. When pin 3 is low, the signal on pin 13 is simply processed for output without being divided internally.

We use a 3.90625 MHz crystal for our time base; the crystal yields a *fast* gate time of 0.256 second. The displayed frequency equals the input frequency divided by 1000 in the *fast* mode. In *slow* mode, gate time is 2.56 seconds. The displayed frequency equals the input frequency divided by 100 in the *slow* mode.

Switch S4, GATE TIME, performs two functions. First it selects the appropriate gate time according to which digit output of IC1 the RANGE input is connected to. Another of the 7216's inputs is also controlled by S4: the DP SELECT input. The decimal point of the digit output to which that pin is connected will be the one that lights up. In our case, the correct decimal point illuminates, according to the position of S4, to provide a reading in MHz.

Self-oscillation

Due to the high gain, balanced-input amplifiers in the CA3179, self-oscillation can occur with no input signal present. The result is a random, constantly-changing count. Although that does not affect the performance of the counter, it can be distracting.

To settle the display we added SENSITIVITY switch S1 and the associated resistors and capacitors. When the switch is on, the RC networks eliminate display bobble. The difference in sensitivity varies with frequency. For example, at 150 MHz, normal sensitivity is typically 15 mV rms, and high sensitivity is about 6 mV rms. But at 850 MHz, normal sensitivity is typically 40 mV rms and high sensitivity is about 25 mV rms.

The MIP output of IC1 drives Q2, which in turn drives LED1. When it is illuminated, a measurement is in progress. The LED goes out for a fraction of a second between measurements.

For greatest accuracy, trimmer C8 can be adjusted so that the output of the oscillator is exactly 3.906250 MHz. For

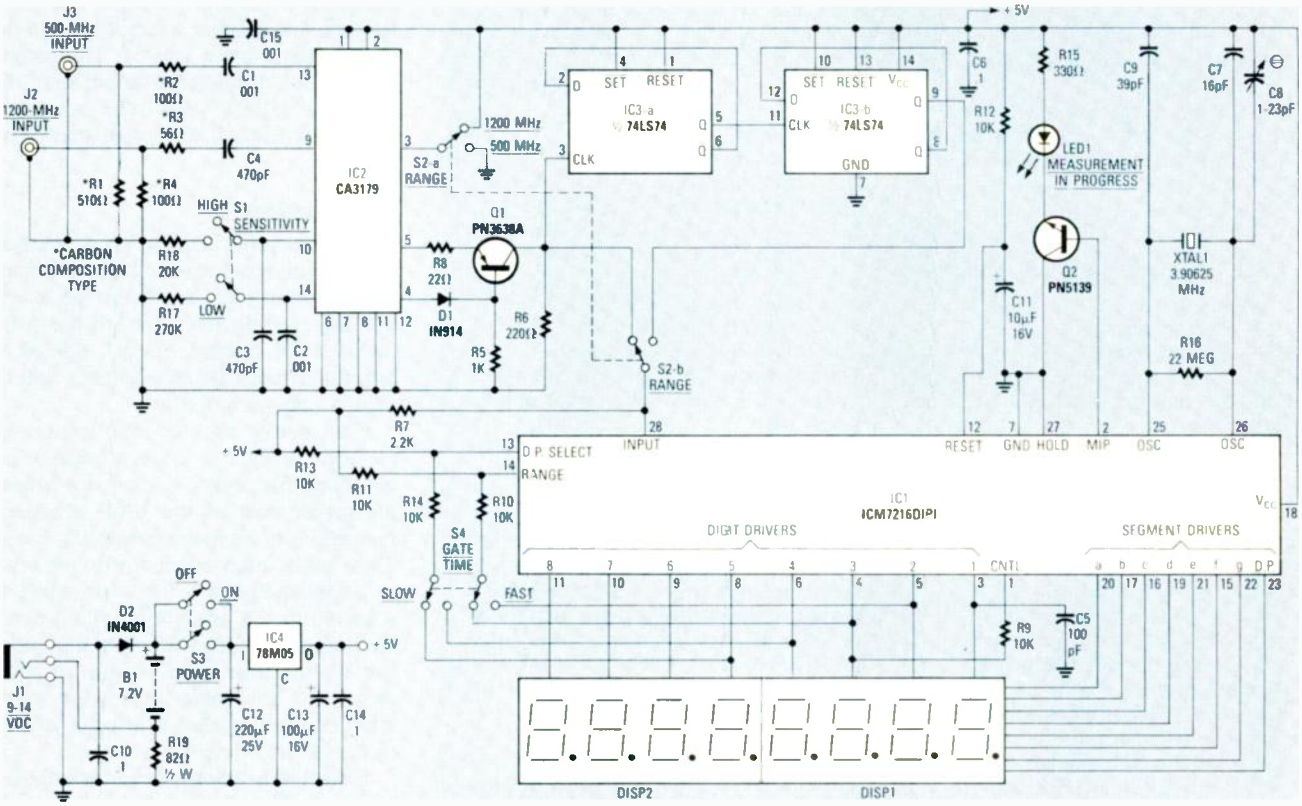


FIG. 4—SCHEMATIC DIAGRAM OF THE FREQUENCY COUNTER is a model of design simplicity. Transistor Q1 and associated discrete components translate IC2's ECL output into a TTL level for IC3 and IC1.

greatest frequency stability, C7 should be an NPO type, and C9 an N750. In case you're wondering, temperature causes almost no change in capacitance in an NPO capacitor; the capacitance of an N750 capacitor will decrease 750 parts per million for each 1°C increase in temperature.

The power supply is a standard 7805 circuit. Input voltage can range from 9–14 volts DC; input should never exceed 14 volts. Diode D2 protects the circuit from an accidental reversed-voltage input.

Power input jack J1 has a switch contact. When no plug is present, the contacts are closed, so the negative terminal of the battery is grounded. When a plug is present, R19 appears in the battery's ground circuit; that resistor is what provides trickle-charging. With a 9-volt input, a charge current of 25–45 mA will be provided. Charging occurs even when POWER switch S3 is off. You should ensure that charge current never exceeds 45 mA; adjust the value of R19 if necessary.

The Ni-Cd battery pack specified in the Parts List is rated at 45 mA. This means that a charge current of 45 mA will fully charge a completely discharged pack in about 14 hours, and that the batteries won't be harmed by continuous charging at that rate (or less). For maximum battery life and capacity, Ni-Cd's should occasionally be "deep cycled" several times by completely discharging and then fully recharging them. That should prevent a discharge "memory" from forming at less than the full rated output voltage.

Voltage regulator IC4 provides a regulated five-volt DC output when S3 is closed. Regulated voltage is especially important to the timebase oscillator, because, as the battery's voltage varied throughout its life, so would the frequency of the timebase. Erroneous measurements would result. With a good source of regulated voltage, however, the timebase circuit should maintain ±1-PPM stability at room temperature. Both temperature stability and accuracy are almost totally dependent upon the crystal used.

The counter circuitry by itself draws about 120 mA; in combination with the battery charger, about 150 mA will be drawn. The optional Ni-Cd battery pack should give up to 5 hours of continuous operation, which is more than adequate for most portable requirements. In any case, we recommend that your DC source be able to supply at least 300 mA for safe and reliable operation.

That's about all there is to the circuit—so let's build a frequency counter!

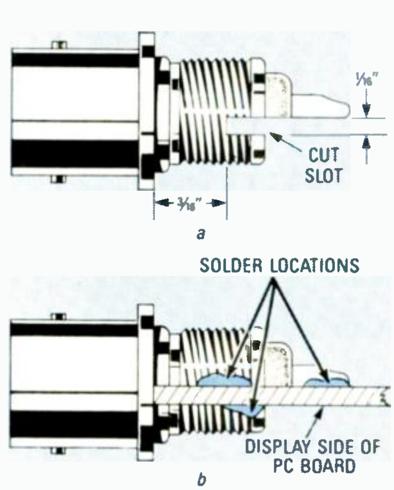


FIG. 5—A BNC CONNECTOR must be modified as shown in *a* so that it can be soldered to the PC board as shown in *b*.

PC board

For ease of construction, we recommend use of a double-sided PC board. You can buy an etched, plated, labeled, and solder-masked board from the source mentioned in the Parts List, or you can etch you own board using the foil patterns shown in "PC Service."

For flexibility, the PC layout has a number of extra pads and holes to accommodate capacitors of various sizes and shapes. That applies to C2, C3, and C4, and to trimmer C8. We designed a partial micro-strip layout for the input connectors (J2 and J3) to simplify assembly and to approximate a 50-ohm input impedance.

PARTS LIST

All resistors are ¼-watt, 5% unless otherwise noted.
R1—510 ohms, carbon composition
R2, R4—100 ohms, carbon composition
R3—56 ohms, carbon composition
R5—1000 ohms
R6—220 ohms
R7—2,200 ohms
R8—22 ohms
R9–R14—10,000 ohms
R15—330 ohms
R16—22 megohms
R17—270,000 ohms
R18—20,000 ohms
R19—82 ohms, 1/2 watt, 10%

Capacitors
C1, C2, C15—0.001 µF ceramic disc
C3, C4—470 pF ceramic disc
C5—100 pF ceramic disc
C6, C10, C14—0.1 µf ceramic disc
C7—16 pF ceramic disc, NPO
C8—1–23 pF trimmer
C9—39 pF ceramic disc, N750
C11—10 µF, 16 volts, electrolytic
C12—220 µF, 25 volts, electrolytic
C13—100 µF, 16 volts, electrolytic

Semiconductors
IC1—ICM7216DIPI universal frequency counter (Intersil)
IC2—CA3179 ECL pre-scaler (RCA)
IC3—74LS74 dual "D" flip-flop
IC4—7805 5-volt regulator (TO-220 case)
Q1—PN3638A transistor (ECG159)
Q2—PN5139 transistor (ECG108)
DISP1, DISP2—DL-4770, four-digit, seven-segment, common-cathode multiplexed display (Litronix)
LED1—standard red LED
D1—1N914 switching diode
D2—1N4001 rectifier

Other Components
S1–S4—subminiature DPDT slide switch
J1—⅛-inch power jack with switch
J2, J3—BNC connector, female, bulkhead mount, modified (see text)
XTAL1—3.906250 MHz crystal, parallel resonant, 22 pF, HC-18 case.
Miscellaneous 3/16" high by ¼" OD nylon spacer, IC sockets, PC board, case, power pack, etc.

Note: The following items are available from Optoelectronics, Inc., 5821 N.E. 14 Ave., Ft. Lauderdale, FL. 33334: PC board (no. PCB-1200H), $16; Kit including PCB and all parts less cabinet (no. 1200HK), $59.95; Anodized cabinet with red lens (no. CAB-1200H), $20; Power adapter/charger (no. AC-1200), $7.50; Ni-Cd battery pack (no. NiCd-1200), $20; Telescoping RF antenna (no. TA-100), $12; Vinyl zipper case (no. CC-70), $10; 50-ohm 1× probe (no. P-100), $18; Wired, tested and calibrated counter (no. 1200H), $110. Individual components also available. Florida residents add 5% sales tax. All orders add 5% for shipping and handling.

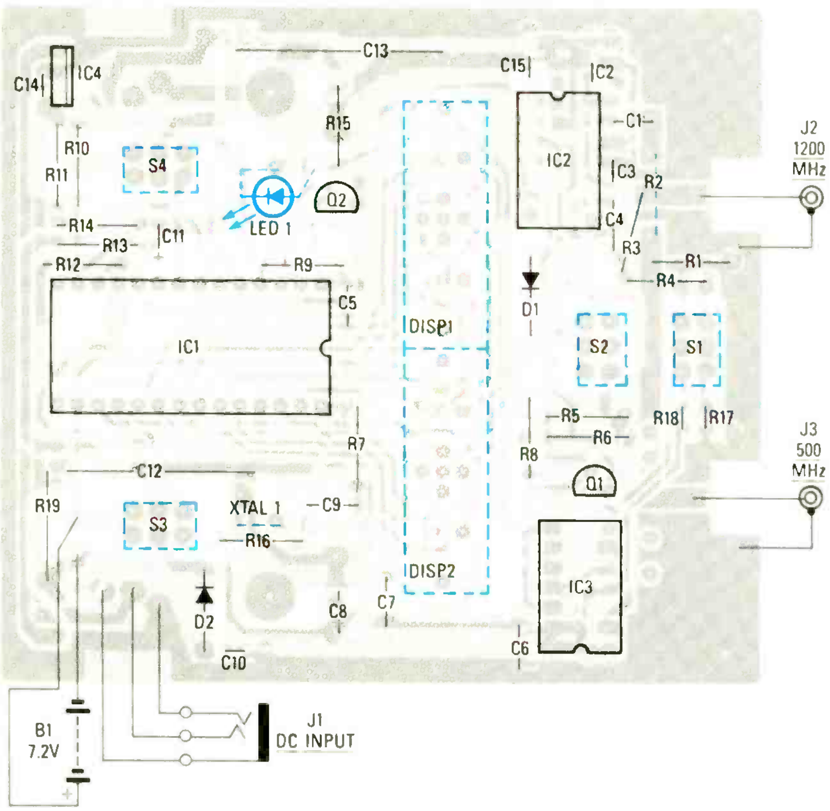


FIG. 6—PARTS PLACEMENT DIAGRAM. Most components mount on the bottom of the board. The switches, displays, R2 and LED1 are shown in dashed lines; they should be mounted on the opposite side of the board. The leads to the battery attach to the bottom side; BNC jacks J2 and J3 should be soldered to both sides of the board.

In addition, the PC board has two notches at the top to accept modified BNC connectors, and another notch along one side for the power-input jack J1. The notches for the BNC connectors should be 0.365" wide and 0.250" deep. The power-jack notch should be 0.430" wide and 0.150" deep.

Construction

Our frequency counter was designed for quick and easy assembly; by following the directions you should have no trouble building, testing, or calibrating the instrument. We'll call the "front" side of the board the side that the switches and the displays are mounted on.

First modify the two BNC connectors as shown in Fig. 5-*a*. Using a hacksaw or a modeling file, cut a 1/16-inch slot beneath the center post of the BNC connector, leaving 3/16 of an inch beneath the flange. Then solder each connector to the board as shown in Fig. 5-*b*. The connectors are soldered to the adjoining ground planes on both sides of the PC board; that makes the installation both strong and well grounded. The center conductors of the BNC connectors should also be soldered to the PC board now.

Next, on the back side of the board, as shown in Fig. 6, install the low-profile components (the diodes and resistors), followed by the IC sockets, then the capacitors, etc. Be certain to observe proper polarity when installing the diodes, the electrolytic capacitors, the IC sockets, the battery connector, and, on the front of the board, LED1 and the displays. By the way, we found almost no difference in performance with and without sockets, but using them makes servicing easier.

Since the counter will be dealing with rather high frequencies, R1–R4 and C1–C4 should be installed with minimum lead length. Also, resistors R1–R4 should be the non-inductive, carbon-composition type; the other resistors may be either composition or film types. Capacitors C1–C4 should be small ceramic disk or monolithic ceramic types. All input components should be installed as neatly as possible.

To complete the back side of the board, install the voltage regulator (IC4), trimmer capacitor C8, and all small capacitors. Bend the leads of the regulator so that its body is parallel to the PC board. A heatsink is unnecessary. Next install power jack J1 and transistors Q1 and Q2.

Clean flux off the front side of the board, and then install the switches, DISP1 and DISP2, XTAL1, LED1, and R2, according to Fig. 6. The LED should be mounted above a spacer 3/16 inch in length. The displays should be mounted flush against the board. When installing the displays, the IC sockets, and any other components with numerous solder connections, it's best to solder two or three

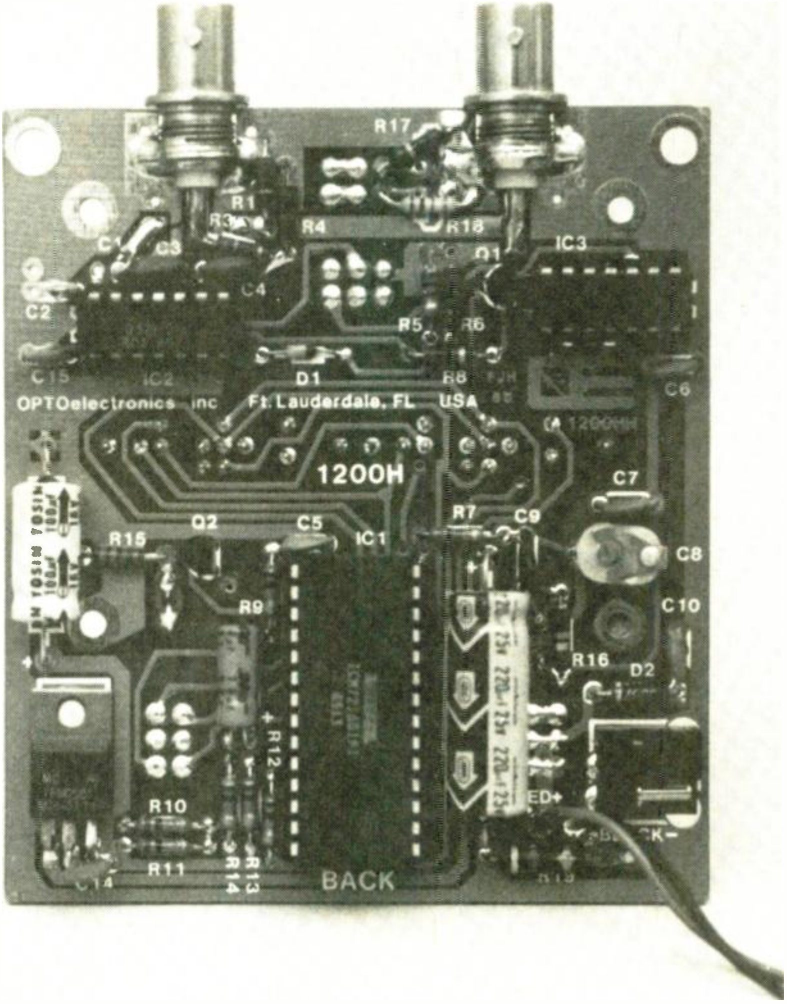


FIG. 7—ONCE ALL COMPONENTS are in place, clean the board and check your work for any shorts or opens.

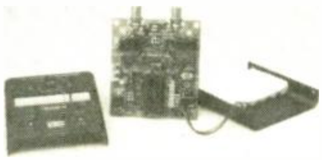


FIG. 8—ONCE INSTALLED IN ITS CASE, the counter makes a neat, compact, and easily transportable test instrument.

pins, check for alignment, correct if necessary, and only then solder the remaining pins. A small piece of double-sided foam tape should be placed under the crystal to insulate its case and to provide a shock mount. Finally, install the electrolytic capacitors, C12 and C13, on the rear side of the board.

Now clean the board and check it thoroughly for solder shorts and opens. When you're satisfied that the board is in good shape, install the IC's. Your board should now appear as in Fig. 7.

Initial check-out

Set the SENSITIVITY switch to NORM and the GATE switch to FAST. With the RANGE switch in either position, apply power. The GATE LED should blink and the display should indicate .000 with leading digits blanked. Move the GATE switch to the SLOW position. The display should now read .0000, and the GATE LED should blink at a slower rate. Now move the SENSITIVITY switch to HIGH; the display should show a random, changing count on both ranges.

If the display is dim or blank, remove power, and make sure all IC's are installed correctly. If so, check the orientation of all the diodes and electrolytic capacitors. Re-check the PC board for shorts and opens if necessary. Finally, your power source may be weak or dead, or a switch may be bad.

Calibration and final assembly

To calibrate the counter, let it warm up for at least ½-hour, connect a stable signal of known frequency to the proper input jack, and then adjust trimmer capacitor C8 for proper display. Use the highest frequency you can and the SLOW gate time in order to get maximum resolution and accuracy.

Remember that a counter's accuracy is specified in PPM (*P*arts *P*er *M*illion), and if a reading is 1 PPM high at one frequency, the counter will read 1 PPM high at all frequencies. At 1 MHz a 100 PPM error would, in many applications, be insignificant. But a 100 PPM error at 1 kHz would be quite significant. So calibrate the counter carefully!

When it is calibrated, you can mount it in its case, see Fig. 8. If you use the case mentioned in the Parts List, the PC board just slips into it. The BNC connectors and the power jack should line up with the holes in the case perfectly. Drop a red plastic filter over the displays and then screw the case together. You're ready to start using your 1.2-GHz frequency counter now!

Usage hints

Keep in mind that the counter requires only a few millivolts to make an accurate reading—seldom more than about 50 mV. Inexperienced users commonly overdrive the frequency counter—and that could cause erroneous readings or circuit damage. Signals of several volts or more should be loosely coupled by a small capacitor or picked up inductively by a loop-type probe or antenna. When connecting the frequency counter directly to a circuit, use a 10K series resistor to reduce ringing and to lighten the load on the test circuit. Other than following those simple precautions, you should have no trouble using the counter.

Since the the price-to-performance ratio of this circuit is so good, you may want to install one permanently in a piece of equipment such as a ham rig or a commercial radio transmitter. That way you could have a continuous indication of output frequency, and any drift could be corrected before it caused interference to stations transmitting on nearby frequencies.

Or, for a very handy and versatile piece of test gear, you could combine our circuit with an inexpensive function generator in a single cabinet. Also, it would be easy to adapt our circuit for automotive or marine use. If you do, be sure to wire a ¼- to ½-amp fuse in series with the counter's power input line.

As you can see, our frequency counter is so inexpensive and so easily adaptable that new applications for it seem to suggest themselves! You'd better start building several—you'll use 'em before you know it! **R-E**

RADAR SIGNAL DETECTOR

If you think that a sensitive radar detector is a complicated and expensive piece of equipment, have we got a surprise for you!

GREGORY HODOWANEC

RADAR DETECTORS ARE USUALLY COMPLICATED and expensive devices, but a simple, yet effective, detector can be built in a small plastic case for less than ten dollars! The circuit, which can be tuned to respond to signals between 50 MHz and 500 GHz, is a modified version of the author's gravity-wave detector presented in April's issue. We'll actually present two different circuits, an "economy" and a "deluxe" model.

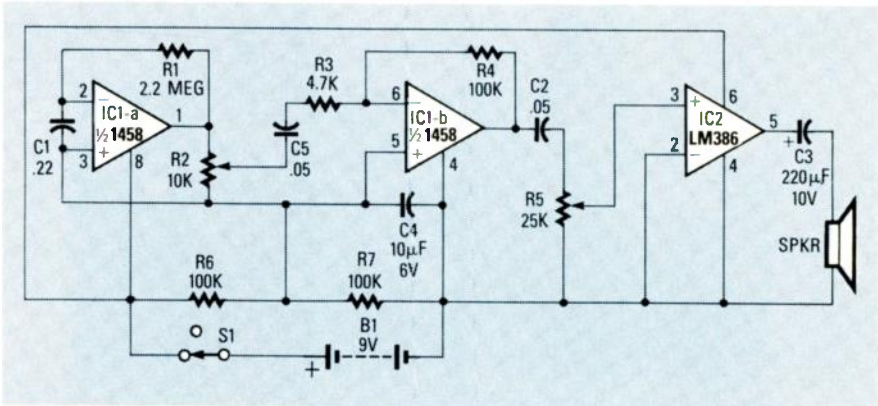


FIG. 2—DELUXE RADAR DETECTOR adds a buffer amplifier and an audio power amp to drive a speaker.

How they work

The economy model's schematic is shown in Fig. 1, and the deluxe model's schematic is shown in Fig. 2. The main difference between the two circuits is that the economy model simply drives a piezo-electric transducer directly from an op-amp, while the deluxe model uses an LM386 audio power amplifier to drive a small speaker. Doing that allows the extra op-amp stage to be used for additional buffering, and that makes for a more sensitive detector.

The first op-amp in each circuit (IC1-*a*) functions as a current-to-voltage converter. Then, in the economy model (Fig. 1), IC1-*b* buffers the output to drive the piezo buzzer. Potentiometer R5 sets the switching threshold of IC1-*b*; normally it is adjusted so that the circuit barely triggers on background noise, then it's backed off a bit. That should provide plenty of sensitivity to incident RF.

Resistors R3 and R4, and capacitor C4, serve to "split" the supply voltage. To get more sensitivity from the detector, those components could be eliminated and two series-connected nine-volt batteries used instead. In that configuration, the junction of the batteries would be connected to the point where R3, R4, and C4 now meet. Alternatively, for mobile operation, twelve volts could be tapped from your car's cigarette-lighter jack.

The deluxe model functions in a similar manner, except that IC1-*b* is configured as a ×20 buffer amplifier to drive the LM386. Potentiometer R2 adjusts threshold here, and potentiometer R5 functions as a volume control.

In both circuits, input capacitor C1 functions as a "transmission-line" that intercepts both electrical and magnetic components of incident radar signals. While it is a low-Q circuit (it is very broadband), the response may be further optimized by trimming C1's lead lengths for the desired frequency, as shown in Fig. 3. To detect typical road-radar systems, the input capacitor's leads should be about 0.5–0.6 inches long.

In both circuits the detector provides a "ringing," or slowly-decaying output with a resonance of about 400–600 Hz for the component values shown. Feedback resistor R1 may be adjusted for another "ring" frequency, if desired.

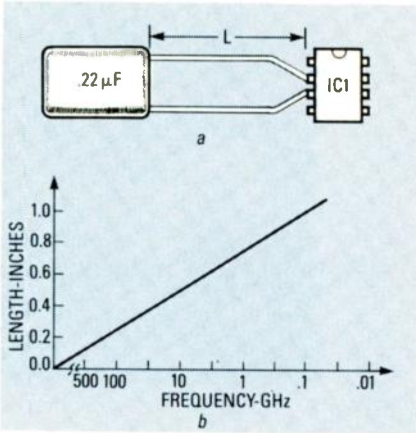


FIG. 3—VARY THE LEAD LENGTHS OF C1 to tune the input circuit.

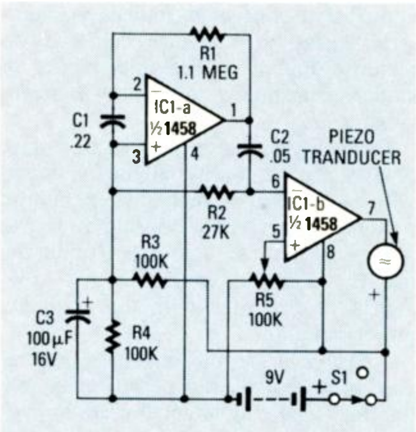


FIG. 1—THE ECONOMY RADAR DETECTOR needs only one IC and a few discrete components.

Construction hints

Whichever detector you choose, build it in a non-metallic case so that incident RF won't be blocked. However, make sure that only R1 provides feedback to the detector's input. Since the gain of the detector is so high, unwanted feedback can force the input stage into continuous oscillation, rather than the "ringing" oscillation that decays in time. Should unwanted feedback become a problem, a small capacitor (0.005–0.01 µF) across resistor R4 may help, as may a 200–500 µF capacitor across the battery.

Perfboard construction is preferable to PC-board construction because reduced wiring capacitance and the absence of a ground plane will reduce the chance of unwanted feedback. Likewise, it's better to use a small *shielded* speaker for output because magnetic (and gravitational) energy from the speaker could feed back to the input. So keep C1 as far from the speaker as possible.

The detector should perform properly with little adjustment. After applying

continued on page 97

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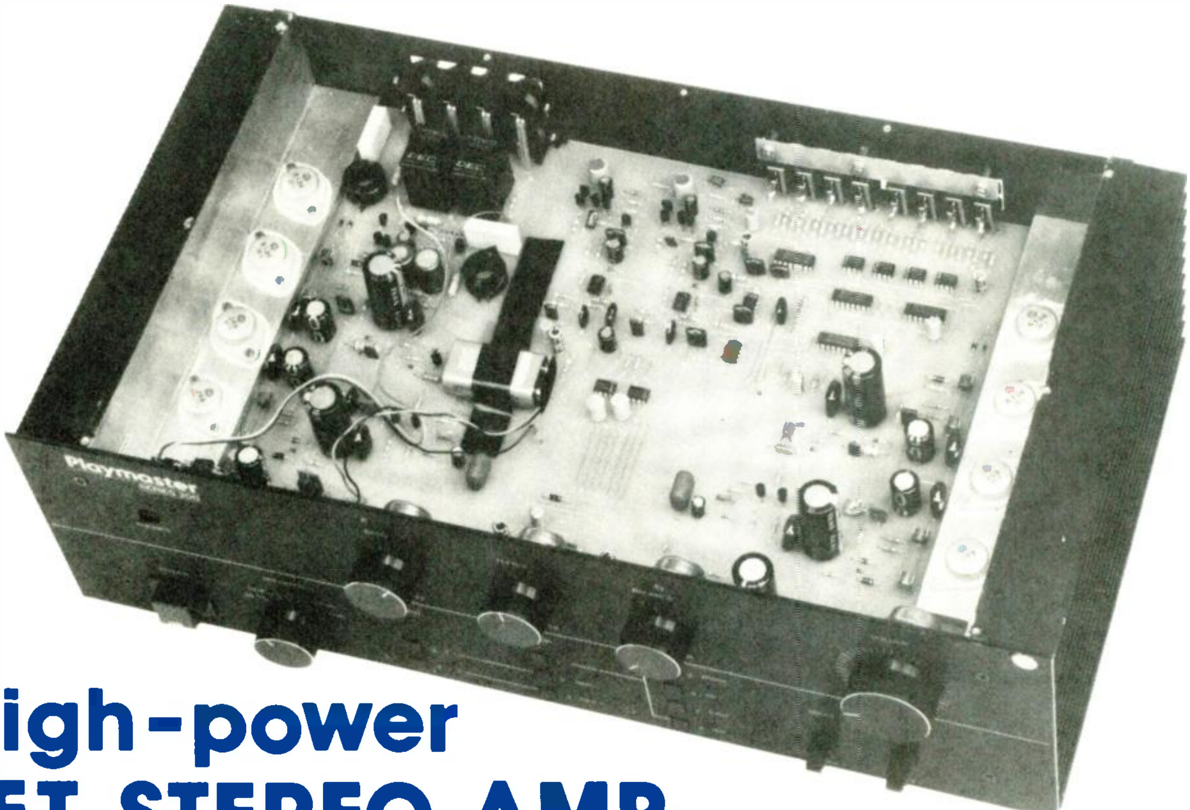


High-power FET STEREO AMP

Our amp's high-power output, low distortion, and easy construction make it a must for audiophiles who demand the very best!

LEO SIMPSON AND JOHN CLARKE*

Part 2 LAST MONTH WE DISCUSSED how the phono preamp and the analog switching sections of our amplifier work. Let's go on now and examine the volume/tone/balance circuit, the power amps, the speaker switching circuit, and the power supply.

Volume/tone control circuit

Whichever source is chosen to drive the amplifier, the signals from that source go through several stages of processing. Let's look at each in turn.

The output of analog switch IC2 is fed to IC105, shown in Fig. 5, which functions simply as a high-impedance, unity-gain buffer that drives the volume control, R110, and the STEREO/MONO switch, S11.

The wiper of the volume control is fed to IC106, another NE5534A, that is connected, in this case, as a non-inverting amplifier with a gain of 5.7. In addition to that gain, the op-amp provides a low-impedance source to drive the tone-control circuit.

We use yet another NE5534A in the tone-control stage; that op-amp is configured as a negative-feedback unity-gain amplifier when the BASS (R108) and TREBLE (R109) tone controls are set to their flat (mid-position) settings. Both BASS and TREBLE controls operate with a "constant-turnover, variable-slope" characteristic. Slope refers to the amount of boost or cut the circuit applies, and is a maximum of 6dB/octave for our circuit. Turnover refers to the frequency at which boost or cut occurs; our circuit uses a turnover frequency of 1 kHz for both bass and treble control circuits. When the wiper of the BASS control is rotated toward the input side of the ap-amp, gain below 1 kHz is increased; similarly, the TREBLE control causes the gain of frequencies above 1kHz to increase.

The tone-control amplifier drives the BALANCE and MUTE controls via a 6.8 µF non-polarized electrolytic capacitor. The mute circuit is a 20-dB attenuator composed of R141 (680 ohms) and R142 (68 ohms). The attenuator is switched into the circuit by S3, MUTE.

By the way, the NE5534's are bipolar op-amps that have higher input offset voltages than FET-input types like the TL071. Since we are using the NE5534's in gain stages, offset error is multiplied and therefore appears as a large DC offset at the output of the IC. The same problem occurs with the phono preamplifier. That's why we use non-polarized DC-blocking capacitors following each NE5534A.

Power amp

Moving on to the power amplifier, shown in Fig. 6, let's discuss a little of our design philosophy before getting into the actual circuit details. Our design, which is based on Hitachi application notes, did not come easily. Indeed, most of the development of the amplifier as a whole revolved around the power amplifier.

We tried many different circuits in many different configurations. Some were completely symmetrical designs with double-differential input stages and so on. We tried cascode driver stages and source degeneration in the MOSFET output stages. We also tried varying the driver stage currents to obtain the best overall distortion and slew rate.

*Adapted from material published by *Electronics Australia*

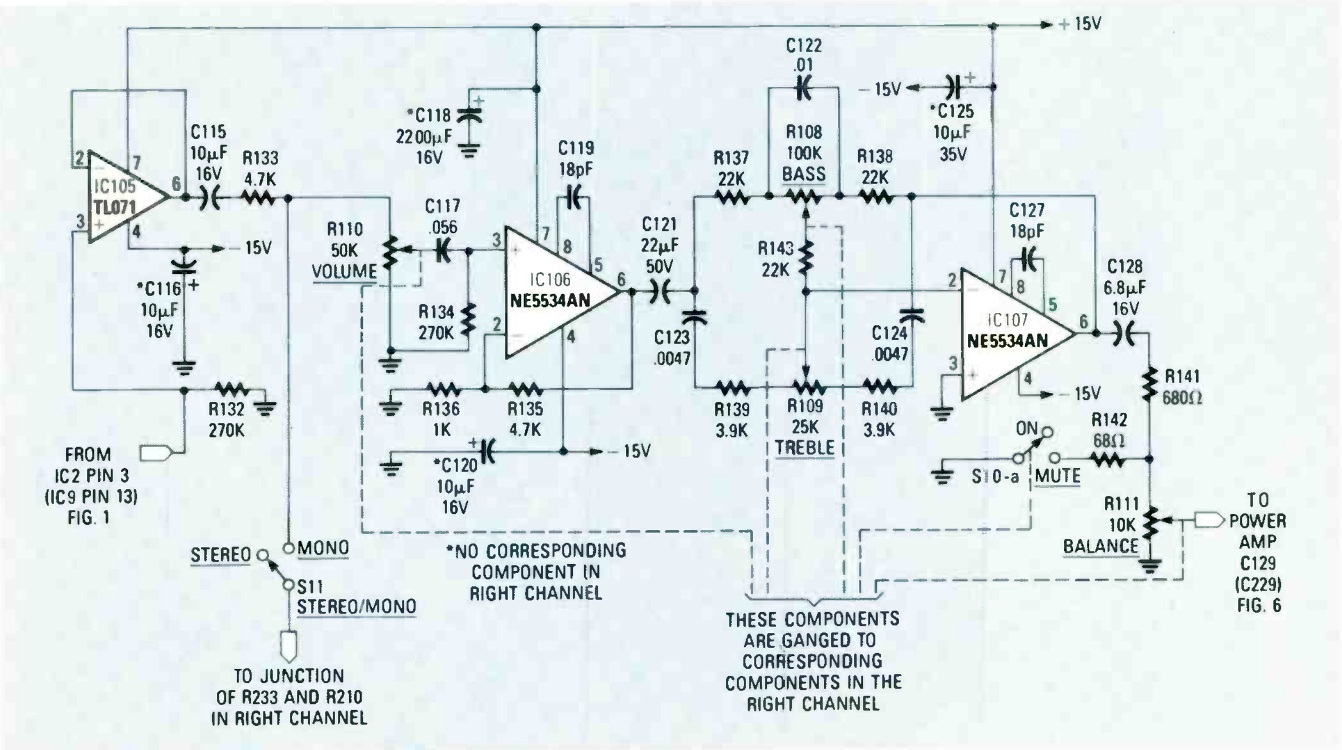


FIG. 5—THE VOLUME/TONE/BALANCE-CONTROL CIRCUITRY allows for ±6 dB of treble or bass boost or cut, volume and balance control, muting, and stereo/mono selection.

After all that we concluded that Hitachi's design was the best overall for both simplicity and performance. And we discovered one rather surprising fact: performance of the power amps is quite dependent on the layout of the printed circuit board. In fact, even subtle changes in layout made quite dramatic reductions in distortion. We'll present what we believe is the best layout next time. But for now, let's see how the power amplifier works.

The BALANCE control (shown in Fig. 5) is coupled to the power amplifier via a 1-μF non-polarized capacitor. Strictly speaking it should be possible to omit that capacitor because C128 (the 6.8-μF capacitor at the output of IC107) should block residual DC across the balance control. However, if C129 were eliminated, Q105's bias current could flow through the balance control as well as through R145, Q105's 22K base-bias resistor.

By itself that would be harmless, but the signal presented to the power amplifier would vary as the BALANCE control was rotated. In addition, whatever DC offset was present at the input would be amplified, and would lead to an increase in the residual DC voltage at the output of the power amplifier. Hence, the output of the push-pull amplifiers composed of Q111–Q112 and Q113–Q114 would become unbalanced, so output distortion could result.

Also, C129, R144 and C130 function as a low-pass filter that removes signals in the RF region. Resistor R144 functions as a "stopper" that reduces any tendency, on the part of the amplifier, to oscillate supersonically. For full power output the input to the power amplifier should be about 1.5 volts rms.

Transistors Q105 and Q106 form a differential pair, and Q107 acts as a constant-current "tail." By virtue of diodes D101 and D102, the base-bias applied to Q107 is about 1.3 volts. That sets the current through Q107 at about one milliamp; that current is shared equally by Q104 and Q106. And, as in the RIAA preamp circuit, the constant-current source improves the PSRR of the amplifier.

The balanced output signals from the collectors of transistors Q105 and Q106 are coupled to a second differential amplifier, consisting of Q109 and Q110, which forms a "current mirror," a circuit often used in IC op-amps. The current mirror helps us obtain higher gain from the stage, as well as better linearity over the full range of output voltage. In fact, the current mirror gives a greater voltage swing than could be obtained with a simple class-A driver stage with a boot-strapped collector load.

Transistors Q108, Q109, and Q110 each has a maximum collector voltage rating of 250 volts; they are intended for use as class-B video-driver stages in television receivers. That voltage rating in conjunction with their 100-Mhz gain-bandwidth product and good beta linearity over a wide range of operating currents makes them ideal for use in a low-distortion audio driver stage.

Those two discrete differential amplifiers provide all the voltage gain of the power amplifier; the MOSFET output transistors are operated in source-follower mode, which gives slightly less than unity voltage gain. No source degeneration resistors are used in the output transistors. We found that we were able to dispense with those resistors and thus gain lower distortion.

Nor does there appear to be any need to take measures to ensure current sharing between the parallel-connected MOSFETs (by using small source resistors). In practice, if one MOSFET becomes warmer that its partner, its transconductance (gain) is reduced accordingly; thus it is temperature-compensated automatically.

The 500-ohm trimpot, R156, connected between the collectors of Q108 and Q110 sets the bias applied to the MOSFET gates; that bias determines the quiescent output current. The amount of current is a compromise between minimum distortion and output-stage power dissipation. Since the power amplifier employs a ±65-volt power supply, even a small current results in high power dissipation. So quiescent current must be set carefully.

Zener diodes D106 and D107, in combination with D104 and D105, determine the maximum voltage that can be deliv-

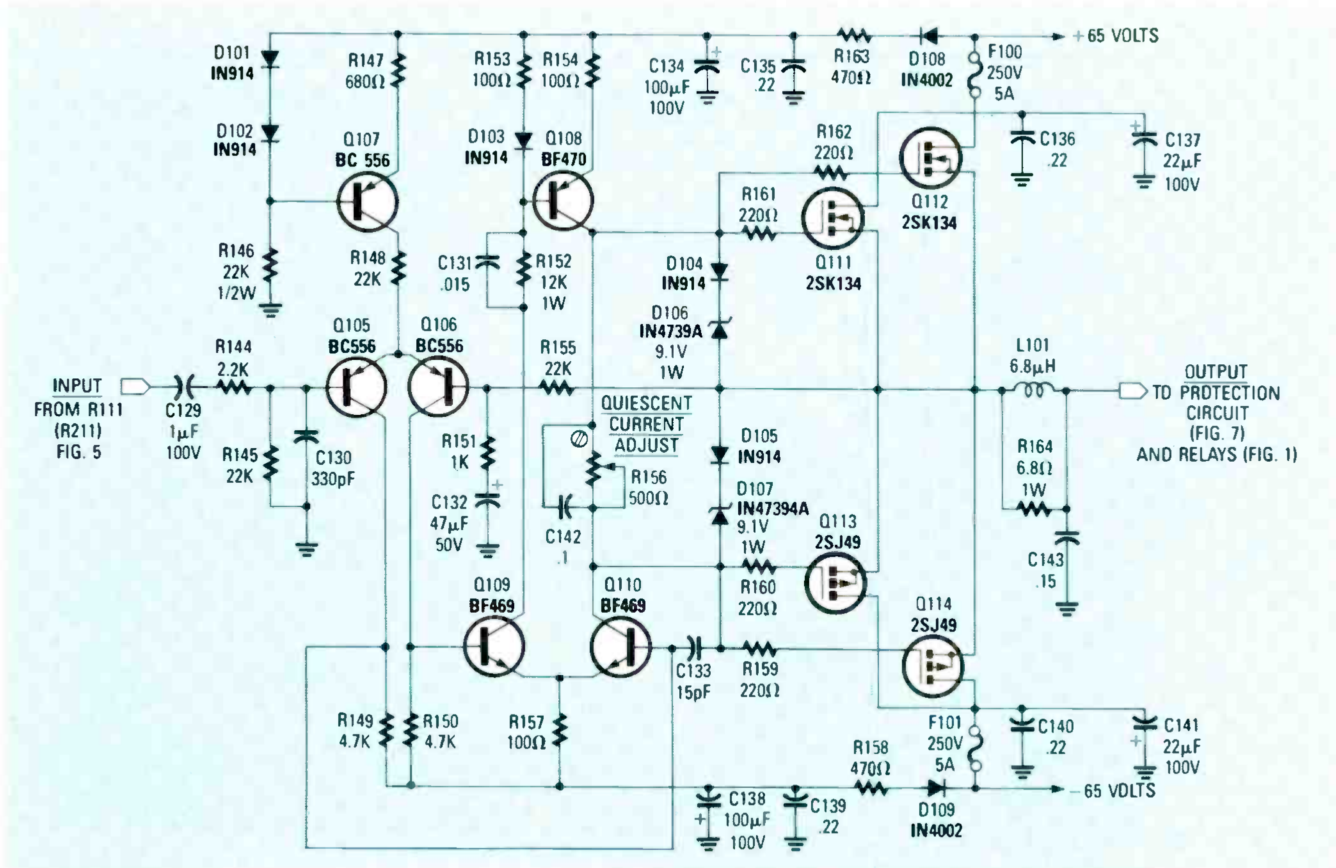


FIG. 6—THE POWER AMPLIFIER is built around two discrete bipolar differential amplifiers and power MOSFETS for output drive.

ered to the output transistors. Any signal in excess of ±10 volts will be clipped. In that way the diodes form an effective overdrive circuit and prevent excessive power dissipation in the event of a short circuit. The gate of each output transistor has a series-connected 220-ohm resistor that functions as a "stopper" to prevent RF oscillation. Fuses are included in the output-transistor supply lines to protect the speakers should the output transistors fail. The fuse clips also provide a convenient way of measuring current (or voltage, when they are replaced by resistors) for trouble-shooting or setting the quiescent current.

Voltage gain of the power amplifier is determined by the ratio of the 22K and the 1K resistors (R155 and R156) at the base of Q106. The lower cutoff-frequency of the circuit is determined by 47 µF capacitor C132; that capacitor is in series with 1K resistor R151.

A final refinement involves the RLC network (L101, R164, and C143) in the output circuit. That network is used to render the amplifier unconditionally stable. We use a toroidal air-core inductor in that network, as a solid ferrite core can give rise to distortion, particularly when the amplifier is delivering a great deal of power.

It is necessary to use a special capacitor in the output network. We originally installed metallized polyester capacitors for C143 and C243, but found that high power operation of the amplifier caused them to fail quickly; they developed short-circuits. However, we found that dual dielectric (mixed paper and polyester) capacitors, normally specified for power-line interference suppression, work fine in that circuit. See the Parts List for more information.

Speaker switching

The main and remote loudspeakers are controlled with two relays rather than an expensive, high-current 4-pole switch. The relays also simplify wiring requirements, as we don't need to run heavy loudspeaker wiring to and from the front-panel SPEAKER SELECTER switch, S12. Instead, S12 controls the coils of the relays, so only low-current wiring is required for that connection.

The DC supply for the relay coils is supplied by the loudspeaker protection circuitry discussed below. When no fault is present, the output of that circuit goes high, and that energizes the coils of both relays, through resistors R4 and R5. Diodes D2 and D3 quench the EMF spike that is generated when the relay coil is de-energized.

The moving contacts of the relays connect to the loudspeakers while the unused stationary contacts are grounded. The reason for this is that, if a large DC voltage is generated in the amplifier by a fault condition, an arc is likely to result as the moving contact opens the circuit. So, as the contact moves to the "de-energized" position, that arc will be more likely to flow to ground than back into the circuit causing damage.

However, because of the high supply voltage used in our amplifier, an arc could be maintained even if the relay contacts were fully open. If that does occur, the power amplifier fuses will blow. There is a very slight chance that the amplifier itself could be damaged, but it is cheaper to repair an amplifier than to replace a loudspeaker.

Headphones

One small drawback to using the relays for loudspeaker control is that the head phones are permanently connected to the amplifier. They are not muted at power-on, but they are protected from DC faults by the 330-ohm feed resistors (R112, R212), which will limit any fault current to a safe amount.

The lack of muting is a problem since the phono preamplifier takes a little while to stabilize. During that time the amplifier is liable to emit some unpleasant sounds via the headphones if the volume control is advanced.

We solved that problem with the network attached to IC2 (shown in Fig. 1 last time), the analog switch that controls tape monitoring. That IC has an INHIBIT pin

PARTS LIST

All resistors ¼-watt, 5% unless otherwise stated.

R1, R3—10,000 ohms
R2—220,000 ohms
R4, R5—47 ohms, ½ watt
R6–R9, R11–R14, R16, R18—100,000 ohms
R10, R15, R17, R19, R100, R102, R104, R158, R163, R165, R167, R200, R202, R204, R258, R263, R265, R267—470 ohms
R20, R21, R22, R23, R146—22,000 ohms, ½ watt
R24, R25, R101, R103, R105, R166, R168, R201, R203, R205, R266, R268—56,000 ohms
R26, R121, R129, R132, R134, R229, R231, R232, R234—270,000 ohms
R27, R128, R130, R144, R228, R230, R244—2200 ohms
R28, R159–R162, R259–R262—220 ohms
R29—130 ohms
R30, R31, R136, R151, R236, R251—1000 ohms
R32—1500 ohms
R33–R99, R169–R199, R269–R299—unused
R106, R206—150,000 ohms
R107, R207—300,000 ohms
R108, R208—100,000 ohms, potentiometer
R109, R209—25,000 ohms, linear potentiometer
R110, R210—50,000 ohms, logarithmic potentiometer
R111, R211—10,000 ohms, linear potentiometer
R112, R212—330 ohms
R113, R213—150 ohms
R114, R214—180,000 ohms
R115, R215—68,000 ohms
R116, R117, R216, R217—820 ohms
R118, R123, R218, R223—39 ohms
R119, R219—1200 ohms
R120, R220—2700 ohms
R121, R221—390 ohms
R122, R222—82 ohms
R124, R224—3900 ohms, 1%, metal film
R125, R225—47,000 ohms, 1%, metal film
R126, R226—10 ohms
R127, R227—4300 ohms
R133, R135, R149, R150, R233, R235, R249, R250—4700 ohms
R137, R138, R143, R145, R148, R155, R237, R238, R243, R245, R246, R248, R255—22,000 ohms
R139, R140, R239, R240—3900 ohms
R141, R147, R241, R247—680 ohms
R142, R232—68 ohms
R152, R252—12,000 ohms, 1 watt
R153, R154, R157, R253, R254, R257—100 ohms
R156, R256—500 ohms, trimmer
R164, R264—6.8 ohms, 1 watt

Capacitors

C1, C14–C22, C116, C120—10 µF, 50 volts, electrolytic
C2, C3—0.047 µF, polyester
C4, C5—47 µF, 50 volts, non-polarized
C6—100 µF, 16 volts, electrolytic
C7—0.01 µF, 250 volts, polyester
C8–C11—8000 µF, 75 volts, electrolytic
C12, C13—1000 µF, 25 volts, electrolytic
C23–C99, C144–C199, C214, C225, C226, C244–C299—unused
C100, C200—0.082 µF, polyester
C101, C107, C113, C142, C201, C207, C213, C242—0.1 µF, polyester
C102, C202—47 µF, 25 volts, electrolytic
C103, C203—100 pF, ceramic
C104, C204—0.0033 µF, polyester
C105, C205—220 µF, 16 volts, electrolytic
C106, C112, C206, C212—100 µF, 25 volts, electrolytic
C108, C208—10 pF, ceramic
C109, C209—0.018 µF, 2%, polyester
C110, C210—0.068 µF, 2%, polyester
C111, C211—2.2 µF, 50 volts, non-polarized
C112, C212—100 µF, 25 volts, electrolytic
C114—10 µF, 25 volts, electrolytic
C115, C215—10 µF, 50 volts, non-polarized
C117, C217—0.056 µF, polyester
C118—2200 µF, 16 volts, electrolytic
C119, C127, C219, C227—18 pF, ceramic
C121, C221—50 µF, 50 volts, non-polarized
C122, C222—0.01 µF, polyester
C123, C124, C223, C224—0.0047 µF, polyester
C128, C228—6.8 µF, 16 volts, non-polarized
C129, C229—1 µF, 100 volts, non-polarized
C130, C230—330 pF, ceramic
C131, C231—0.015 µF, 250 volts, polyester
C132, C232—47 µF, 25 volts
C133, C233—15 pF, ceramic
C134, C138, C234, C238—100 µF, 100 volts, electrolytic
C135, C136, C139, C140, C235, C236, C239, C240—0.22 µF, polyester
C137, C141, C237, C241—22 µF, 100 volts, electrolytic
C143, C243—0.15 µF, 250 volts, dual-dielectic (Philips type PKT-P)

Semiconductors

IC1, IC2—4052 4PDT analog switch
IC3–IC6—4011 CMOS NAND gate
IC7—74C14 CMOS hex Schmitt trigger
IC8—4013 CMOS dual D flip-flop
IC9—7815 15-volt positive regulator
IC10—7805 5-volt positive regulator
IC11—7915 15-volt negative regulator
IC12–IC99, IC105–IC199, IC205–IC299—unused
IC100, IC102, IC103, IC105, IC200, IC202, IC203, IC205—TL071 low-noise op-amp
IC101, IC106, IC107, IC201, IC206, IC207—NE5534AN bipolar op-amp
IC104, IC204—4053 CMOS triple SPDT analog switch
BR1—400-volt, 10-amp bridge rectifier
D1, D4–D17, D23, D101–D105, D201–D205—1N914
D2, D3, D18–D22, D108, D109, D208, D209—1N4002
D24–D99, D110–D199, D210–D299—unused
D100, D200—1N752A, 5.6-volt, ½-watt Zener diode
D106, D107, D206, D207—1N4739A, 9.1 volt, 1-watt Zener diode
LED1–LED9—Standard red LED
Q1, Q3, Q4—BC547
Q2—BC557
Q5—BC327
Q6–Q99, Q115–Q199, Q215–Q299—unused
Q100–Q103, Q200–Q203—2SC2545
Q104, Q204—2N5485
Q105–Q107, Q205–Q207—BC556
Q108, Q208–BF470
Q109, Q110, Q209, Q210—BF469
Q111, Q112, Q211, Q212—2SK134
Q113, Q114, Q213, Q214—2SJ49

Other components

B1, B2—Size AA Ni-Cd battery
F1, F2—Fuse, 250 volts, 5 amps
J1—Stereo headphone jack
J100–J103, J200–J203, J104–J107, J204–J207—RCA Phono jack
J108–J111, J208–J211—speaker connectors
L100, L200—see text
L101, L201—6.8 µH
P1, P2—9-pin SIP plug, 0.1-" centers
RY1, RY2—DPDT relay
S1–S9—SPST normally open, momentary contact
S10—DPST toggle
S11—SPST toggle
S12—2P4T rotary
S13—SPST toggle switch, 250 volts AC
T1—117 VAC primary, dual secondaries: 90 VCT and 30 VCT

Miscellaneous: Battery holder for B1 and B2, PC-mount fuse clips, Ferrite beads, 11-mm × 25-mm coil forms

Note: The following components are available from Dick Smith Electronics, Inc., P.O. Box 8021, Redwood City, CA 94063; 800-332-5373 (orders) 415-368-8844 (inquiries). Complete kit of all parts (No. K-3516) including PC boards, heatsinks, screened front and rear panels, and transformer T1, $299 plus $10 shipping. Separate components: set of two PC boards (No. KH-0106), $49.00; 2SC2545 transistor (No. KZ-1683), $0.39 each; 2SK134 transistor (No. Z-1815), $4.50; 2SJ49 transistor (No. Z-1816), $4.50; transformer T1 (No. KM-2000), $57.00; case including panels and heatsinks (No. KH-2700), $115. All component orders must add $1.50 for handling plus 5% of total price. California residents must add 6.5% sales tax. Orders outside U.S. must include U.S. funds and add 15% of total price for shipping.

that opens all switches. The network connects to that pin and simply prevents signals from the preceding stages from passing on for a second or two at power-on.

The muting network works as follows. At power-on C1 is a virtual short-circuit. This means that pin 6 is pulled high, so all the switches in the IC are open. Then, as the capacitor charges, pin 6 is pulled low, and signals can pass on to succeeding stages. The delay that results makes for more pleasant headphone listening.

Loudspeaker protection circuit

A portion of the signal from each channel's power amplifier is fed to the speaker protection circuit shown in Fig. 7. The

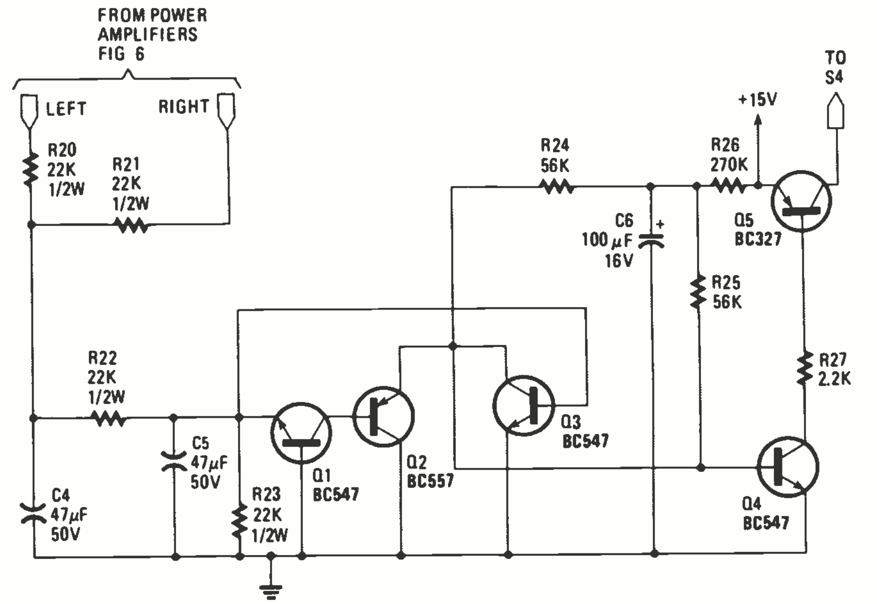


FIG. 7—THE SPEAKER PROTECTION CIRCUIT will disable the the output control relays (RY1 and RY2—shown in Fig. 1 last time) whenever the voltage produced by the output transistors becomes excessive.

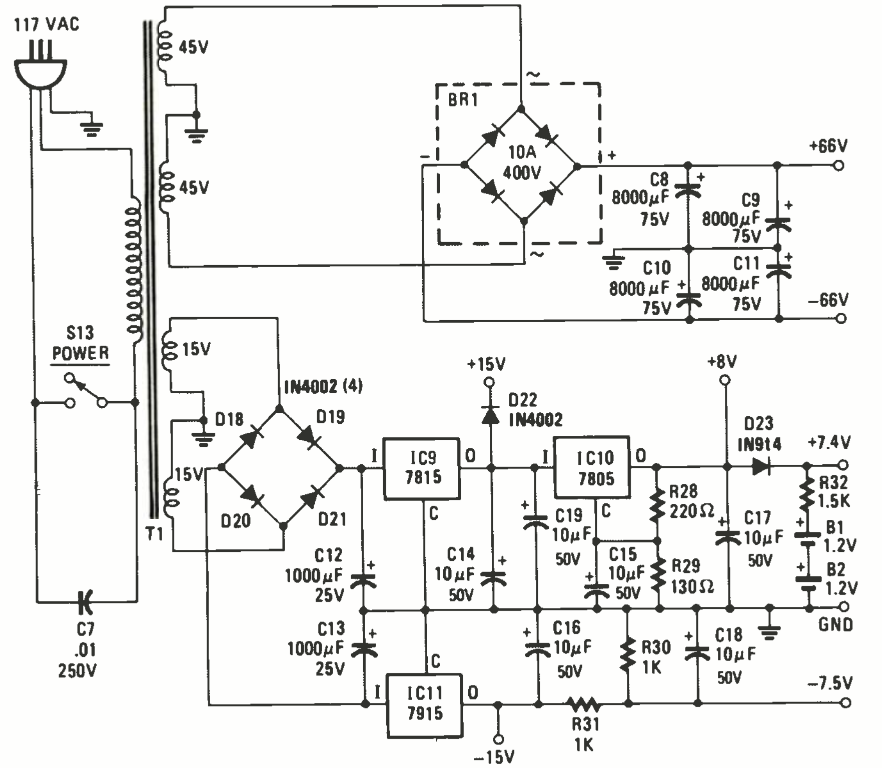


FIG. 8—THE AMPLIFIER'S POWER SUPPLY is built around a toroidal power transformer and it includes a trickle-charger for the CMOS-memory batteries, B1 and B2.

protection circuit does not protect the amplifier—it protects the loudspeakers. If a fault occurs in the amplifier that results in a large DC voltage at an output, a loudspeaker could be severly damaged. The loudspeaker protection circuitry prevents that from happening by de-energizing the relays that control the loudspeakers whenever an excessive DC voltage is sensed at the output of a power amplifier. The protection circuit also de-energizes the relay if a large low-frequency signal is presented to the circuit for an extended period of time. That could happen for a variety of reasons; for example, if the amplifier became unstable and began to motorboat.

Both power amplifier outputs are monitored via a low-pass network consisting of the four 22K-ohm resistors (R20–R23) and the two 47-μF non-polarized capacitors (C4 and C5). The two capacitors render the protection circuit immune to normal output voltages. But if one of the amplifiers develops an excessively negative DC voltage, Q1 will turn on. That turns on Q2 and removes the bias voltage from Q4; that in turn switches off Q5 so that no power can be fed through S4 (shown in Fig. 1), the speaker-selector switch that controls the coils of the relays. By the same token, if one of the power amplifiers develops an excessively positive DC voltage, Q3 will be forward biased. That again removes the bias from Q4 and Q5, preventing power from reaching the switch that controls the operation of the relays.

Note that the protection circuit is effectively fail-safe. If a malfunction prevents the relays from operating, the loudspeakers will be disconnected from the amplifier, so they will be safe from any potential damage.

Muting

The loudspeakers are muted (i. e., the relays are disconnected) for three seconds after power-on. That works as follows. When power is first applied, the 15-volt supply to Q5 is available almost instantly, but Q5 is unable to turn on because the base of Q4 is at ground potential, so it, too, is off.

The reason Q4 can't turn on is that its base is supplied via 56K resistor R25. That resistor is supplied by 100 μF capacitor C6, which is a short circuit at power-on. After power-on, C6 charges slowly via 270K resistor R26. Eventually Q4 turns on, so Q5 can turn on and energize the relays.

Switch-off thump

Another problem we faced was a loud thump from the loudspeakers whenever the amplifier was turned off. After investigation, we discovered that the problem was caused by the rapid collapse of the ±15V supply, which supplied the op-amps in the preamplifier stages enough juice to give a thump before the output relays released. If uncorrected, such thumps could eventually damage the speakers.

The solution was to isolate the op-amp supply. We did that by installing a 1N4002 diode (D22, shown in Fig. 8) in series with the +15-volt supply line, and by increasing the value of decoupling capacitor C118 by IC106 (the tone-control driver in Fig. 5) from 10 to 2200 μF. That large capacitor keeps the op-amp energized until the relays open. Hence, no switching transient can get through to the speakers, preventing the switch-off thump.

Power supply

The schematic of our power supply is shown in Fig. 8. In order to reduce induced hum, AC is provided by a dual-secondary toroidal transformer, shown in Fig. 9.

continued on page 74

MARTIN CLIFFORD

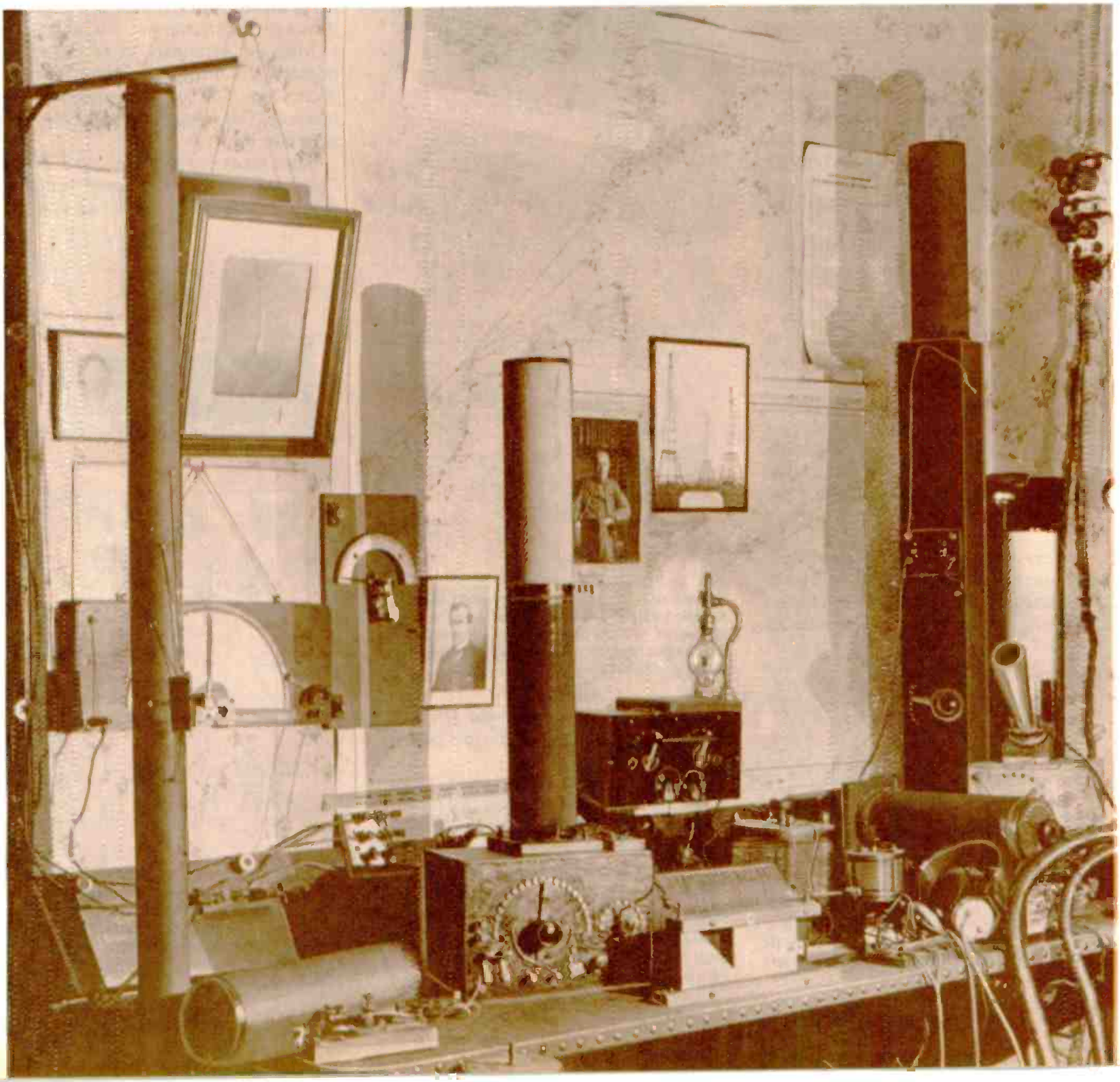
In this, the first installment of our new, occasional series about the early days of radio, we look at the original "solid-state" receivers.

DID YOU KNOW: THAT SOLID-STATE ELECtronics can trace its roots back to 1835? That radio signals can be demodulated using sulfuric acid or nitric acid? That oil-filled variable capacitors were once used in radio receivers? That a single crystal detector can be used as a radio receiver? That there are some radio receivers that never need to be turned off, have no on/off switch, and do not require battery or AC power? Or that lenzite, zincite, bornite, tellurium, and chalcopyrite are all semiconductors?

Most of us believe that the age of solid-state electronics began with the invention of the transistor; Bardeen and Brattain of Bell Laboratories produced that first crystal triode in 1948. However, lost in the mists of history is the fact that true solid-state receivers have been with us since about 1918.

In more recent times, the term solid-state has been so firmly associated with germanium, and subsequently with silicon, that no one should be blamed for thinking that those are the only materials

The Early Days of RADIO



suitable for use in semiconductors. Yet there are numerous materials that are just as suitable. Among them are carborundum (silicon carbide); galena (a crystal sulphide of lead); molybdenum; lenzite; zincite (an oxide of zinc); tellurium; bornite (a sulphide of iron and cooper); chalcopyrite (also known as copper pyrites); and cerusite. Except for carborundum, a manufactured material also used as an abrasive, all are materials that are found in nature.

Early solid state

The fact that certain materials have rectifying properties (that is, they allow current to flow in one direction only) has been known since 1835, thanks to the research of one Munk Af. Rosenshold. At the time a laboratory curiosity, his discovery was largely forgotten until it was unearthed again by F. Braun in 1874.

However, a practical use for that discovery was not found until many years later. It came at at time when interest in radio was heating up and many early experimenters had radio setups in their attic or basement workshops.

Rectifiers are key components in simple radio detectors. Along with vacuum tubes, early experimenters turned to solid-state rectifiers made from one of the substances that exhibit natural rectifying properties. Since most of those substances are crystalline in nature, such rectifiers were called *crystal detectors*; radios that used such detectors were called *crystal radio sets*, or simply crystal sets.

The simplest radio

Early vacuum-tube rectifiers, such as the UX-201A and UV-199 triodes, cost about $15. Since $15 a week was considered good pay for a workman back then, and since crystal detectors cost only a small part of that amount, many experimenters turned to crystal sets. Such radios were among the simplest possible, consisting of just a crystal detector and a headset. See Fig. 1.

The crystal set of Fig. 1 has its virtues, but it also has plenty of faults. Selectivity is non-existent; after all, that radio has no tuning circuits. So whatever the radio re-

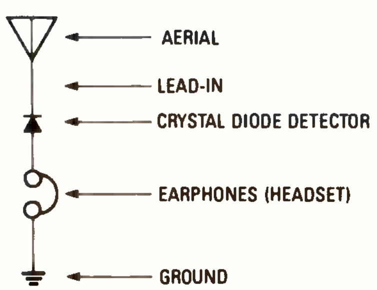


FIG. 1—THE SIMPLEST CRYSTAL RECEIVER consists of an antenna, a detector, headphones, and a ground.

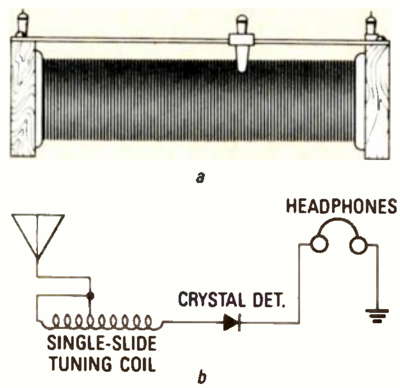


FIG. 2—TO IMPROVE SELECTIVITY a slide-tuned coil can be used (see *a*). The schematic of a crystal set that used such a coil is shown in *b*.

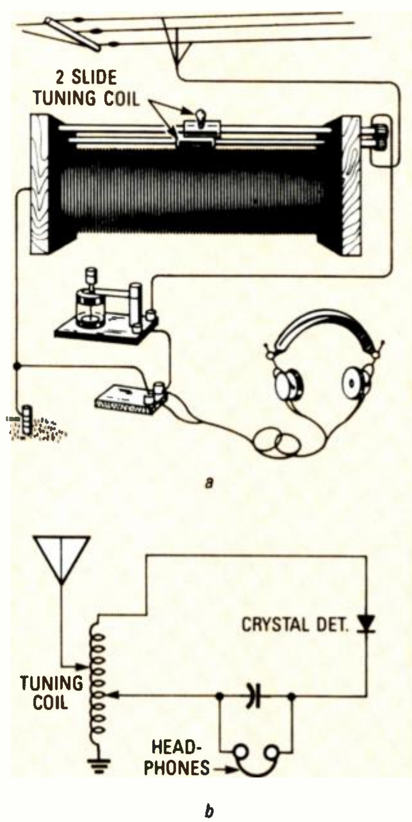


FIG. 3—FOR EVEN GREATER selectivity, receivers with double-slide-tuned coils were developed (*a*). The schematic of such a set is shown in *b*. Note the inclusion of a capacitor across the headphones. Its purpose was to bypass the RF carrier.

ceives is what you hear—the strongest signal dominates, and all the rest provide background noise.

The earliest effort at improving selectivity was to add a tuning coil like the one shown in Fig. 2-*a*. That coil consisted of enamel insulated wire wound on a round form; experimenters often used cylindrical oatmeal boxes as the coil form. The amount of inductance could be selected using a metal slider. The tuning method was crude, but the radio circuits that included that coil (see Fig. 2-*b*) did offer at least some improvement over those with no tuning at all.

Another problem was that the output of the crystal detector consisted of both an audio signal and an RF carrier; both were passed directly to the headphones. Subsequently, a small capacitor was placed across the headphones to bypass the RF carrier.

Also, it was found that selectivity could be further improved by adding a second slider to the tuning coil. The radio shown in Fig. 3-*a* incorporates both those improvements; the schematic for that circuit is shown in Fig. 3-*b*.

Improved designs

As time went on, various methods were used to improve tuning. In one arrangement, shown in Fig. 4-*a*, the single-slide tuner was used as the primary winding of an RF transformer. The secondary winding, which was tapped, was wound on a form that could travel into the primary by means of a pair of rods. That resulted in triple tuning. The primary was tuned by the single slider; coupling was adjusted by moving the secondary in or out of the primary, and finally, the appropriate secondary tap could be switch selected by the operator. The schematic for the circuit is shown in Fig. 4-*b*.

Since most crystal radio receivers are "powered" by the radio signal itself, they require no voltage supply or battery. (They

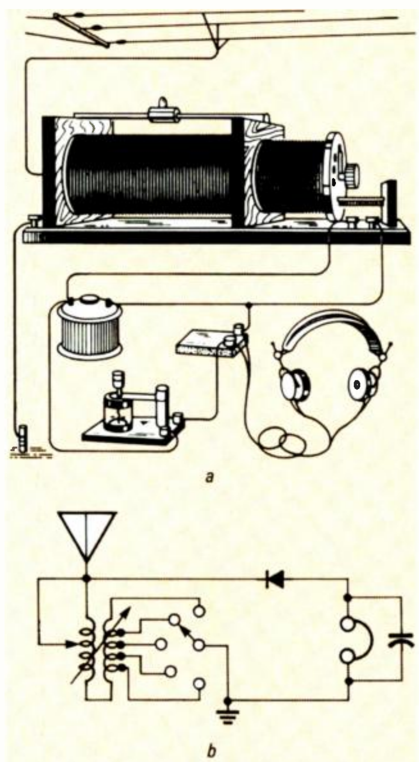


FIG. 4—IN THE CRYSTAL SET SHOWN in *a* the slide-tuned coil is used as the primary of an RF transformer; the secondary had multiple taps and was wound on a form that could be moved in to or out of the primary. The schematic of the circuit is shown in *b*.

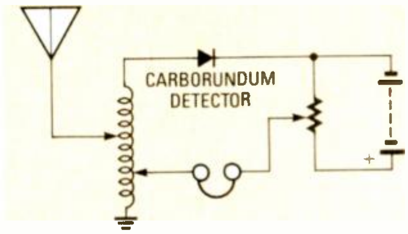


FIG. 5—BATTERY POWER was needed in crystal sets that used carborundum detectors.

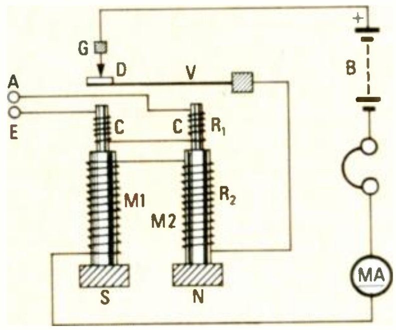


FIG. 6—BECAUSE OF THEIR LOW OUTPUT, some sort of amplification was often used with carborundum sets. Here, a popular mechanical amplifier of the time is shown.

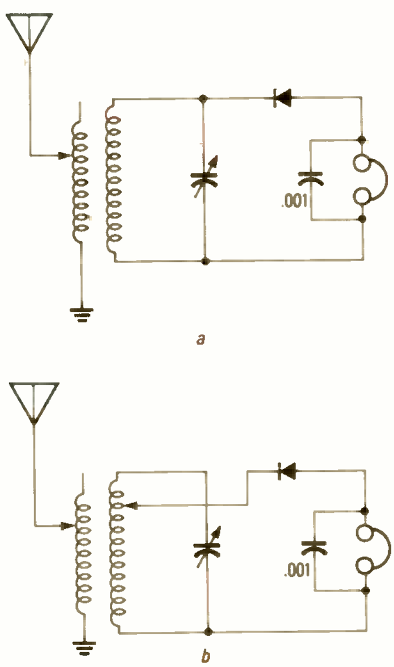


FIG. 7—THE SELECTIVITY OF CRYSTAL SETS was further improved by the addition of a variable capacitor. Here two designs, one (*a*) using a single-slide-tuned coil, the other (*b*) a double-slide-tuned coil, are shown.

also require no on/off switch.) However, that is not always the case.

One detector that was popular for a while was made from carborundum. As you can see in Fig. 5, a receiver design using that detector required a voltage source. Further, the output of the detector was weak. Those two factors eventually caused the carborundum detector to fall out of favor, but not before it gave rise to some interesting circuit innovations.

One of those was the concept of the amplifier. The early amplifier shown in Fig. 6 was a mechanical one known as the Brown amplifying relay. The leads identified as A and B were connected to the output of the detector. The signal current through relay coil M1 caused relay armature V to vibrate, thus varying the magnetic field around winding R2 of the second relay. That caused the current supplied by the battery to be varied at an audio rate. That current flowed through the headphones, producing sound. In some instances a series arrangement was used; the current from the battery drove still another mechanical amplifier.

The need for clumsy tuning coils was finally eliminated through the use of a variable capacitor, then known as a condenser. For a while, however, variable capacitors were used in conjunction with single- and double-slider variable coils. Two examples of capacitor-coil-tuned circuits are shown in Fig. 7.

In some of the more advanced sets, a vario coupler, sometimes called a variometer (see Fig. 8), was used. That consisted of a pair of coils mounted in such a way that one could be rotated within the other.

Ordinarily, the variable capacitors used were air types; that is, the dielectric between the stator and rotor plates was air. Air, though, has a dielectric constant of 1. To increase the capacitance without adding more plates, one design had the variable capacitor positioned in a leak-proof, transparent case, filled with oil. Oil has a dielectric constant of five, so the capacitance of such a capacitor is five times that of one with an air dielectric (assuming all other variables to be the same). One such capacitor had 17 plates and a total maximum capacitance of 0.0004 µF, while another had 43 plates and a maximum capacitance of 0.001 µF.

Anyone who has had any contact with radio knows that the antenna plays an important role in determining the quality of the received signal. Antennas were even more important in the days of the crystal set. That's because that design made no provision for amplification. Thus, the strength of the signal heard was wholly dependent on the strength of the signal delivered by the antenna. Some of the schemes devised were quite elaborate; others were quite simple. For apartment dwellers, a bedspring was a popular alternative to an outdoor design; the ground connection was made to a cold-water or radiator pipe.

The crystal detector

So far, we've spoken about how crystal detectors were used in early radios. But we've not looked at the detector itself and how it was made. It is time now to correct that oversight.

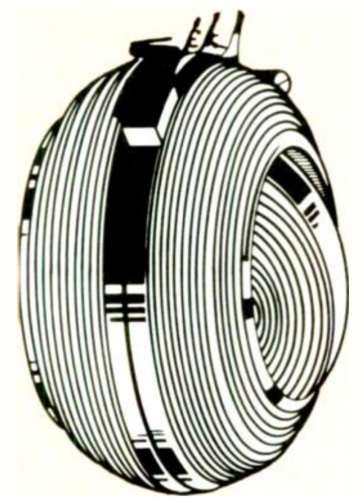


FIG. 8—A VARIO-COUPLER, or variometer, consisted of two coils mounted in such a way that one could be rotated within the other.

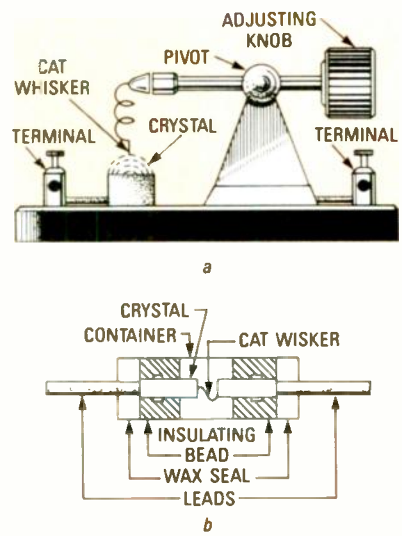


FIG. 9—TWO CATWHISKER DETECTORS. A variable contact type is shown in *a*; a sealed, fixed unit is shown in *b*.

Crystal detectors were available in two basic forms: contact and combination. Of those, the contact detector was cheaper and more popular.

A single crystalline substance was used in the contact detector. A small bit of spring wire, called a *catwhisker*, was placed so that it made contact with a point on the crystal. In early detectors, the catwhisker was designed to be variable because finding the most sensitive spot on the crystal was a trial-and-error procedure. See Fig. 9-*a*.

The catwhisker was usually made from stiff phosphor bronze, but in more expensive detectors silver or 18-karat gold was used. The wire was coiled, with a small straight extension ending in a blunt point—an arrangement much like that used in the first point-contact transistors many years later. There were two connections to the crystal detector: one to the catwhisker and another to the cup holding the crystal.

Later on, fixed-position catwhiskers in sealed containers became available. See Fig. 9-*b*.

The combination crystal detector consisted of two different crystals in close contact. Various combinations of minerals were tried, including bornite and either zincite or copper pyrites. Another combination detector used tellurium and chalcopyrite (copper pyrites). The chief advantage of the combination detector was that it was less susceptible to vibration than the catwhisker type.

Some of the many different types of crystal detectors are shown in Fig. 10. We've so far looked at all of those save one—the Perikon detector, invented by Pickard in 1906, and shown in Fig. 10-*b*. That detector used a small, cone-shaped piece of zincite. The zincite could be positioned so that it contacted one of several segments of chalcopyrite located on a circular plate. By selecting which segment of chalcopyrite was used, the detector could be "tuned."

As we stated earlier, most detectors were made using a crystalline material. However, "most" is not "all." One detector that was at least briefly popular was the electrolytic detector, shown in Fig. 11. The design of that detector was similar to that of the catwhisker, but nitric acid, or a dilute solution of sulphuric acid, was used in place of the crystal. Despite that detector's high sensitivity, it had disadvantages. One was that the wire tended to curl away from the acid—so the wire frequently had to be repositioned or replaced. Secondly, the detector used exposed acid, which is dangerous.

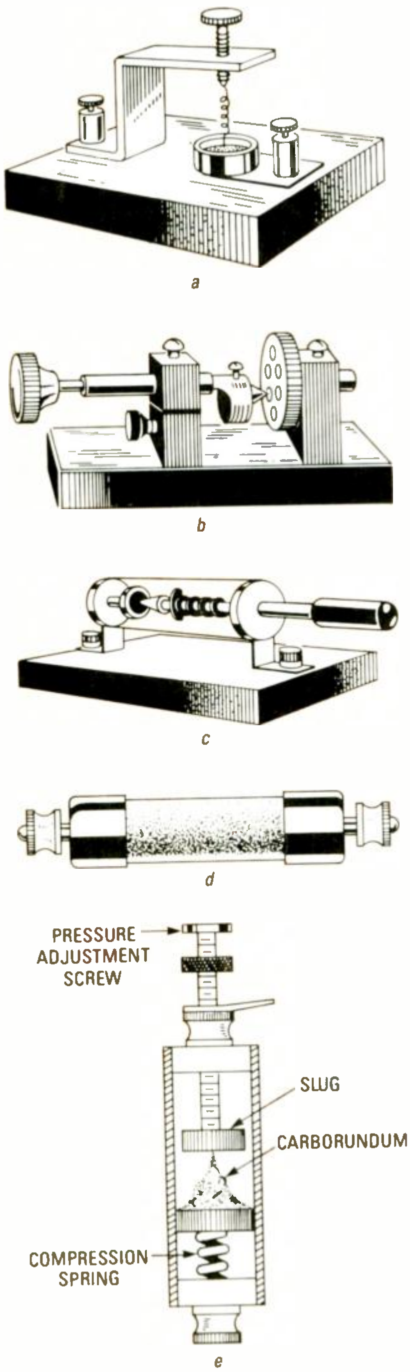
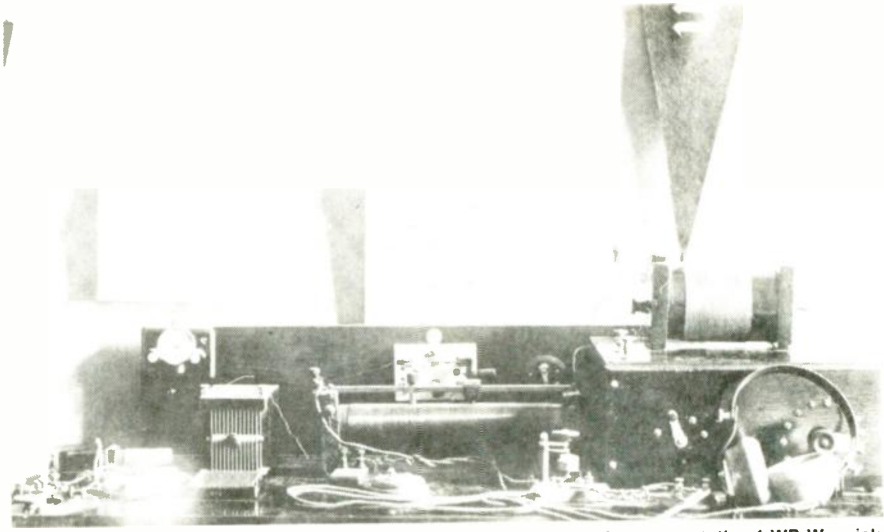


FIG. 10—FIVE POPULAR DETECTORS: Variable-contact catwhisker (*a*), Perikon (*b*), combination crystal (*c*), fixed-contact catwhisker (*d*), and carborundum (*e*).



AN EARLY WIRELESS RECEIVER. With this set-up, which was part of amateur station 1-WP, Warwick, RI, circa 1913, the operator was able to log stations from Maine to Florida. Note the variable-contact catwhisker crystal detector, 23-plate tuning capacitor, and double-slide-tuned coil.

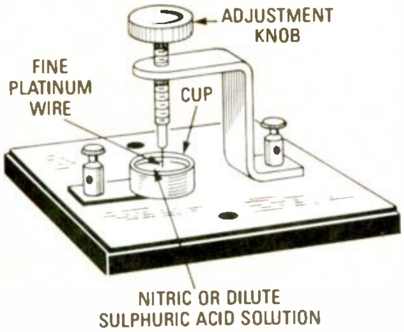


FIG. 11—IN AN ELECTROLYTIC DETECTOR the rectifying material was nitric acid or diluted sulphuric acid.

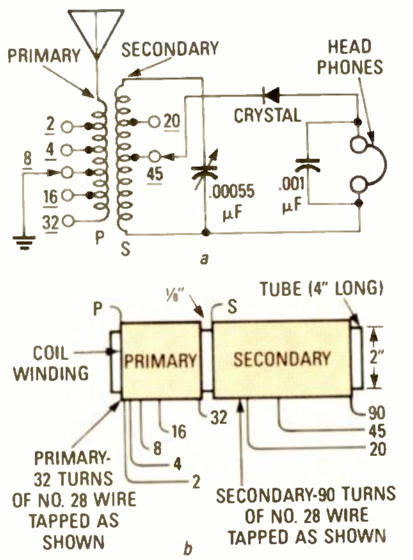


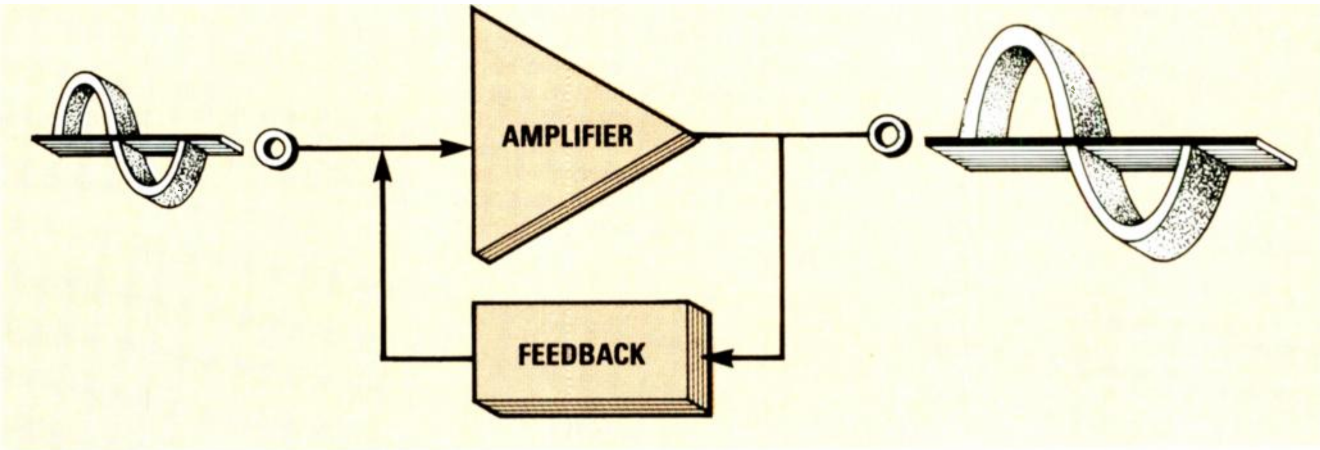
FIG. 12—YOU CAN BUILD this crystal set (*a*) using modern components. Winding details for the coil are shown in *b*.

Building your own

We hope this article has aroused your interest in the electronics of days gone by. If you want to recapture some of the flavor of the early experimenters, perhaps you'd like to try building your own crystal receiver. If so, the circuit shown in Fig. 12-*a* can be built using modern parts.

In that circuit we've replaced the slide-tuned coil with a tapped one. (Finding a slide-tuned coil these days would be nearly impossible.) Full details of the coil are given in Fig 12-*b*. Just about any diode can be used for the detector. For best results, plan on using an outdoor antenna that's at least 75 feet long. **R-E**

How to Design OSCILLATOR Circuits



JOSEPH J. CARR

Here's the first installment of our new back-to-school series that teaches you all about oscillators, multivibrators, and digital clocks.

OSCILLATORS OF ONE SORT OR ANOTHER are at the heart of all kinds of devices ranging from radio transmitters to digital computers. So, at one time or another, everyone involved in electronics—both hobbyist and professional—must build an oscillator, a multivibrator, or a digital-clock circuit. A simple oscillator, for example, might be used to generate the carrier frequency in a radio transmitter. A multivibrator that produces squarewaves might be the heart of a test instrument such as a function generator. A digital clock is a special multivibrator that is used in most digital logic and computer circuits.

In this series we'll examine the two major types of oscillator circuits in detail. We'll start off this time discussing relaxation oscillators; then we'll go on to the basic theory of feedback oscillators. And, because they are more commonly used than relaxation oscillators, we'll spend the bulk of our remaining installments discussing feedback oscillators. In particular, we'll talk about LC and RC sinewave oscillators of all types, one-shots, crystal oscillators, and digital clocks built from both TTL and CMOS IC's. Along the way we'll give many practical circuit examples that you should have no trouble adapting to your needs. We have a lot to do, so let's get started.

Basic definitions

There is some overlap between the terms oscillator, multivibrator, and clock, and in conversation people have a tendency to blur the distinctions between those terms even further. But for our purposes let's use "oscillator" to refer to all three kinds of circuits. In fact, let's define oscillator to mean *any* circuit that produces a periodic waveform—one that produces similar outputs at regular intervals of time. That output could be a sinewave, a squarewave, a triangle wave, a sawtooth wave, a pulse train, or some other waveshape. The important point is that it repeats at a regular interval.

As we said, there are two basic types of oscillators: relaxation oscillators and feedback oscillators. The basic difference between the two is that the feedback oscillator is built from active circuit elements—those that provide gain, whereas the relaxation oscillator is built from passive devices—those that do not provide gain.

Some relaxation oscillators are built from electronic devices that pass little or no current at voltages below some threshold, and that pass a relatively large current at voltages above that threshold. Examples of that sort of device are neon lamps and UJT's (*U*ni*J*unction *T*ransistors). Other relaxation oscillators use a negative-resistance device such as a tunnel diode. If you're unfamiliar with any of those devices or terms, hold on—we'll discuss each below.

A feedback oscillator uses an active device (a transistor or an op-amp, for example) as an amplifier; a special network connected to the amplifier provides a controlled amount of positive feedback. That allows the circuit to work regeneratively. By way of contrast, filters of various types (lowpass, highpass, notch, bandpass, etc.) work degeneratively. In other words, in a filter, feedback components are used to decrease the amplitude of a frequency or a range of frequencies; in an oscillator, those components are used to increase the amplitude of a frequency or a range of frequencies.

With those basic distinctions in mind, let's discuss relaxation oscillators now; we'll catch up with feedback oscillators below.

A neon-lamp oscillator

A simple neon-lamp relaxation oscillator is shown in Fig. 1. The lamp contains a low-pressure inert gas—neon—in a glass envelope with a pair of electrodes. When the voltage across the electrodes exceeds the ionization potential of neon (V_T in Fig. 2), the gas will glow. It will continue to glow as long as the voltage

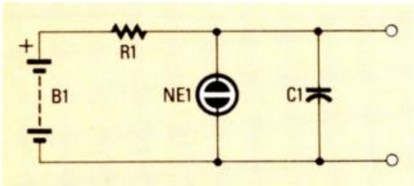


FIG. 1—THE NEON-BULB OSCILLATOR is a classic relaxation oscillator.

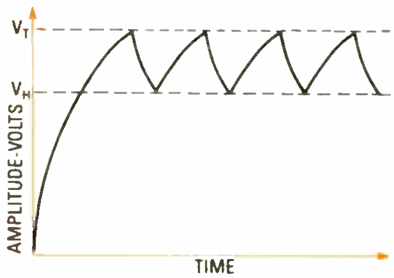


FIG. 2—VOLTAGE BUILDS UP across a neon bulb until V_T is exceeded. The bulb then begins to conduct, and voltage begins to fall. When it goes below V_H, conduction ceases, so the cycle can begin again.

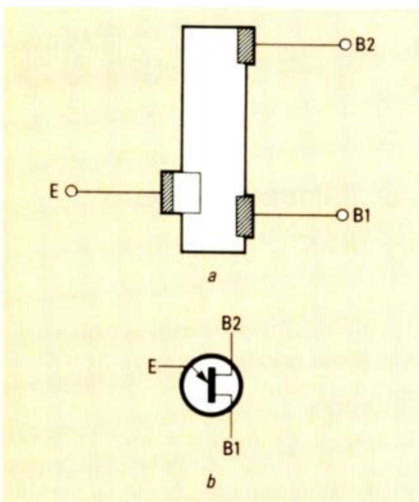


FIG. 3—THE UJT'S INTERNAL STRUCTURE is shown in *a*, and its symbol is shown in *b*.

across the lamp's electrodes exceeds the holding voltage, V_H in Fig. 2. When the lamp is not ionized, it conducts no current. That is the situation at all potentials below V_H. The popular NE-83 lamp has a V_T of 60 to 100 volts, and a V_H of 60 volts.

The circuit works like this: When power is applied to the circuit, C1 begins to charge. When the voltage across it exceeds V_T, the lamp ionizes and its resistance drops to a very low value. A series resistor may be necessary to prevent the lamp from being destroyed by the sudden onrush of current. Anyway, that low-impedance path allows C1 to begin discharging. Discharge continues until the voltage across the lamp falls below V_H. At that point the lamp de-ionizes and reverts to its high-resistance state. Then C1 begins charging again, and the cycle repeats. Hence, the voltage across C1 varies between V_H and V_T. The circuit's frequency of oscillation is determined by both V_T and V_H, as well as by the R1-C1 time constant.

The unijunction transistor

The UJT is a special semiconductor device that has one emitter, two bases, and no collector. Its basic structure is shown in Fig. 3-*a*, and its schematic symbol is shown in Fig. 3-*b*. The UJT is built from a single chunk of silicon; the bases are just the electrodes at the ends of the block. The emitter forms a PN junction with the block. Like most other PN junctions, the UJT's PN junction will not conduct when it is reverse biased. However, it *will* conduct when it is forward biased; usually 0.6 to 0.7 volts is sufficient to get current flowing.

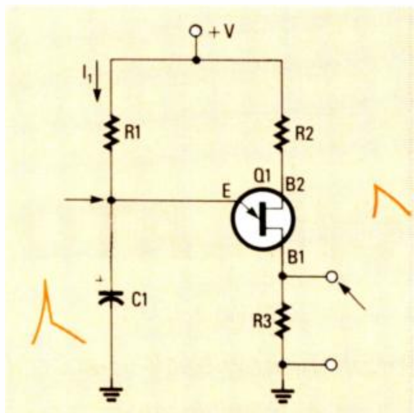


FIG. 4—THE CLASSIC UJT OSCILLATOR is a relaxation type; it provides a narrow spike at the B1 terminal.

A UJT relaxation oscillator is shown in Fig. 4. Its frequency of oscillation is set by R1 and C1 in conjunction with the characteristics of the UJT. When the circuit is turned on, the B1-emitter junction is unbiased, so no current flows through R3. Capacitor C1 begins charging through resistor R1. When the UJT's threshold voltage is exceeded, the UJT turns on. Capacitor C1 is quickly discharged by the low-impedance PN junction, so the UJT quickly turns off. A narrow pulse thereby appears across R3.

Typical UJT's need very little turn-on current (0.4–12 μA), and that makes them useful in high-impedance circuits for detecting very small amounts of current. Also, oscillators with frequencies ranging from 1 Hz to 1 MHz may be built from UJT's.

The third major type of relaxation oscillator is built from a negative-resistance device, the tunnel diode. Let's find out what negative resistance is, and then let's see a practical example of how a tunnel diode may be used.

Negative resistance

What is negative resistance? Let's approach that question in a roundabout way. A garden-variety resistor functions according to Ohm's law. When voltage

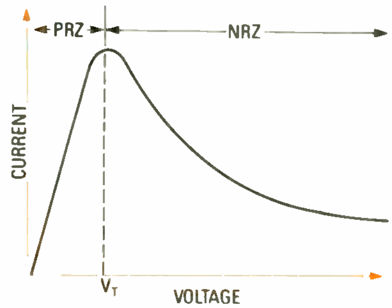


FIG. 5—TUNNEL DIODE'S CHARACTERISTIC curve reveals that, below V_T, current increases as voltage increases. Voltages above V_T cause current to *decrease*—and that allows oscillation to occur.

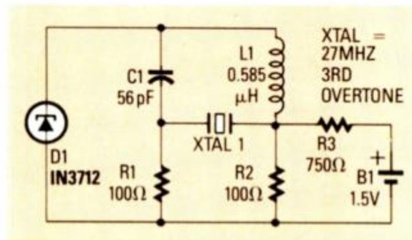


FIG. 6—THIS 27-MHZ OSCILLATOR can be used as a low-power citizen's-band signal generator.

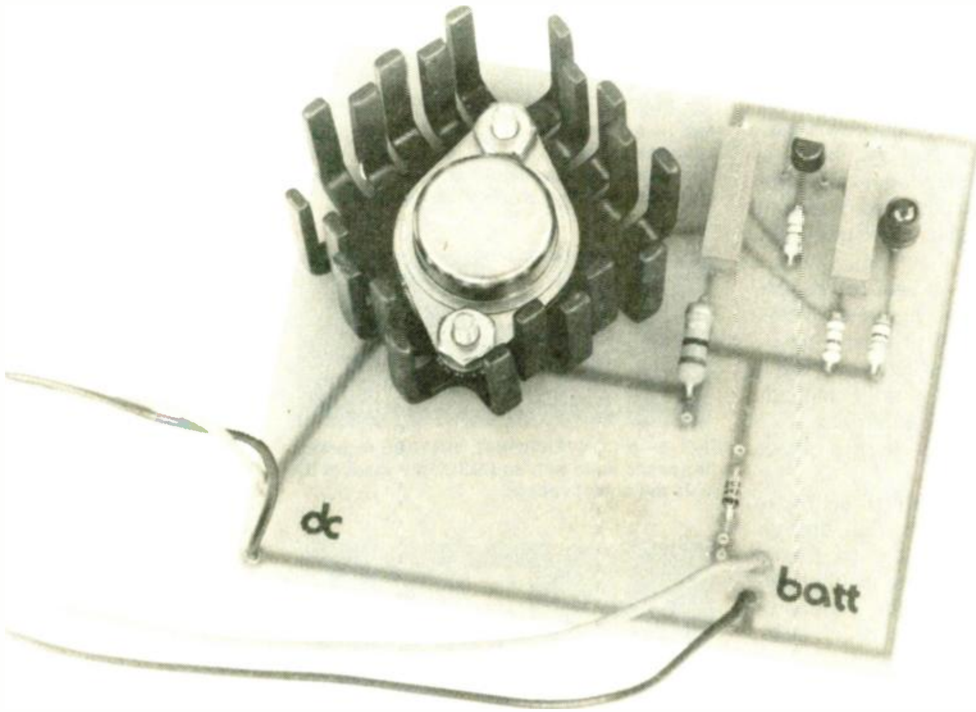
across the resistor increases, current flowing through the resistor will also increase. A device with negative resistance, however, operates in the inverse manner. In other words, as voltage across the device increases, the current that flows through the device decreases.

The tunnel diode (also called an Esaki diode after its inventor) is a negative-resistance device; its characteristic curve is shown in Fig. 5. Note that, in the region labeled *PRZ* (for Positive Resistance), the device functions in the normal manner—increased voltage causes increased current. However, in the *NRZ* (Negative Resistance) region beginning at V_T, the opposite is true—increased voltage causes *decreased* current.

A tunnel-diode oscillator is shown in Fig. 6. That circuit was popular in the 1960's for tuning up citizen's-band gear, and for other uses at frequencies near 27 MHz. With the component values shown, the circuit will oscillate in the 27-MHz region using a 27-MHz 3rd overtone crystal. A similar circuit can be used to cause a tunnel diode to oscillate in the UHF and microwave regions. In that type of application, strip-line tuners and cavities are used to establish the resonant frequency.

In general, as you can see, relaxation oscillators are simple, so they're good for getting a quick-and-dirty periodic waveform, and for specialized uses. However, feedback oscillators built with active devices are much more flexible, and, therefore, much more widely used. So now let's take a look at the theory behind feedback oscillators.

continued on page 74



Universal Battery Charger

Don't let your battery-powered portables run out of energy unexpectedly! Keep your batteries fully charged with this inexpensive circuit.

MICHAEL R. WRIGHT

ONE COROLLARY TO MURPHY'S LAW states that things always go wrong at the worst possible moment. One example familiar to electronics enthusiasts is the way that batteries tend to go dead just when you need them most. In addition, if you use many portable devices—a *Walkman*, a "boom-box," a portable TV, a portable computer, flashlights, and toys—the cost of batteries can become excessive.

One way to cut costs is to use rechargeable batteries. And if your portable battery-eater has a DC INPUT jack, you've got an easy way to save some cash and to go longer between recharges. All you have to do is wire up a cable that connects a high-current-capacity battery-pack of the proper voltage to your portable.

The problem is that the price of a commercial charger may cause you to think twice about converting from conventional non-rechargable cells. However, with the circuit presented here, there's no longer an excuse. Not counting a case, the total cost of the few easy-to-obtain components in our circuit shouldn't exceed $10. And that's for all new parts; by using spare parts you could reduce your cost to nothing!

The circuit can easily recharge batteries with a wide variety of voltages and current capacities. The circuit was specifically designed to recharge gel-cells, but it can also be used to recharge Ni-Cd's and any other type of battery that needs a constant-current source, a constant-voltage source, or both. The values of a few resistors need to be altered to accommodate batteries of various voltages and currents. The simple design equations used for resistor selection are presented below, but first let's talk about gel-cells.

The low-down on gel-cells

Before we get started, it's worth pointing out that the term "battery" really refers to any collection of two or more single "cells," although the term is loosely applied to single-cell power sources like AA cells. The gel-cell battery is a relative newcomer to the world of rechargable batteries; its name is really a shortened from of "gelled-electrolyte battery cell."

Basically, the gel-cell is very similar to a modern automotive battery. The gel-cell provides high power density in a sealed, multi-cell, maintenance-free, lead-acid battery. Gel-cells are not manufactured in small cases like those that enclose the familiar AA, C, and D cells. However, they *are* manufactured in larger cases that range in size from a cigarette-pack to an automobile battery, and even larger. Gel-cells are made by (among others) Panasonic (Battery Sales Division, Division of Matsushita, P. O. Box 1511, Secaucus, NJ 07094), Globe (P. O. Box 591, Milwaukee, WI 53201), and Saft (P. O. Box 1886, 711 Industrial Blvd., Valdosta, GA 31603-1886).

Common gel-cell batteries come with voltage ratings that range from 2 to 24, and in current capacities ranging from 1.2 to 120 AH (*A*mp-*H*ours). The AH rating refers to the amount of current that can be delivered over a period of time; 20 hours is usually the specified period of time. For example, a battery might be rated at 2 volts and 30 AH. That means that the battery should be able to deliver a current of 1.5 amps (30/20) continuously for a period of twenty hours.

A properly treated battery should last for years, but an improperly treated one may last only a few months, or even weeks. For example, the author's first gel-cell battery lasted only about six weeks, because he was ignorant of how to take care of it. After uncovering and applying the information related here, his second one is already more than a year old and still going strong.

The most common means by which a gel-cell battery is abused is "deep-cycling;" that term refers to the practice of discharging a battery deeply and then over-charging it. That practice is sometimes appropriate for Ni-Cd's, but it is definitely inappropriate for gel-cells. Our charger can't repair a damaged or abused gel-cell battery; it's up to you to treat your batteries with care.

The number of cells in a gel-cell battery is equal to the battery's nominal voltage divided by two. A 12-volt battery therefore has six (12/2) cells. Each cell has a 2.3-volt output when it is fully charged, so a 6-cell battery, nominally rated at 12 volts, actually has a fully-charged output of 13.8 volts.

You can tell when a gel-cell battery is nearly discharged by the fact that, under a no-load or low-load condition, it will have an output voltage that is near its full rated output. However, when the battery is placed under a moderate to heavy load, voltage drops by about 4.6 volts.

The reason for the two-cell drop is that a discharged cell actually reverses polarity and acts as a load that "cancels" the voltage of a good cell. So you might measure only about 9.2 volts (13.8 − 4.6 = 9.2) across a 12-volt battery that needs to be recharged. And speaking of charging, let's find out how to do it now.

Charging methods

Gel-cell batteries from different manufacturers are made in different ways, and they have different charging requirements. Many batteries can be charged using the circuitry described here, but you should check with the manufacturer of your battery to be sure.

A common and reliable method of charging is as follows. First, a regulated, constant current that is equal to 10% of rated output is applied to the battery. For example, a 12-volt 1-AH battery would start off with a charging current of 100 mA. Voltage must be monitored; when it reaches 90% of rated output, the circuit removes the constant-current source and applies a regulated voltage to complete charging. The switchover is necessary to prevent over-charging in case a battery is left connected to the charger for a long period of time. The battery can float-charge in that way indefinitely.

You may be able to use a charging current different than 10%—for example, for "fast-charging." However, if you use a different current, follow the manufacturer's recommendations carefully.

To determine the voltage the charger will have to supply, you'll have to multiply the number of cells in your battery by 2.3 and then add 5, to allow for circuit losses. To charge our example 12-volt battery,

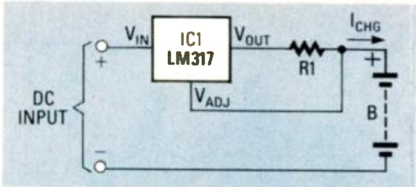


FIG. 1—A CONSTANT-CURRENT CHARGER can be built from an LM317. The value of R1 is what determines the charging current. See the text for information on how to calculate its value.

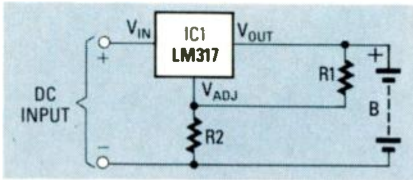


FIG. 2—A CONVENTIONAL VOLTAGE regulator is easy to build with an LM317; the value of R2 sets the output voltage.

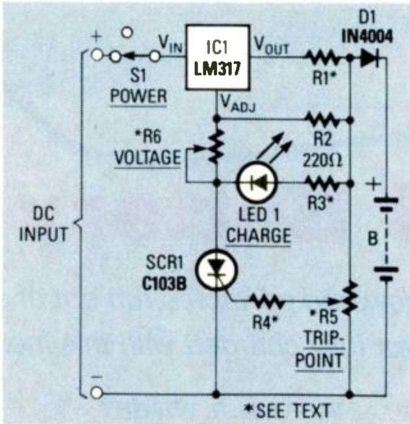


FIG. 3—THE COMPLETE CHARGER is a hybrid of the previous circuits. When the SCR is off, the circuit functions as a constant-current source; when the SCR is on, the circuit functions as a voltage regulator.

we'll actually need an unregulated DC supply of about 19 volts.

Circuitry

The constant-current charger is right out of the manufacturer's data book. As shown in Fig. 1, the heart of the charger is an LM317 adjustable regulator. An LM317K can supply as much as 1.5 amps of current if it has proper heatsinking; it can also handle as much as 37 volts. If your battery requires a higher charging voltage, you can substitute an LM317HV, which can handle as much as 57 volts. To increase current, you could use an LM338, which can provide five amps of current at a maximum of 32 volts. Calculate the value of R1 from the charge current (I_{CC}) you need, and from the 1.25-volt bias required by the LM317:

$$R1 = 1.25/I_{CC}$$

For a 1-AH battery, I_{CC} = 0.1 A, so R1 = (1.25/0.1) = 12.5 ohms. R1's wattage is determined in the usual manner: 0.1 A × 1.25 V = 0.125 W. Just to be safe, use a ½-watt flame-proof resistor.

That takes care of current, but what about voltage? Take a look at Fig. 2. There an LM317 is configured as a conventional constant-voltage regulator. In normal applications, the manufacturer recommends that R1 have a value of 240 ohms. The value of R2 is what determines the output voltage, and its value may be arrived at by a fairly complex equation. It's usually simpler to wire up the circuit with a 5K or a 10K potentiometer, set the output voltage, and then substitute the closest standard fixed resistor for the potentiometer.

We've got a current regulator and a voltage regulator now. But how do we put them together? See Fig. 3.

The complete charger

Let's discuss the overall operation of the circuit and then show how to calculate resistor values. When power is applied to the circuit, SCR1 is off, so there is no bias-current path to ground; thus, the LM317 acts as a current regulator. The LM317 is connected to the battery through steering diode D1, limiting resistor R1, and bias resistor R2. That portion of the charger is similar to the circuit shown in Fig. 1 above. The steering diode was added to prevent the battery from discharging through the LED and the SCR when power is removed from the circuit.

As the battery charges, the voltage across TRIP-POINT potentiometer R5 rises and at some point turns on the SCR. At that point, current from the regulator can flow to ground, so the regulator now functions in the voltage mode. When the SCR turns on, it also provides LED1 with a path to ground (through R3). So, when LED1 is on, the circuit is in the voltage-regulating mode; when LED1 is off, the circuit is in the current-regulating mode.

Calculating resistor values

Now let's find out how to calculate the resistor values. Assume that we're still talking about a 12-volt, 1-AH battery. Let's start with the VOLTAGE adjustment potentiometer, R6. First we have to calculate a multiplication factor, F; that can be found from:

PARTS LIST

All resistors are ¼-watt, 5% unless otherwise noted.
R1, R3, R4, R6—see text
R2—220 ohms
R5, R6—ten-turn trimmer potentiometer, see text
Semiconductors
IC1—LM317 variable-voltage regulator
D1—1N4004
LED1—standard LED
SCR1—C103B, 800 mA, 200-volt SCR
Miscellaneous
SPST toggle switch, PC board, input and output connectors

TABLE 1—EVERREADY Ni-Cd CHARGE CURRENT

Number	Size	Charge Current	Charge Voltage
CF15	AA	50 mA	1.50–1.60
CH15	AA	50 mA	1.35–1.45
CH35	C	120 mA	1.35–1.45
CH50	D	120 MA	1.35–1.45

$$F = (V_{CC}/1.25) + 1$$

In that equation V_{CC} is the battery's full-charge output voltage; in our case, V_{CC} = 13.8, so F = (13.8/1.25) + 1 = 12.04. Then we calculate the value of R6 as:

$$R6 = F(R1 + R2)$$

We already saw that R1 has a value of 12.5 ohms; R2 has a value of 220 ohms, so R6 = 12 × (220 + 12.5) = 2800 ohms. That value is approximately what is required to obtain the end-of-charge voltage we need. The value is an approximation because it does not take into account the voltage drop across the SCR. So we simply round up to the next highest value, and use a 5K potentiometer for R6. That will allow you to adjust the circuit for use with batteries having different voltages.

The manufacturer recommends that R2 have a value of about 240 ohms. The series combination of R1 and R2 is within 5% of 240 ohms, and that's close enough. You may have to adjust the value of R2 to accommodate a different charge current, voltage, or both, or if you use the high-current LM338. See the 1982 *Voltage Regulator Handbook* by National Semiconductor (2900 Semiconductor Drive, P. O. Box 58090, Santa Clara, CA 95052-8090) for more information.

Next we need to determine the value of TRIP-POINT potentiometer R5, which sets the voltage at which the SCR turns on. We have found empirically that, if the end-of-charge voltage is less than 20 volts, a 5K unit will work. For voltages greater than 20 volts, a 10K unit will work.

The value of the LED's current-limiting resistor, R3, is easy to calculate:

$$R3 = (V_{CC} - 2.2)/20 \text{ mA}$$

$$R3 = (13.8 - 2.2)/0.02 = 580\Omega$$

You may want to substitute a 1000-ohm ½-watt resistor for R3. Doing that will prevent damage to the LED when the charger is used with batteries having voltages greater than 12.

The last value we need to calculate is that of R4, which limits the current that can be applied to the gate of SCR1. That current could blow the SCR if the TRIP-POINT potentiometer were turned too far in the direction of the output of the regulator. The value of R4 may be determined thus:

$$R4 = V_{CC}/50 \text{ mA}$$

So, in our case,

$$R4 = 13.8/0.05 = 276\Omega$$

Rounding up to provide extra current limiting, the closest standard value is 300 ohms, which should work fine.

Regarding the SCR, it must be able to handle the bias current of the LM317K when the latter is in the voltage mode, and it must be able to withstand the full, no-load voltage supplied by your DC source—19 volts in our example. The SCR specified is rated to handle 200 volts at 800 mA; it should be able to handle any battery you're likely to come across.

Construction

Layout and assembly are quite simple; a foil-pattern for a printed-circuit board is shown in "PC Service." A stuffing guide is shown in Fig. 4. Stuff the board, solder the components, and then check your work to make sure that the semiconductors are all oriented correctly.

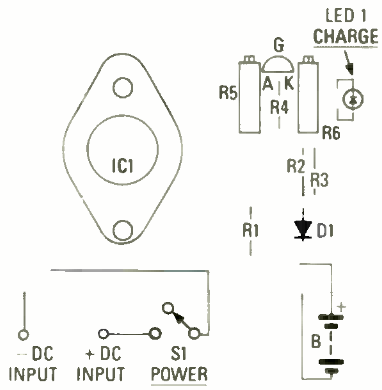


FIG. 4—PARTS-PLACEMENT DIAGRAM for the complete voltage/current charging circuit shown in Fig. 3.

Before applying power, set both trimmer potentiometers (R5 and R6) to the middle of their ranges; and *don't* connect the DC source or a battery to the charger yet. You must calibrate the charger first. We'll continue working with a 12-volt, 1-AH battery; substitute the appropriate values for your battery where necessary.

1. Connect an ohmmeter across the VOLTAGE adjustment potentiometer (R6). Adjust R6 so that the ohmmeter indicates the calculated set-point value—2.8K, in the example. Remove the ohmmeter from the circuit before proceeding.

2. Apply power to the circuit and check for smoke and other signs of catastrophe. Fix any mistakes.

3. Connect a 4.7K resistor to the circuit where the battery would normally.

4. Apply power to the circuit and measure the voltage across the 4.7K resistor. That voltage should be about 13.8, or your calculated output voltage. If the measured voltage is much different from what you expect, measure the voltage across the SCR. If you don't measure about 0.7 volts, the SCR has not turned on, so adjust TRIP-POINT potentiometer (R5) until the LED turns on. If the LED won't turn on, the SCR may be bad.

5. Connect a voltmeter across the output terminals and adjust the VOLTAGE control (R6) so that the meter indicates your calculated V_{CC}—19 volts, in our case.

6. De-energize the circuit and connect an ohmmeter between the wiper of the TRIP-POINT potentiometer (R5) and ground. Adjust R5 so that the meter reads zero ohms. That will disable the current-to-voltage shift. Remove the ohmmeter and the 4.7K resistor.

7. Connect a partially-discharged gel-cell battery to the output terminals of the charger. *Be careful to observe proper polarity!* The LED should not light; if it does, steering diode D1 is in the circuit backward.

8. Connect a voltmeter across the battery, apply power to the circuit, and measure the voltage across the battery. If the battery is not discharged enough, V_{CC} may be reached before you have a chance to adjust R5. If your meter indicates V_{CC} now, you'll have to discharge your battery further and try again. What you want to do is adjust R5 so that the SCR trips just after V_{CC} is reached.

9. Partially discharge the battery and reset R5 several times until you're satisfied with the accuracy of the trip-point setting.

Charger use

When charging a battery, you'll want to take an occasional look at LED1. After it turns on, interrupt power for about three seconds. That allows the SCR to unlatch. Re-apply power, and, if the LED re-illuminates quickly, the battery is fully charged. If not, let the battery charge longer and then repeat the test.

You can also use this circuit to recharge lead-acid and Ni-Cd batteries. You'll have to re-calculate resistor values to provide the appropriate charging current, which can be obtained from manufacturers' data books. We show the required charge current for several common *Eveready* Ni-Cd cells in Table 1 as a point of reference.

When charging a (non gel-cell) lead-acid or Ni-Cd battery, power should be removed when the LED lights up, or overcharging may occur, and the battery may be damaged. **R-E**

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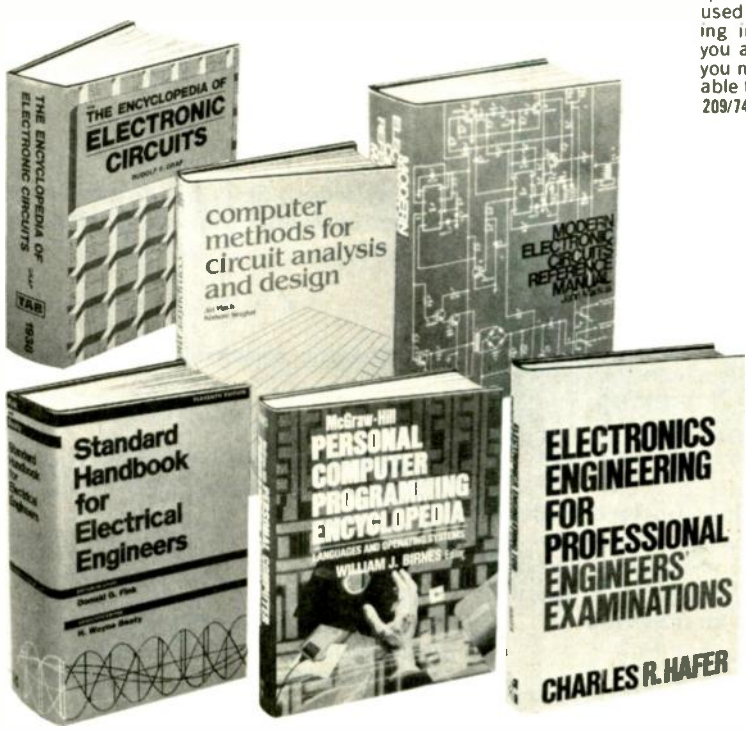

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E33805

FET STEREO AMP

continued from page 60

One winding feeds a 10A 400V bridge rectifier, which in turn feeds four 8000-μF capacitors. That well-filtered supply powers the output amplifiers.

The other winding of the torrodial transformer provides a 30 VCT output that is rectified and filtered with 1000 μF capacitors C12 and C13. Separate positive and negative three-terminal regulators, IC9 and IC11, provide fully regulated

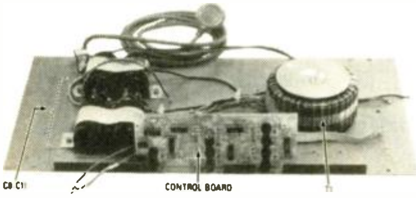

FIG. 9—THE LARGE TOROIDAL TRANSFORMER and filter capacitors provide low-ripple +/−65-volt outputs.

+15V and −15V supplies for the op-amps. As we just stated, D22 provides an isolated positive supply for the op-amps.

The negative supply that feeds the analog switches is derived from the −15-volt supply via a simple resistive divider composed of R30 and R31. We can get away with using that simple scheme since the CMOS IC's draw only about 100 μA of current, and that loads the resistive divider negligibly.

The positive supply must provide more current than the negative supply because the LED's are fed from the positive supply. Hence a 7805 regulator is used. The 220-ohm resistor (R28) between the output and the ground terminals of the regulator has about 23 mA of current flowing through it, and that current in conjunction with the 15 mA flowing out of the ground terminal impresses about three volts across 130-ohm resistor R29. That raises the output of the regulator from five to eight volts. The latter voltage feeds the LED's, and diode D23 isolates that voltage for the CMOS memory circuit.

Standby power

Two nickel-cadmium batteries are used to supply standby power to the CMOS IC's. The batteries provide just enough voltage so that the flip-flops retain their contents when the main power is switched off. Diode D23 ensures that the the LED's don't drain the battery. Note that the minus rail is not powered by the batteries. That is because we are only interested in maintaining power in the logic circuits. Also, when the main power is on, the battery is trickle-charged via R32.

That (finally!) completes the circuit description. Start warming up your soldering iron; next time we'll go on and build an amplifier! **R-E**

OSCILLATOR CIRCUITS

continued from page 66

Amplifier and feedback network

The essential components of a feedback oscillator are, as shown in Fig. 7, an amplifier and a feedback network. The amplifier could be any amplifying device—a transistor, an op-amp, even a tube. The feedback network could be built from various combinations of resistors and components such as capacitors, inductors, and crystals. A purely resistive network is seldom used in an oscillator because a network of that type is not frequency-selective. It might oscillate, but at a frequency we would have little control over.

However, we're getting a little ahead of ourselves. Before getting into the details of circuits and components, we really

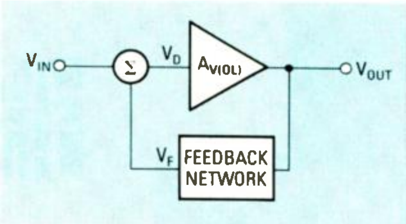

FIG. 7—THE FEEDBACK OSCILLATOR'S gain equations are based on this circuit model.

ought to approach the feedback oscillator from a more theoretical point of view. So let's see what the conditions for oscillation to occur are. We'll do that by deriving the gain equation for the circuit.

Feedback amp math

To begin with, let's simply name a few of the quantities that we'll be working with. Let's call the open-loop gain—the gain that would be obtained with no feedback—of the amplifier $A_{V(OL)}$. Gain when the feedback loop is connected is A_V—and that's the quantity we're trying to find an expression for. The circuit's output voltage is V_{OUT}, and its input voltage is V_{IN}. The output of the feedback network is V_F, and the difference between V_{IN} and V_F is V_D. In other words, $V_D = V_{IN} - V_F$.

The gain, or *transfer function*, of any circuit is simply the ratio of its output voltage to its input voltage. For the amplifier in our model circuit, we would express that relationship as:

$$A_{V(OL)} = \frac{V_{OUT}}{V_D} \quad (1)$$

In other words,

$$V_{OUT} = A_{V(OL)} \times V_D \quad (2)$$

And since the overall gain (A_V) of the circuit can be expressed as:

$$A_V = \frac{V_{OUT}}{V_{IN}} \quad (3)$$

we can substitute the right side of equation (2) into the numerator of equation (3) to obtain:

$$A_V = \frac{V_{OUT}}{V_{IN}} = \frac{A_{V(OL)} \times V_D}{V_{IN}} \quad (4)$$

As we saw above:

$$V_D = V_{IN} - V_F \quad (5)$$

So, rearranging things:

$$V_{IN} = V_D + V_F \quad (6)$$

Now we can substitute the right side of equation (6) into the denominator of equation (4) to arrive at a complete expression of the circuit's gain:

$$A_V = \frac{V_D \times A_{V(OL)}}{V_D + V_F} \quad (7)$$

Now we define a factor B that represents the ratio of feedback voltage to the output voltage:

$$B = \frac{V_F}{V_{OUT}} \quad (8)$$

By rearranging equation (8) we see that:

$$V_F = BV_{OUT} \quad (9)$$

so we can substitute the right side of equation (9) for V_F in equation (7), yielding

$$A_V = \frac{V_D \times A_{V(OL)}}{V_D + BV_{OUT}} \quad (10)$$

Our job is nearly complete; what we want to do is eliminate V_D from the preceding equation. By substituting the right side of equation (2) into equation (10) we see that:

$$A_V = \frac{V_D \times A_{V(OL)}}{V_D + B\,(A_{V(OL)} \times V_D)} \quad (11)$$

That allows us to eliminate V_D:

$$A_V = \frac{A_{V(OL)}}{1 + BA_{V(OL)}} \quad (12)$$

And that's we set out to find. The quantity $B \times A_{V(OL)}$ in the denominator of equation (12) is the *loop gain* of the circuit, and its value is important in determining whether a circuit will oscillate.

A feedback circuit will oscillate if two conditions are met: 1. Loop gain is unity or more, and 2. The feedback signal is in phase with the input signal. Those conditions are known as the *Barkhausen Criteria*. For the feedback signal to be in phase with the input signal we need a total phase shift of 360 degrees. And since a typical amplifier inverts the signal, or provides 180 degrees of phase shift, the feedback network must provide an additional phase shift of 180 degrees. There are many ways of providing that phase shift; next time we'll show how to do it using coils and capacitors. **R-E**

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 across the back of the artwork. That helps make the paper transluscent. 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 probably used to.

We can't tell you exactly how long an exposure time you will need 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. Don't forget the "three C's" of making PC boards—care, cleanliness, and consistency.

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:

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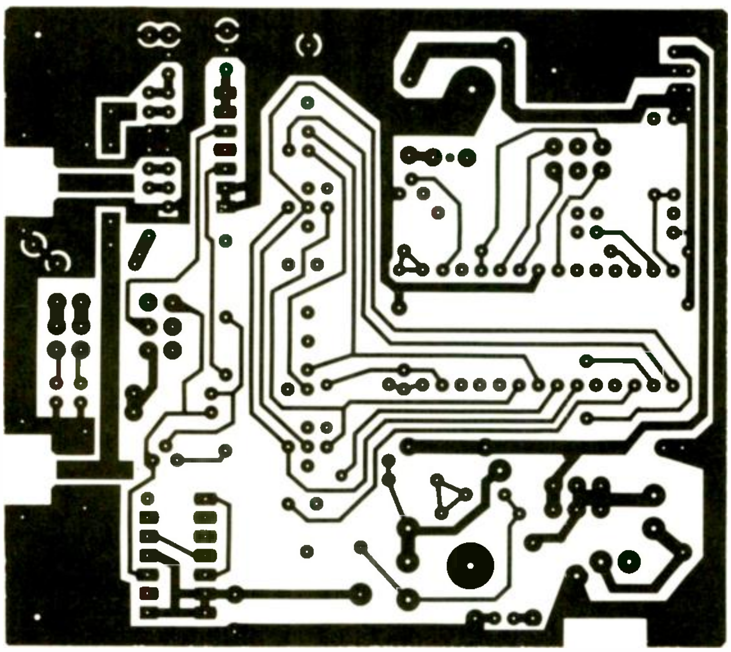

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THE COMPONENT SIDE of the frequency counter board is shown in a full-size mirror image.

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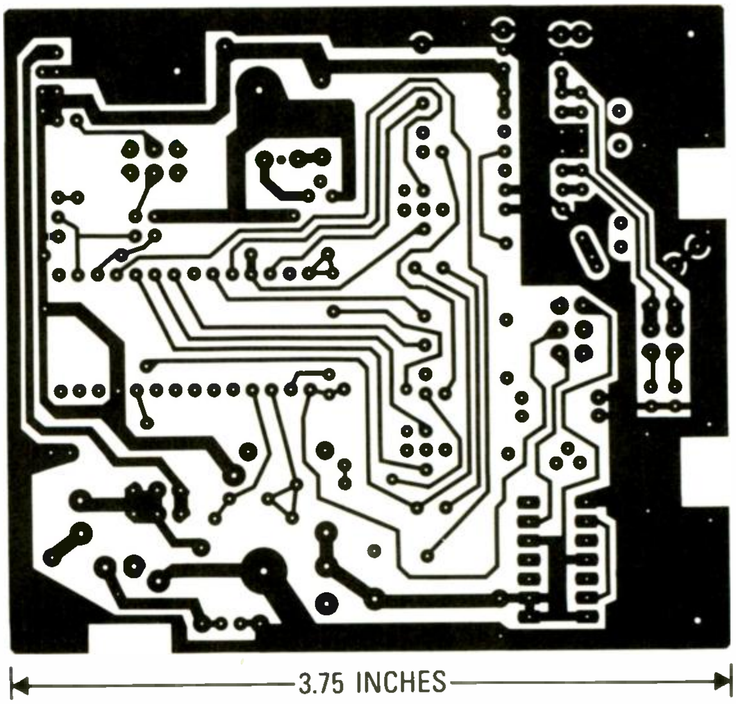

THE DISPLAY SIDE of the frequency counter board in a full-size mirror image.

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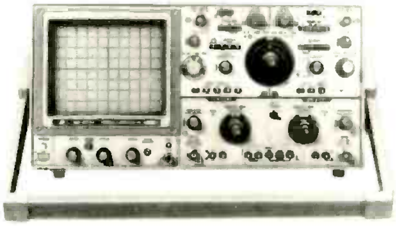

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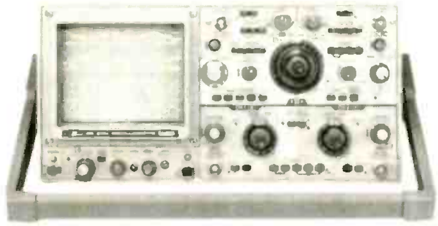

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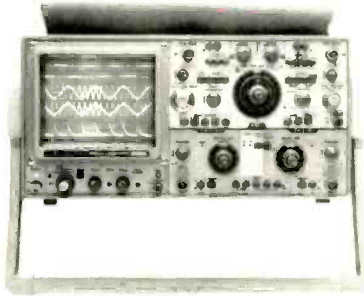

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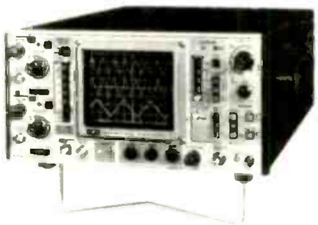

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BOB COOPER, JR.,*
SATELLITE-TV EDITOR

Scrambling woes

THOSE OF YOU WHO HAVE BEEN FOLlowing the ups and downs of the home-TVRO industry are aware that several pieces of legislation are pending before Congress. Little of that legislation is likely to be made into law this year, and, even if it should, little of it seems likely to benefit our industry.

When HBO first announced it planned to start delivering scrambled signals, there was widespread opposition to both plans and planners. M/A-Com, in particular, and other firms were crucial to the distribution of scrambling equipment; those firms have been justly criticized for their lack of preparedness. But before scrambling became official, a then-defiant trade-industry association believed that scrambling would not happen, and that it would not hurt if it did. However, it did happen, and it did hurt—badly.

Many people who hoped that scrambling would never come to pass pinned their hopes on various pieces of legislation introduced early in 1984. Had that legislation passed, it would have delayed scrambling for at least two years, and it might have gotten the FCC involved in the fray as a mediator between the disputing parties—TVRO users and program suppliers.

However, hearings regarding the pending legislation were held in early March of this year, and at least one additional round of hearings is planned. But the congressmen responsible for both the hearings and the legislation see little chance that any legislation will be enacted this year. They acknowledge the strength of the TVRO lobby, but they believe that differences between users and suppliers will sort itself out in the marketplace with no Congressional intervention.

* Editor-in-Chief, *Coop's Satellite Digest*

Satellite	Transponder	Description
G1	12	Request TV
W5	24	The FUN Channel
	24	PPV (The pay-per-view channel)
S1	11	HSN (Hospital satellite network)
	21	BTN (Baptist telecommunications)
	21	VMT (Vanderbilt medical television)
AD1	8	CHCH (Hamilton, Ontario)
	9	WDIV (Detroit NBC affiliate)
	10	WXYZ (Detroit ABC affiliate)
	14	TCTV (Sherbrooke, Quebec)
	18	CITV (Edmonton, Alberta)
	21	WTVS (Detroit PBS affiliate)
	22	BCTV (Vancouver CTV affiliate)
	23	WJBK (Detroit CBS affiliate)
W4	11	CTNA (Catholic telecommunications)

The proposed legislation relates to two largely-unresolved issues: access to scrambled programming, and the price of that access. Access itself is a matter of little dispute. Virtually all cable-programming services have indicated willingness to offer services to TVRO owners.

Monopoly?

Price is a more difficult issue. For example, just what is a fair price for the TVRO owner to pay for HBO? If you subscribe directly from HBO, the price is $12.95 per month. But some cable vendors have been offering services to cable subscribers for $9 to $10, and that is $2 to $4 per month less than the typical *cable* subscriber pays for the same service. And it's interesting to note that, when the dish owner buys directly from HBO, the local cable operator receives a $5 per month "sales commission." In effect, HBO retains $7.95 of the $12.95 collected, the rest is retained by the cable operator.

However, some cable operators have offered HBO to TVRO owners for as little as $6.75 per month. As you might suspect, HBO has tried to put a halt to that sort of price-undercutting. One cable vendor (in Arkansas) offered HBO for a very low price; that company was told that HBO would no longer accept orders from subscribers living outside of the cable operator's county. That effectively shut down the company's national sales effort.

What presently galls the TVRO industry is that, to date, virtually all marketing of descrambling services has been done only by the cable programmers (e.g. HBO), and the cable franchises. But there has been no program marketing by firms involved in the satellite-TV industry. Those firms have cried "foul!" And they have claimed that prices are being set, monopoly-like, by cable-program vendors.

Price is important

Perhaps as many as 20 different program services are now scheduled to scramble their offerings; several are indicated in Table 1. The cost of unscrambling all of those services will amount to a fair piece of change for the consumer because possible incompatibilities between different systems may require different descrambling hardware. Consequently, many people feel that the total monthly charge for descrambling will be so high as to discourage the sale of new home-TVRO systems. In fact, there are indications that there will be 50% fewer systems sold in 1986 than were sold in 1985. The conclusion is that the price of descrambling a number of different, and very possibly incompatible systems is a key factor holding down sales of new systems.

Help from Congress?

Legislation might be able to help TVRO vendors. But key members of Congress show no interest in pushing legislation that attempts to rescue a faltering industry. The attitude, as one member of Congress noted, seems to be: "Adopting legislation to rescue home dishes will ultimately result in more legislation to rescue some other industry. There is no end to this once it starts; the marketplace must sort it out."

The problem is that the marketplace to date has not been doing a very good job of "sorting it out." Dish sales are much worse than a year ago, inventories are excessive, and new models are not being released by manufacturers. The reason is that consumers are delaying purchases until they see who is going to scramble what, when it will be done, how compatible it will be, and how much it will cost.

Things have gotten so bad that Congressman Tauzin of Louisiana, a rare Capitol-Hill proponent of the need for legislation, is predicting that, unless the TVRO industry gets help from federal legislation in six to eight months, the industry may go under. That's not a pretty prospect to say the least; it reminds us of the speed with which the CB-radio market suddenly collapsed some ten years ago under different circumstances.

Hopefully things won't go that route. But, in the interim, we'll continue to examine the growing amount of confusion the program scramblers are creating in the marketplace. **R-E**

Interested in TVRO?

For nearly two years Bob Cooper has provided a no-charge kit of printed materials that describes the challenges of and opportunities in selling TVRO systems today. With the present intense interest in scrambling systems, Coop's *CSD* has made available a new no-charge service.

The SCRAMBLE FAX hotline is a 24-hour-per-day telephone service that provides accurate, detailed, and hard-to-find facts concerning the changeover to scrambling in the satellite communications industry. Information describing satellite receivers tested for scrambling compatibility, sources for authorized descramblers, wholesale rates of scrambling equipment and services—all are provided on the SCRAMBLE FAX hotline. There is no charge for that service, other than your long-distance telephone expenses. Simply dial (305) 771-0575 for a concise and timely three-minute capsule report that covers the latest in scrambling news.

ROBOTICS

MARK J. ROBILLARD,
ROBOTICS EDITOR

Inexpensive robotics arms

YOU DON'T HAVE TO BE INVOLVED WITH robotics for very long to understand that the vast majority of real-world applications involve a mechanical arm of sort sort. However, few affordable arms are available for hobbyist and educational purposes.

For example, at least three companies supply arm systems that are used in education. Those arms cost between one and two thousand dollars; and it is my belief that that's beyond the range of most hobbyists and many small educational institutions.

At the other end of the scale, for several years Radio Shack has been marketing an arm called *Armatron* for less than $30. However, its purely mechanical nature makes it hard to interface to an electrical control system (but see the May 1985 issue of **Radio-Electronics** for one approach.—*Editor*). Until recently, I knew of no other arms in the under-$100 range. Let's look at why there have been no inexpensive robot arms.

What's in an arm?

You might wonder just what makes robot arms so expensive. We are used to electronics devices being aggressively priced—after all, IC's are made of sand! However, robot arms are mostly mechanical, and mechanical linkages require expensive machining. Even inexpensive plastic parts are made from molds that are costly to make.

Motors can also be expensive, but clever design can reduce the number of motors that are required. For example, when you take apart Radio Shack's Armatron (which I highly recommend as an educational exercise), the first thing that strikes you is its lack of motors—there's only one, and it can move six different joints.

The next potentially-expensive items are gears. Most arms (including Radio Shack's) are filled with gears of various sizes and configurations. And rarely can a stock catalog gear perform the desired function; thus gears must be designed and manufactured for each individual application. That makes it hard for hobbyists to find gears that are suitable for building an arm from scratch.

So, if parts are expensive or simply unavailable, how can the robotics hobbyist get an arm to experiment with?

It happens that Milton Bradley has begun marketing a kit, the *Robotix*, that will allow you to build an experimental arm for a surprisingly low price—only $39! The kit consists of a two-fingered manipulator, a rotating base in which the battery supply is located, counterweights, and numerous other parts for construction of arms in various configurations. Each finger comes with two pieces of non-slip rubber for traction.

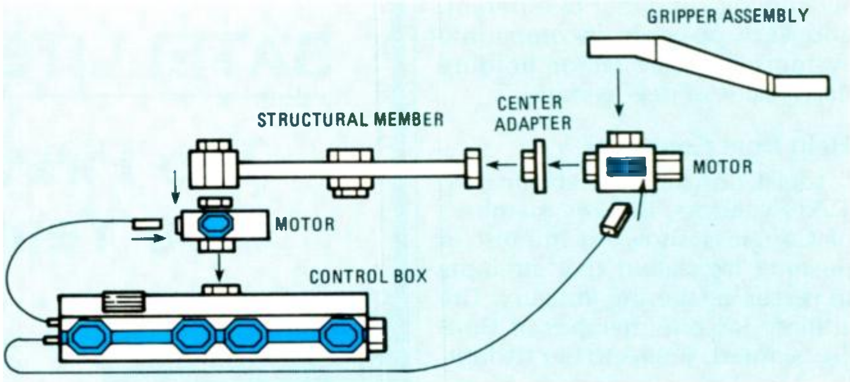


FIG. 1

Two custom-designed motors include complex internal gearing mechanisms, and each motor can produce a torque of 50 inch-ounces. The output shaft of the motor is an octagonal male plug that fits snugly into one of several supplied structural elements. Electrically, the motors are connected to the base through specially designed cables that have easy-to-use two-pin plugs.

To give you an idea of what you can do with the *Robotix*, I built a six-jointed arm from two kits—in seven minutes! It can rotate about the vertical axis, and move at the shoulder, elbow, and wrist; and it incorporates a two-fingered gripper. Vertical-axis rotation allows the arm to transfer a part or object from one area to another along a horizontal arc. For $78, that's impressive!

You could build a simple arm from a single *Robotix* kit by following the illustration in Fig. 1. The arm is not capable of lifting an automobile, but you could use it learn quite a bit about the kinds of problems that robotics designers face. When you master the basics, you can extend the arm's reach by adding another structural member through a supplied coupler. But how do you master the basics?

Arm fundamentals

A device used to transport materials from one place to another is called a transfer mechanism. In its simplest form, a transfer mechanism can be a gripper and a rotary indexing table that allows the robot to grasp an object and place it on the table in another place. A rotary transfer mechanism is probably the ideal way for people on a limited budget to begin investigating robotics arms.

There are many types of grippers. Electromagnets can be used to grip ferrous metals; the advantage of an electromagnet is that it doesn't require much to control it. A small vacuum pump connected through a tube is another possibility. However, grippers with two (or more) fingers are the most common and the most popular because of their versatility.

After you've settled on the basic mechanical configuration, it's time to get the hardware wired up. The *Robotix* motor runs on three volts and draws approximately 170 mA while stalling. A simple relay arrangement (like the one shown in "Building Your Own Robot," **Radio-Electronics**, March 1986, p. 50) can be built that will allow you to reverse motor direction under computer control.

That circuit could be extended to add as many motor controls as are necessary. For simultaneous control of several motors, add an enable circuit and duplicate the direction-control circuit for each motor used.

As for interfacing, there are many brands of personal computers, so we can offer no precise guidelines about specific ways of interfacing a motor-control circuit to particular models. Suffice it to say that you must have some sort of parallel output port. Commodore *VIC's*, *C64's* and *C128's* have a "user port" that can be used. Most other brands of personal computers will require a separate parallel interface card.

Don't expect that you'll be able to use a parallel printer output port. Those ports require handshaking signals that our circuit does not supply.

For you Apple *II* owners, Crabapple Systems (118 Commercial Street, Portland, ME 04101) has a product specifically des gned to drive the *Robotix* motors. For you TRS-80 *Color Computer* fans, MJR Digital (Mason Road, Milford, NH 03055) has a board with connectors that allows direct connection to the *Robotix*; software and experiments are also included.

The real problems begin only after you've got the hardware all hooked up. If you've never attempted to control an electromechanical arm before, I suggest that you start with a simple device before moving on.

One of the first lessons you'll learn is that it's hard to determine how far to move each joint when moving toward an object. There is a tremendous amount of literature available on methods of controlling mechanical arms. Most involve complex mathematics. That's another reason to start with a simple arm.

Anyway, keep in mind that the transfer mechanism moves through space in an arc, so keep the area surrounding the robot free. For a first experiment, try making your arm locate a light plastic block at location *A*. Then the arm should grasp the block and move it to a new location, *B*. Because the simple arm has no capacity for vertical motion, the block must be placed at *A* after the gripper arrives there. Otherwise, the gripper will dislodge the object as the gripper approaches it.

Your control program should flow something like this: First move the arm to *A*, and then open the gripper. Wait for a keypress from the user (that's you) to indicate that the block has been placed between the jaws of the gripper. Close the gripper, and move the arm to *B*. Finally, release the gripper.

Reader request

If you own a Heath *HERO I*, I'd like to hear from you. You don't have to say whether you like it, just that you own one. **R-E**

SERVICE CLINIC

Dead-set servicing

JACK DARR,
SERVICE EDITOR

MANY PEOPLE WONDER WHERE TO start servicing a completely dead TV set. If the circuit-breaker trips as soon as you turn the set on, you've got a "crowbar short" in it. And chances are that it's in the B+ supply. So get out your ohmmeter, locate the B+ section of your chassis, and start hunting.

After you find the B+, unplug the set, discharge all large capacitors, and start measuring the resistance from various points to ground. You should always measure fairly high resistances, at least 50K, or even more. If you do find a resistance of zero (or close to it), you're in the right neighborhood. In fact, the input filter capacitor is probably shorted. But if you measure say 15–20K to ground, the short is somewhere farther down the "B+-string." So continue measuring resistance at other points. Chances are that your problem will be due to a shorted capacitor.

Replacing capacitors

If you replace a shorted high-voltage capacitor, be sure that the replacement has a good margin of safety. For example, if a capacitor normally has 300 volts across it, use a capacitor with a rating of at least 450 volts; 600 volts is better, of course.

If you replace a shorted or leaky capacitor, and your picture improves, but still has problems, the one that you replaced may have set off a chain reaction that affected other components. Remove power and check other components in the vicinity.

A shorted filter capacitor is about the only *simple* thing that can cause the "dead-set" symptom. But if replacing that capacitor doesn't clear up the trouble, and all the nearby components seem to be OK, start checking for other problems. Things like incorrect bias on an audio-output stage or even the horizontal-output stage can wreak havoc. And check all of the high-voltage stages, like the one shown in Fig. 1, for normal operation, because trouble there can disrupt operation severely.

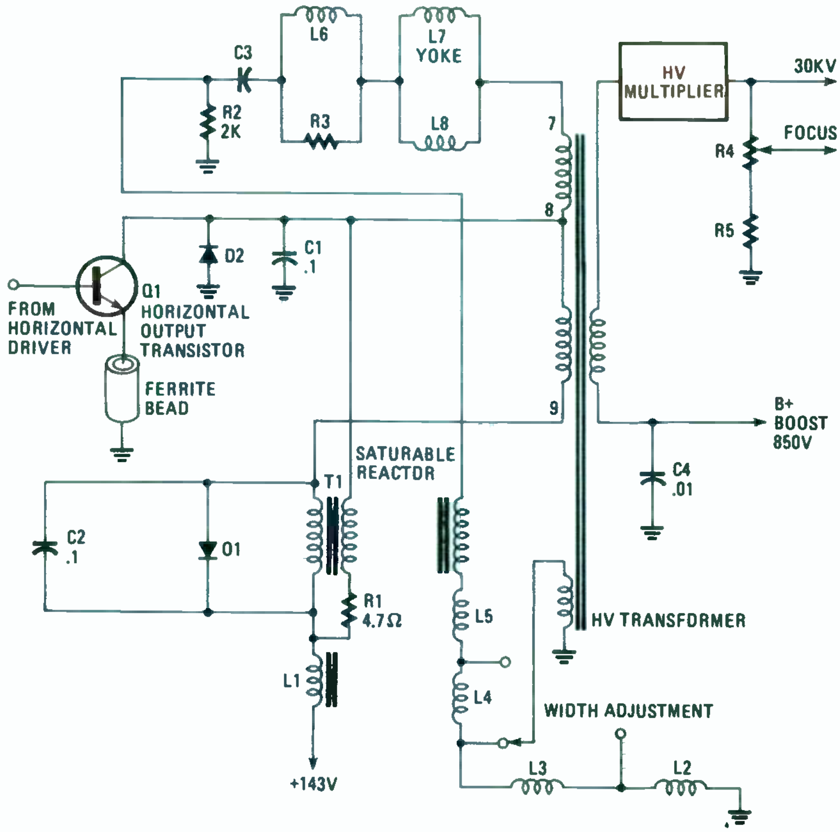


FIG. 1

Of course, a dead set could be caused by other things, too—but have you ever seen *any* problem that couldn't have at least half-a-dozen causes? So check the whole chassis very carefully for something odd—like a solder-blob in the wrong place. I worked on one set that had a dead short somewhere and I just couldn't locate it. Finally I saw a dribble of solder concealed under a terminal point. After removing it, the set worked like a charm.

So when you run into one of those monsters, take up your ohmmeter, set it on its lowest range, and start checking the resistance of the B+ string until you find the troublemaker! **R-E**

SERVICE QUESTIONS

OSCILLATION IN RCA CTC-107

I had several problems with an RCA CTC-107. I replaced the flyback as well as several small transistors in the voltage regulator circuit. Now I have vertical lines on the right side of the screen, and the set interferes with other sets in the vicinity!—T. M., Virgin Islands.

From the sound of it, your set is generating parasitic oscillation somewhere. Scope it out, especially the DC supply lines. Look for any sign of "fuzz" on the signal; that indicates the presence of stray or parasitic oscillation. Check all capacitors; scope the "hot" lead of each and look for fuzz, etc. If the capacitor is open you'll see garbage; there should be none with a good capacitor. Try bridging a suspect capacitor; that should show whether that one is causing the problem.

VOLTAGE PROBLEM

I replaced a blown fuse and the horizontal output transistor in my set, but the transistor still ran hot. The integrated flyback was defective, so I replaced it. But the transistor still runs too warm! What gives?—P. G., Columbia, SC.

I can think of two possible causes. Either the voltage regulator isn't working properly, or the bias on the horizontal output transistor is incorrect. Check both of those and you should solve your problem. You might also check the output drive while you're there.

FRENCH CONNECTION?

I've got a surplus chassis labeled "Morse-Electrophonic 7900." I've been looking for service data on it without any luck. It needs a power transformer with two 12-volt windings and a separate winding for the clock-chip, a 5387AA. The chassis may be Canadian because the back is marked in French.—T. S., Pahrump, NV.

Non, monsieur! Pas de Francais, c'est Americain (by way of the Far East.)! That chassis was used in several brand names. Sams does not show an address for the maker, but they do list several models.

But you don't really need a schematic. Connect an external 12-volt power supply to each of the two supplies and measure the current drain. Now you can substitute a transformer with the appropriate current rating. If you really need a schematic, Sams provides details on several chassis in the 7000 series. Look at those schematics and see if one resembles yours; chances are you'll be able to find one that's close enough. That's what I used to do.

SHORTED FLYBACK?

Thanks for your suggestion about using a reduced line voltage when I was blowing new transistors. That helped a lot, but now I've got a new problem. As you suggested, I put a DC milliammeter across the fuse holder and gradually raised the line voltage. Normal current is 320 mA; at only 45-volts AC I got that much! I measure about 10 KV of HV, but nothing else. Do you think the flyback is the culprit?—H. S., Austin, TX.

I can say this: It certainly could be! If you get some HV, the flyback is trying to work, but it's drawing too much current. That indicates a possible "AC short;" that is, something that doesn't show up in an ohmmeter test, but does show up when the flyback is driven by a normal signal.

Check the flyback with the well-calibrated eyeball. See if any of the smaller windings look dark or discolored. Measure the resistance of all windings, especially the big one. If any has low resistance, look out; that may be the sign of shorted turns, and one is all you need! Digital ohmmeters, which can read as tenths of an ohm, are very handy for that type of measurement.

DC ON CRT HEATER?

Here's one I've always wondered about. Why is there a DC voltage on the CRT's filament?—B. M., Hastings, MI.

Thanks, Bill; that's one question I'm sure of the answer to! DC is applied to the heater of the CRT in order to reduce the stress between the cathode and the heater and to avoid possible heater-cathode shorts. If that happened, the tube would be inoperable. R-E

DRAWING BOARD

ROBERT GROSSBLATT,
CIRCUITS EDITOR

More on memory management

ANYONE WHO HAS EVER BUILT A SYSTEM that uses memory for one thing or another should be familiar with the truth of Grossblatt's Twelfth Law: *There's no such thing as too much memory.*

No matter how much memory you design into your system, it's a foregone conclusion that you'll wind up using all of it, and when you do, you'll start looking for ways to increase it. It's like buying a new house. I know many guys who swore they'd never need more than eight rooms. Two years later they had finished the attic and the basement, and they were eyeballing the garage!

Unfortunately, it takes more than a hammer and some nails to add more memory to an electronics system. And it's slightly difficult to add memory to a system that's already using the full width of its address bus. That's the problem we started talking about at the end of last month's discussion. There are several ways to solve that problem, and each has unique advantages and disadvantages. We'll use the circuit we put together last time to examine one solution; others are certainly possible.

You'll recall that, since we're dealing with 512 bytes of memory space, the address bus is nine bits wide. We use the most significant address bit to select one of two 256-byte banks of memory automatically, and that gives us 512 bytes of continuous memory. Let's assume, for purposes of discussion, that our memory system is managed by a controller that has an eight-bit *data* bus, a nine-bit *address* bus, as well as the usual set of read, write, control, and I/O signals. Given those parameters, let's see what we have to do to add more memory to the circuit.

Memory banking

No matter how you implement the circuit, the basic idea is to "page" or "bank" additional memory into the system. To understand the idea of bank-selecting memory, take a look at Fig. 1. Since our basic system can deal directly with only 512 bytes of memory, each page of memory will have 512 bytes. But in order for us to access different pages, we need a signal that the system can use to generate appropriate page-select signals.

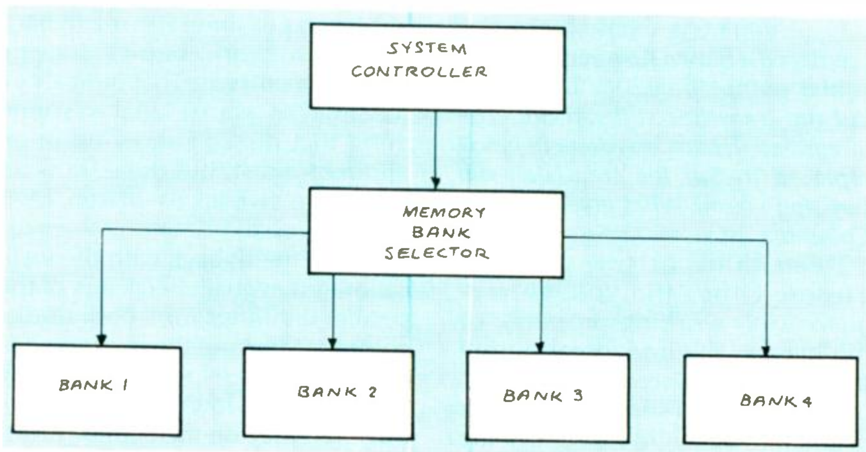


FIG. 1

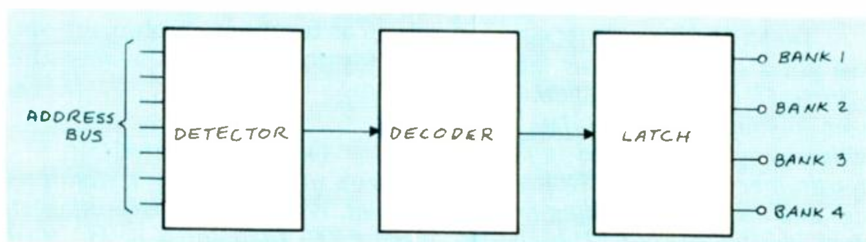


FIG. 2

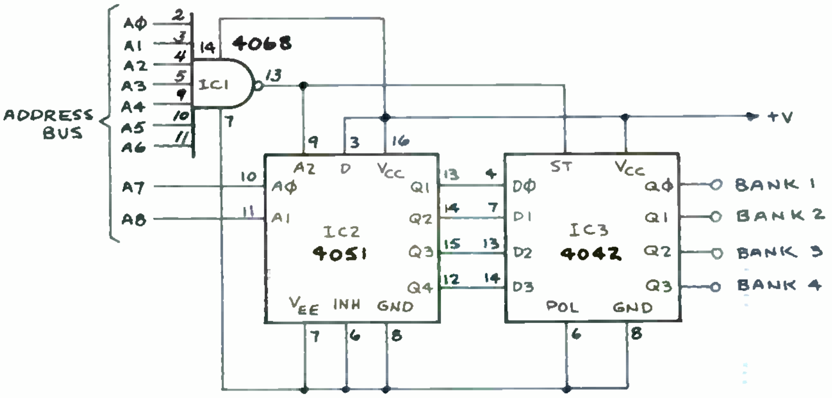
We were faced with the same sort of problem when we assembled the demonstration circuit. This time, however, there's no handy-dandy address line to do the job for us. But, even though we have to look elsewhere for an answer, the problem is basically the same now as it was then. We need some sort of switch to toggle from one page to another.

The whole problem of getting from one bank of memory to another is one that computer designers face all the time. For example, any eight-bit computer that features 128K of memory uses some scheme to switch between two 64K banks.

You could always do the job with mechanical switches, but that's a

ENABLE BANK	ADDRESS	
	HEX	BINARY
1	1FF	1 1111 1111
2	1FE	1 1111 111Φ
3	1FD	1 1111 11Φ1
4	1FC	1 1111 11ΦΦ

a



b

FIG. 3

bit rude and crude. A much better way is to use "soft switches" to do the toggling for us. "Soft switching" is a term that computer people use all the time; it represents a technique that we've used over and over in the circuits we've put together. All it means is that we put a decoder on the address bus and let it watch for a particular address. When that address shows up, the soft switch detects it and changes the state of its output.

As with any other problem in logic design, the first two steps are to decide exactly what you want to do and then to draw a good block diagram of the circuit. So, first, let's say that we want to piggy-back four banks of memory and have our new circuitry select the desired bank by flipping a couple of soft switches.

Second, the block diagram in Fig. 2 indicates the three basic elements we'll need: The *detector* senses the address we're looking for and causes the *decoder* to put out a signal that we can then *latch* to control our system. Now that we know what we need, let's see what we have to do to build it.

The detector is a snap—we've put together many of them during the last few years. You can use anything from a simple gates-only approach to dedicated decoder chips. Since we're just starting to find out how to build and use soft switches, let's take the most straightforward design approach. After we've got the system working, we'll see what we can do to simplify things.

Memory is addressed in our system from 000 to 1FF. We have to pick four addresses to use as our soft-switch locations. In a real-world system there would probably be circuit considerations that would dictate which locations to use. But since we're building our circuit from the ground up, we can pick any addresses we want. Let's take the four highest addresses in the system and define them according to the table shown in Fig. 3-*a*. As you can see, the highest address (1FF) selects the first page, 1FE selects the second page, and so on.

A starting point for the circuit we need is shown in Fig. 3-*b*. Since the four addresses we're looking for are all at the top of memory, the seven most significant lines will all be high when one of those addresses is accessed. That means we can use an eight-input NAND gate as the front end of our circuit. So, any time the NAND gate outputs

continued on page 90

ANTIQUE RADIOS

Tuning "eyes" and AVC

RICHARD D. FITCH,
CONTRIBUTING EDITOR

LAST TIME WE LOOKED AT ONE POPULAR advance in early radio circuits: the automatic tuner. This month we'll take a look at several other, more controversial advances: tuning indicators and Automatic Volume Control (AVC) circuits. If you ever wondered how a "magic-eye" tuning indicator works, or how to troubleshoot one, you'll find our discussion valuable.

The Truetone model *D925*

Our Antique of the Month, made by Western Auto, is a fine-looking radio that incorporates several of the advanced features we'll be discussing. It has a magic-eye tuning indicator and pushbutton tuning, as well as a tone control and the ability to receive shortwave signals. To override the pushbuttons, the spring-loaded tuning knob is pushed in. The seven-tube (not counting the magic eye) superhet uses a type-80 rectifier tube, and it has an IF of 455 kHz.

Automatic tuning devices like that on the Truetone model *D925* did little to hold the cost of a radio down; and cost, in the early 1930's, was of prime consideration to manufacturers. But not all circuit improvements increased cost. In fact, one of the most important advances actually reduced cost in the final analysis. The superheterodyne circuit reduced interference and improved reception to such an extent that pounds of shielding could be eliminated.

During World War I, many engineers worked on the superheterodyne circuit, which was first patented by Major Armstrong after the war. Because of patent-right contention, superhet sets didn't really become widely available until the early 1930's. However, as late as 1940, TRF (*T*uned *R*adio *F*requency) receivers were still being built. But long before patent restrictions were eased, hobbyists began converting their sets from information published in radio magazines. If you come across one of those altered sets, you'll never be able to track down an accurate schematic.

FIG. 1

Along with circuit refinements like the superhet, accessories like tuning indicators became popular. The tuning aids we'll discuss were, in a sense, a spin-off of AVC circuits. Of course, if a set was properly aligned, and if the dial pointer was set accurately, you could tune stations in with few problems. But manufacturers thought that it would be a good idea to provide a *visible* indication of tuning status.

The magic eye was one popular tuning indicator. It is a tube-like device that mounts in a socket similar to a panel-light socket. A metal bracket holds the tuning eye and the socket so that the top of the tube is visible through the front of the cabinet. A fluorescent coating and a "shadow" indicate relative signal strength. The smaller the shadow, and the larger the fluorescent area, the better a station is tuned in. A tuning eye was often considered as just another of the set's tubes, so it was tested with the other tubes when a service man repaired a set.

The magic eye is similar to a dual-triode tube that has a common cathode. One triode is connected to the set's AVC circuit; it determines the brightness with which the fluorescent part illuminates. The other triode is really the indicator; its plate is the fluorescent target, and its grid, which is controlled indirectly by the other triode, is what actually determines brightness.

The eye works as follows. When a signal is *not* tuned in, the AVC voltage will be very positive. That will decrease the current flow through the second triode, so the "shadow" area of the fluorescent screen will increase. But as a station is tuned in, AVC voltage decreases, so more current flows, so the illuminated area increases.

Tuning-eye troubleshooting

Problems with the eye shouldn't be difficult to diagnose, especially if you have an antique tube tester like my NRI model *70*. First test the regular triode section of the tube with the usual short and emission tests. Then check the eye section; but watch the fluorescent screen, not the meter, while making the test. Without the tube tester, only a limited continuity test can be done. If the tube tests OK, there's a good chance you've got a problem in the AVC circuit.

If your radio produces no audio, but the tuning eye still appears to operate, your set's RF stages are probably in working order. The problem is probably in the audio output stage or in a speaker. If the set is dead and the eye has a red glow, you probably have a defective power supply.

You might be baffled by a receiver that works OK, but whose eye doesn't close, especially if the eye and the AVC check out. In that case, the problem may be a resistor connected to the fluorescent plate. That resistor may be located *in* the socket of the tuning eye. Remove the eye from its socket, and carefully pry the socket open with a small screwdriver. Measure the resistor and replace it if necessary. It'll probably be a high-valued unit—100,000 ohms or so.

Other tuning indicators

In the late 1920's there were a dozen or more different kinds of tuning indicators, including a not-too-popular tuning meter. Such meters have fancy escutcheons and make fine collectables. As a station was tuned in, the pointer would swing to the right. There is also an indicator that makes an audible sound when the station isn't tuned in properly.

A popular tuning indicator in the 1930's was the *Shadowgraph,* used on Philco and other sets. By opening its case, it becomes obvious that it's really a meter-type tuning indicator. The moving vane serves to obscure light emanating from a pilot lamp inside the meter. The movement of the vane is controlled by the AVC. As the vane moves, it changes the size of the shadow from the pilot light; that shadow is then imposed on a celluloid screen. The screen is visible on the front panel, and, as with the magic eye, the smaller the shadow, the better the signal. Here's a few hints on *Shadowgraph* troubleshooting.

If the screen is completely dark, first check the pilot lamp. If the lamp is good but the shadow doesn't change when tuning, check the AVC. If that checks out, you may have to open the case to examine the meter movement.

Tuning indicators went hand-in-hand with AVC. But so far we've been talking about AVC circuitry as if it came into existence with no birth pains at all. However, that's not the case; let's see why.

The birth of AVC

In the 1920's there was much debate in radio circles concerning the merits of AVC versus its cost. Was the added cost of an extra tube, an extra socket, a tuning indicator of some sort, and other parts worth it just to get a receiver that didn't blast or fade? As we'll see below, AVC helped to sell radios; but even so it took patience to tune in a station while watching an indicator. Later, many listeners tired of watching the tuning indicator just to be able to see what their ears were already hearing.

Most people who thought that AVC was unjustified lived in areas of good reception. Also, they attached little importance to the popular hobby of DX'ing. And they thought that programming on distant stations wasn't high quality. They were often, but not always, right. Programs originating from independent stations sometimes were amateurish, as those stations couldn't afford to hire the best entertainers.

However, even people in good signal areas sometimes suffered the effects of interference. For example, if a receiver had an antenna tuner or a loop-operated superhet, any nearby radio could be overloaded by a deafening squeal.

Those in favor of AVC usually wanted to—or could only—listen to distant stations. Not all receivers were located in the shadow of the transmitter. Also, by that time, consumer radios had to be simple to operate. Housewives, shopkeepers, and other workers wanted to listen to their radios while going about their daily routine. Having to make frequent volume adjustments was a nuisance to them as it interfered with their tasks.

Audio amplifiers

After the RF and AVC stages comes the audio amplifier. Many designs were popular, but an interesting one is the push-pull amplifier, which was popular in larger, more expensive antique radios. The push-pull amplifier is also called a balanced amplifier. It has two tubes that are operated 180 degrees out of phase with each other. In other words, one tube amplifies the positive, and the other, the negative, half-cycle of a signal.

The grids of the two tubes are connected to opposite ends of the secondary of the input transformer. The plates of those tubes are connected to opposite ends of the primary winding of the output transformer. Both transformers have center taps that are connected to AC ground.

The pentode

In the past we've discussed the origin of the diode and the triode. The screen-grid tube has also been mentioned. Now let's talk about the pentode, which was announced in the early months of 1930 by the CeCo manufacturing company. Of course, it's called a pentode because it has five elements including a cathode and a plate like a diode, a control grid like a triode, and a screen grid for the plate like a tetrode. CeCo's innovation was to add a screen grid between the cathode and the control grid.

CeCo said its five-element tube was three times as powerful as the screen-grid tube. That proclamation brought much criticism from other radio manufacturers, despite promises to share advances and circuit designs. Critics said that tube sales were already low and that a new tube was unneeded at the time. They also said that the pentode wasn't really new, as it was already in use in Europe, especially in England.

Furthermore, it was unclear how the pentode could be used. However, CeCo engineers said that the more powerful pentode would increase tube sales because radios could be made with fewer tubes; thus, radios would cost less, and more people would buy them—by the millions! And that, of course, would increase tube sales.

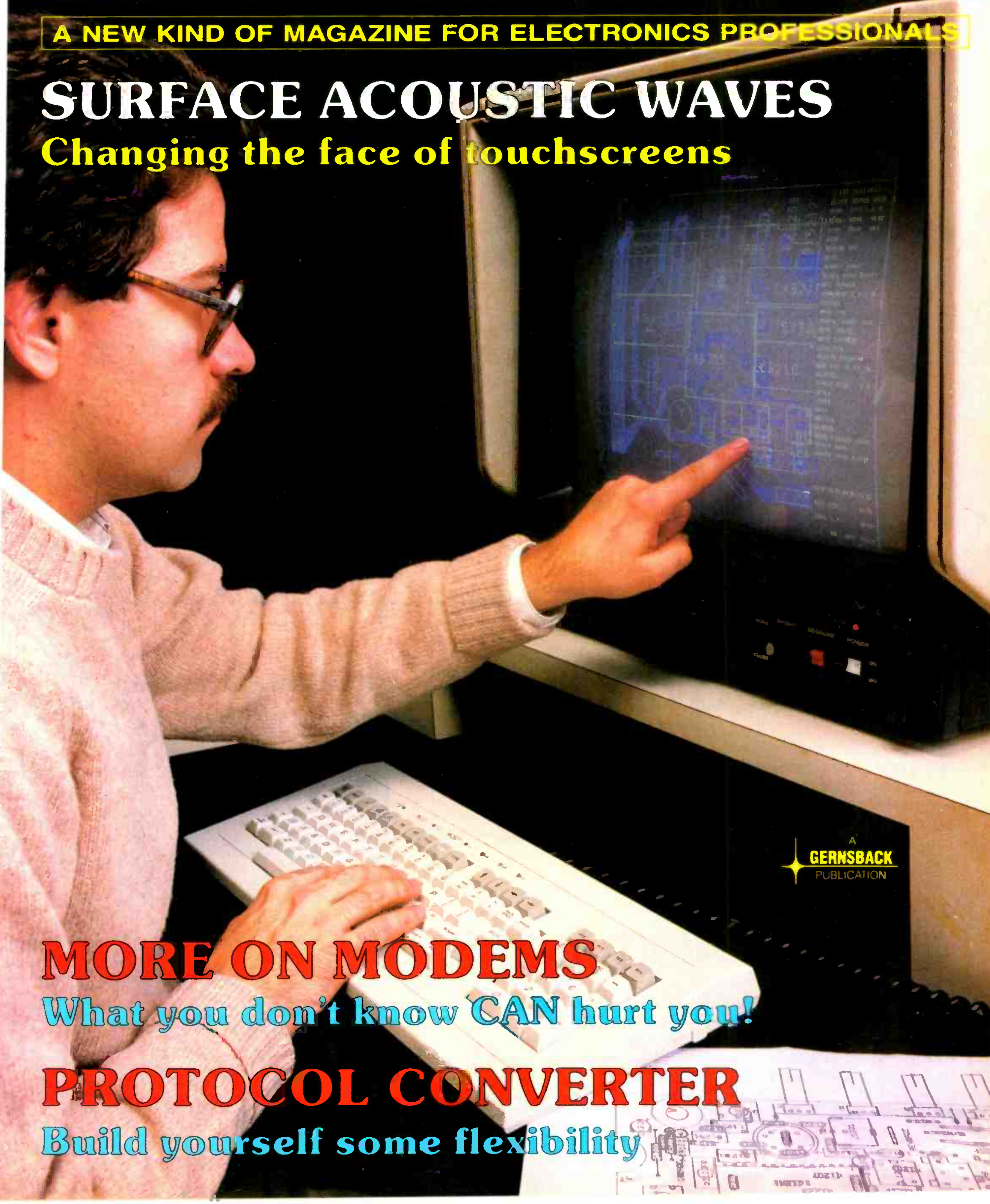
Of course, the pentode *did* survive. By the end of 1930 several pentodes were available: the 238 and the 247. The original pentode was probably made from a 24 screen-grid tube, a tetrode. Using the same base and envelope, the extra grid was attached to a terminal on the side of the tube base, instead of adding another prong to the tube base. In later designs, the suppressor grid was usually connected to the tube's cathode internally.

Hobbyists and other experimenters were quick to purchase the new tubes from the mail-order houses. Again, they were guided by information and circuits in the radio magazines. It's unlikely that you'll find any of those early pentodes around. If you do, consider yourself lucky. **R-E**

COMPUTER DIGEST

VOL. 3 NO. 7 JULY 1986

A NEW KIND OF MAGAZINE FOR ELECTRONICS PROFESSIONALS



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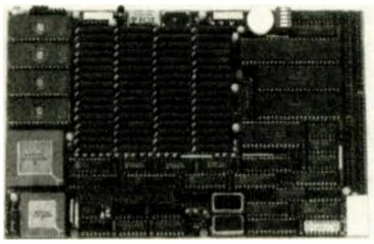
SINGLE-BOARD COMPUTER, the model *GMX Micro-20,* combines a Motorola MC687020 32-bit microprocessor and an optional MC68881 floating-point coprocessor with 2 megabytes of 32-bit wide RAM, up to 256 kilobytes of 32-bit wide EPROM, four serial ports, an 8-bit parallel port, a 5.25" floppy disk controller, a SASI peripheral interface, and a clock with battery backup. 16-bit expansion connector allows the addition of off-the-shelf or custom I/O interfaces.

The board, measuring 8.8" × 5.75", mounts on and uses the same power connector and supply voltages as a standard 5.25" disk drive. Power requirements are +5-volts DC at 4.5A max., and +12-volts DC at 125Ma. A



CIRCLE 12 ON FREE INFORMATION CARD.

separate board, included with the model *GMX Micro-20,* provides RS-232 level translation, and 4 DB-25 type connectors for the serial ports. A DC-to-DC converter supplies the −12 volts.

The model *GMX-Micro-20* is priced at $27.50.—**GMX, Inc.,** 1337 West 37th Place, Chicago, IL 60609.

WORD-PROCESSING SYSTEM, is an enhanced version of Timeworks Inc., *Word Writer 128* program for the Commodore *128* computer.

The upgraded *Word Writer 128,* an 80-column professional word-processing system for home and business use, works in C-128 (128k) mode with either a 40- or 80-column monitor. Additional features now include On-screen highlighting, right-margin justification, superscript and subscript, headers and footers, and speed keys for more experienced users.

On-screen highlighting allows the printer to underline, italicize, boldface, or use all three together at the press of a key. It also allows the user to see each highlight on-screen before hard copy is printed. *Superscript and subscript* displays and prints numbers in superscript or subscript for fast footnote references. *Headers and footers* displays

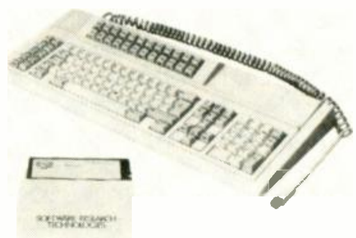
CIRCLE 13 ON FREE INFORMATION CARD.

and prints headers and footers throughout the user's document, as commanded. *Speed keys* let the user access *Word Writer* commands quickly, using a minimum of keystrokes.

The *Word Writer 128* already includes an 85,000 word-spelling checker, a built-in 5-function calculator, "pull-down" menu technology, and a full-screen format. It can be used by itself, or interfaced with Timeworks *Data Manager 128, Swiftcalc 128,* and *Sylvia Porter's Personal Financial Planner.* Each of those programs carry a $69.95 retail price. Backup disks are available for Timeworks' registered users for $14.70.—**Timeworks,** 444 Lake Cook Road, Deerfield, IL 60015.

ENHANCED KEYBOARD, *Style 3270,* has 126 keys and is designed to go with *SmartKey* 5.0 Keyboard Enhancement software.

The *SmartKey* software allows the user to redefine the keyboard for specific needs. It also defines special 24 function keys to the user's use and simplifies complex commands by defining single key macros.



CIRCLE 14 ON FREE INFORMATION CARD.

The *Style 3270* keyboard is PC compatible. It sends IBM PC synchronous format and responds to handshake and reset signals from the IBM PC and XT. Additional features include: Cherry MX full travel gold crossbar contact configuration key module; full N-key rollover with auto-repeat and chassis ground.

The unit is 1.133" from enclosure base to center point at home row-keycap top. It also has keyboard micro with 16-deep FIFO and scanning phase in the event that FIFO is filled.

The *Style 3270* enhanced keyboard is priced at $195.00. With *SmartKey* software included, the price is $245.00 complete.—**Cherry Electrical Products Corp.,** 3600 Sunset Avenue, Waukegan, IL 60087.

MORE ON MODEMS

When your modem won't talk...

Herb Friedman

■A modem is the easiest peripheral to interface with a personal computer. You simply connect them together through matching plugs and everything works. But theory falls down before practice when the software becomes sophisticated, or a manufacturer has taken short cuts and left out circuits because "the average user probably won't ever need them." Unfortunately, it often works out that the circuit, wire, or signal indicator that's "missing" or unconnected is the one that's required by your software or the computer itself.

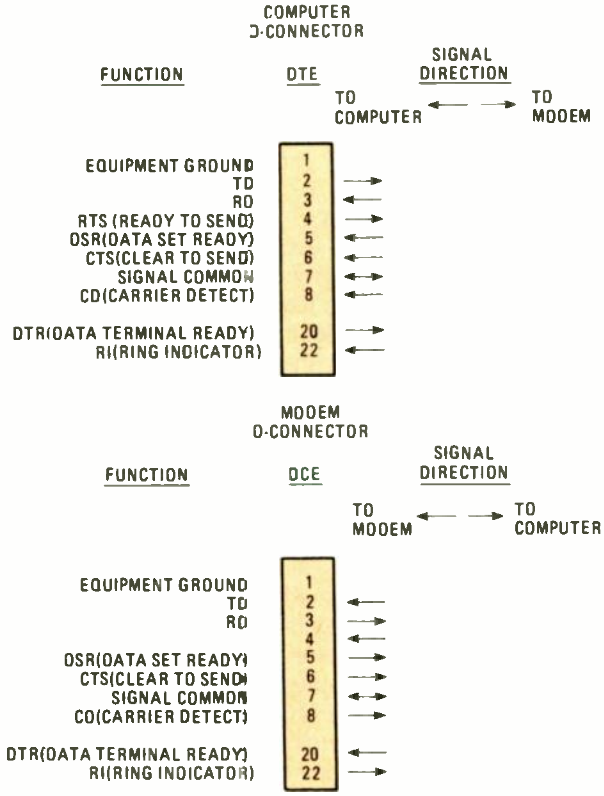
Although virtually all conventional RS-232 I/O modems utilize the 25 terminal subminiature D-connector, it takes only three connections from your computer to its modem to establish communications using a non-automatic modem. At the computer itself these connections are usually labled as TD (transmit), RD (receive), and "common," which is always terminal #7. Although there is supposedly a "standard," TD can be terminals 2 or 3, and RD can be terminals 3 or 2. (Some manufacturers use Tx for RD and Rx for TD—and don't ask why.)

Much mumbo-jumbo has gone into describing the TD and RD connections because the original RS-232 "standard" was murky on the subject. When connecting a personal computer to a modem it's easy to keep track by remembering that TD, or transmit, means the *output* signal *from* the computer, while RD means the *input* signal *to* the computer. Unfortunately, you will find the modem's connections are probably also labled TD and RD, so what do the connections represent at the modem? Whether at the computer or the modem TD means the computer's output signal and RD means the computer's input signal; connect the computer's TD terminal to the modem's TD terminal and the computer's RD terminal to the modem's RD terminal.

Straight-across wiring

If a computer's RS-232 I/O connections are intended for connection to a modem the wiring order of the connections is called DTE and will be what is called "straight across," meaning computer terminal #2 connects to modem terminal #2, computer terminal #3 connects to modem terminal #3, etc.

The problem comes in when the computer's serial I/O has connections intended for a printer, the so-called DCE wiring order. The functions of DCE terminals #2 and #3, among others, are reversed; if you connect



NOTE: THE RTS HANDSHAKE IS RARELY USED WITH ASYNCHRONOUS MODEMS

FIG. 1—ALTHOUGH THE DTE AND DCE wiring order uses the same descriptive terms for the functions, the signal direction is completely opposite.

DCE computer terminals "straight across" to the modem nothing will happen because neither the computer nor modem will know what's going on. The way out of the DCE/DTE bind (if you don't know what goes where) is to match the TD and RD terminals on the computer to the modem, which means "crossing" the connections, that is, connecting DCE computer terminal #2 to modem terminal #3 and computer terminal #3 to modem terminal #2. Make a copy of Figure 1, which shows the differences between the DCE and DTE wiring order for RS-232 D-connectors.

Modem communications would be simple if all you had to do was match the TD and RD connections, and, this is all you have to do with an acoustic modem, where you dial up the remote computer and place the telephone's handset in a pair of cups on the modem. But much modern software, and some modems, won't work with such a simple connection because they require some form of electrical "handshaking," meaning an electrical signal that informs either the modem, the computer, or both that the other device is ready to receive data. Depending on the particular software used, handshaking might be required from both acoustic and direct-connect modems—the kind that's "permanently" connected to the telephone line: and handshaking is generally needed when using an *automodem*—the kind that can automatically answer a call or dial out. For example, to prevent an automodem from answering every ring they are generally designed—or programmed by a switch—not to go "on-line" until a DTR (DATA TERMINAL READY) "handshake" is received from the computer, the DTR being a digital "high" that tells the modem that the terminal is ready to send and receive: it is usually provided by a terminal or computer's DTE wiring order on terminal #20.

Handshaking

Software intended for use with an automodem looks for a handshake from the modem that indicates the modem is turned on and ready, unfortunately, unlike the computer's DTR handshake there is no real standard for the "modem ready" handshake. Many modems create three handshakes, and only one, two, or the full three might be required by the communications software. To make certain the software receives what it considers to be a "correct" handshake the modem might internally connect several terminals on the connector so that a single modem handshake appears on the D-connector as two or three handshakes, forcing the computer to "see" the required handshake.

A modem usually outputs a "high" DSR (DATA SET READY) signal on terminal #5 when power is applied. This tells both the computer and its software that the modem is "ready for use." (Note that this is the equivalent of the DTR terminal #20 handshake signal from the computer; it's one of the connections you might have to cross-wire.)

Another modem handshake is the CTS (CLEAR TO SEND) "high" from terminal #6. This handshake can be used for just about anything, but for personal computers it is often combined with the CARRIER DETECT (CD) "high" from terminal #8 by a simple shorting wire.

The CARRIER DETECT is the handshake that modern communications software is looking for because the CD "high" is generated only when the modem senses the "carrier tone" produced by the modem at the remote computer. Because reception of a carrier means the modem is actually "talking" to the remote computer, the CD "high" is often used as the "master handshake" for the computer, so it is often internally connected within the modem and also appears as the CTS (CLEAR TO SEND). If a carrier tone isn't being received the modem isn't talking to the remote computer, hence, it is not clear for sending data from the computer. (There really is a logic to all RS-232 connections when they concern a computer and a modem—not a printer.)

If the software is only looking for a "modem ready" handshake it might check only the the CTS and CD handshakes. However, some software intended for use with automodems won't do anything until is "sees" the DSR (DATA SET READY) handshake, the reason being that the software automatically downloads programming for the auto-modem's internal microprocessor, forces the modem to go "on-line," and causes the modem to dial only when the software sees through the DSR handshake that the modem is actually turned on. After dialing, the modem will time-out reception of the CD handshake. If it doesn't receive a CD handshake within a specified time period it will disconnect the modem or disconnect and redial.

Although software can force a Hayes-compatible automodem to go off line by transmitting a command code such as ATH0 (meaning the modem should go "on hook"), some software causes an automodem to disconnect by forcing the computer's DTR handshake "low." The modem sees the low, assumes the computer is turned off, and drops off the line. But a problem can arise when using the DTR to disconnect the modem from the telephone line because not all software and/or computers support (provide) the DTR, and not all modems which claim to be Hayes-compatible respond to the DTR; they go disconnect from the telephone line only if a direct ATH0 command is received from the computer. If either the computer or the modem don't support the DTR, and the software—or the user cannot provide an ATH0 command—the modem literally gets "stuck" and won't disconnect unless its power supply is physically turned off.

Handshake signals always appear at the same modem terminals if the modem employs a conventional 25 terminal D-connector. (The D-connector is only a general "standard" for convenience; some manufacturers of external modems employ proprietary connectors.) D-connections at the modem are always DCE and are wired as shown in Figure 1. On the other hand, computers can have either a DTE or DCE wiring order. If they are DTE the connectors are wired, as previously mentioned, "straight across." But if the computer's serial I/O is wired DCE then several wires—not just the signal pair—must be crossed if full handshaking is to be attained. Your computer or the software might not require all the handshakes provided by the modem. If all the software wants is a "modem ready" handshake before it transmits data, then just the DSR—meaning modem power is on—would be adequate, although the CD is preferred because then the software knows for certain that it is linked up with another computer. There is much software around that appears to go on-line when it's actually working into an unconnected modem because the software is responding to the DSR handshake, which only means the modem is powered—that's all.

If it still won't work

If everything is connected together and the modem still won't work with the computer, doublecheck the modem's DSR and CTS terminal connections. Somewhere along the line the DSR and CTS got tangled and the Hayes and some Hayes-compatible modems combine the DSR and CD handshakes, using the CTS as the "power on" handshake. It makes no difference whether DSR or CTS is connected to the CD, but *usually* doesn't mean *always*.

Finally, there is the modem's RI (RING INDICATOR) handshake on DCE terminal 22, which is intended for use by software that controls automodems. The RI is a "high" that indicates a telephone is ringing; it causes the software to force the modem to go "off hook" (to connect to the telephone line).

As a general rule of thumb, the more sophisticated the software the greater its use of handshaking with the modem, so when you can't get a computer to talk to its modem check that the various signal and handshakes go to the right terminals on both the modem and the computer before you start looking for glitches in the software. More often than not the problem is usually one or more "reversed" connections.

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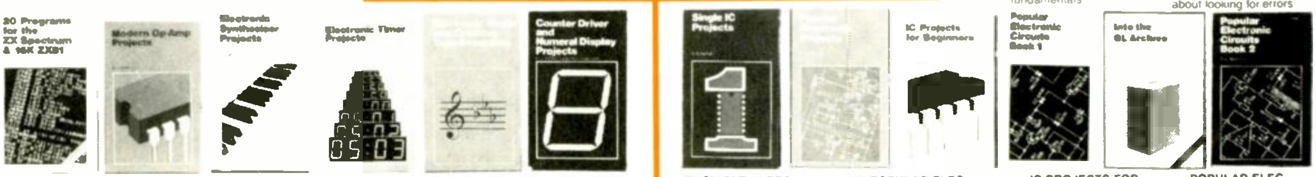

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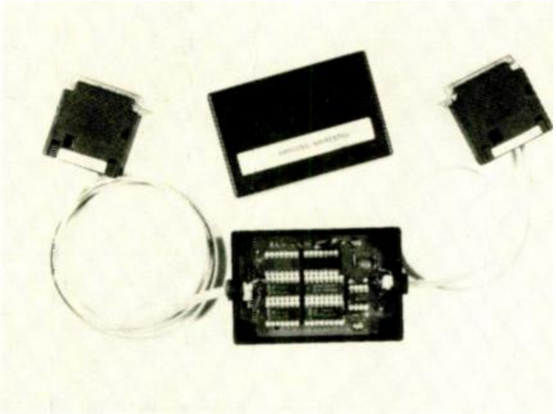
PROTOCOL CONVERTER

Allow X-on/X-off devices to interact with lead-control devices.

R. L. L. Hu

■When physical differences exist between devices, special adapters and interface converters can resolve the problems of electrical and mechanical interconnection (for example, interfacing between RS232 and RS422 circuits which differ in signal level and connector size). However, when logical differences exist, then a protocol or code converter is required. Protocol and code converters are used in situations where communication between devices cannot proceed due to lack of comprehension of each other's data. They "bridge the gap" for differences in transmission mode, transmission code, communications protocol, etc.

This article describes a protocol converter that will allow RS232 asynchronous terminals or CPU's which operate in X-on/X-off (also called DC1/DC3, Control-Q/Control-S) protocol to communicate with devices that use RS232 lead control for handshaking (e.g. RTS, CTS). Specifically, this project was developed to run a serial printer with hardware-busy handshake from an RS232 port which supported only X-on/X-off software handshake. The use of this converter has freed the host program from all timing considerations (insertion of delays or filler characters), and results in faster and



THE COMPLETED CONVERTER, ready to use. Considering the massive task it performs, it requires very little space and even less attention.

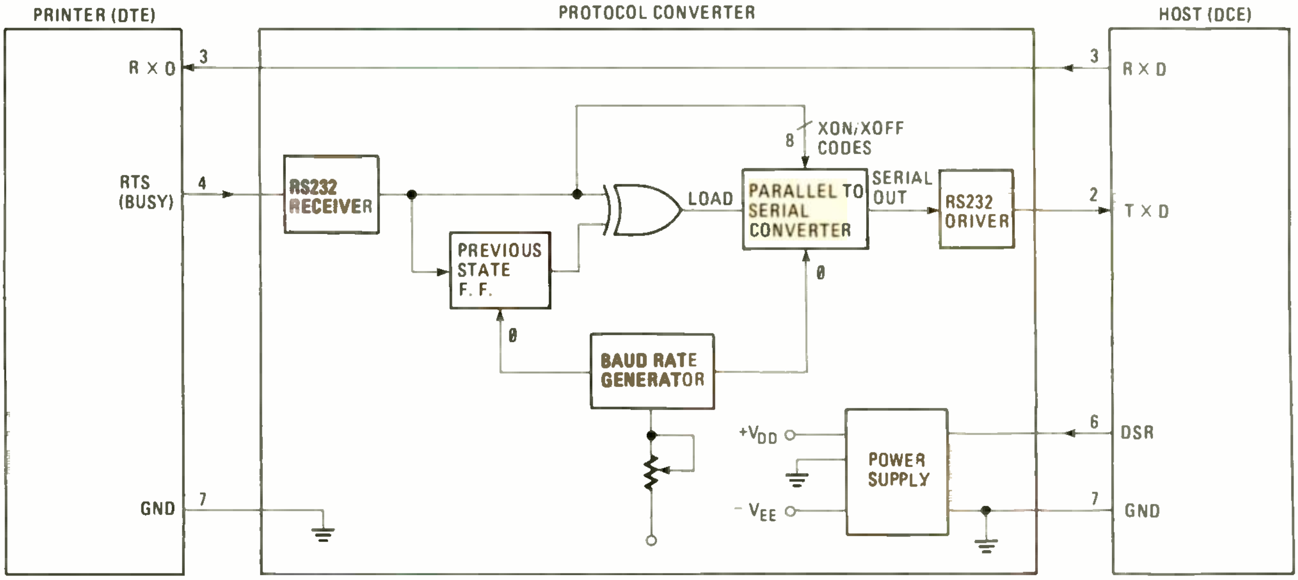


FIG. 1—BLOCK DIAGRAM provides an easy means to overview the circuit and gain sufficient grasp to make it easy to understand. See text.

more reliable operation. Notable features of this project are that it is powered by the RS232 signal lines and it does not even use a UART or ACIA chip! The whole circuit is built using standard digital CMOS chips.

Description

First, a quick overview, using host-to-printer interface as an example of the X-on/X-off protocol in operation. The printer keeps track of how many characters are in its buffer and signals the host when it can and cannot accept more data. When the printer buffer is almost full, the printer sends the host an X-off character to stop the data transmission. Meanwhile, the printer continues to print the data in its buffer. When the buffer content is reduced below a certain threshold, the printer sends the host an X-on character to resume the data transmission. Thus, during normal printing, the printer buffer is kept nearly full by the host, resulting in maximum throughput on the printer.

Refer to the block diagram in Figure 1 to see how this

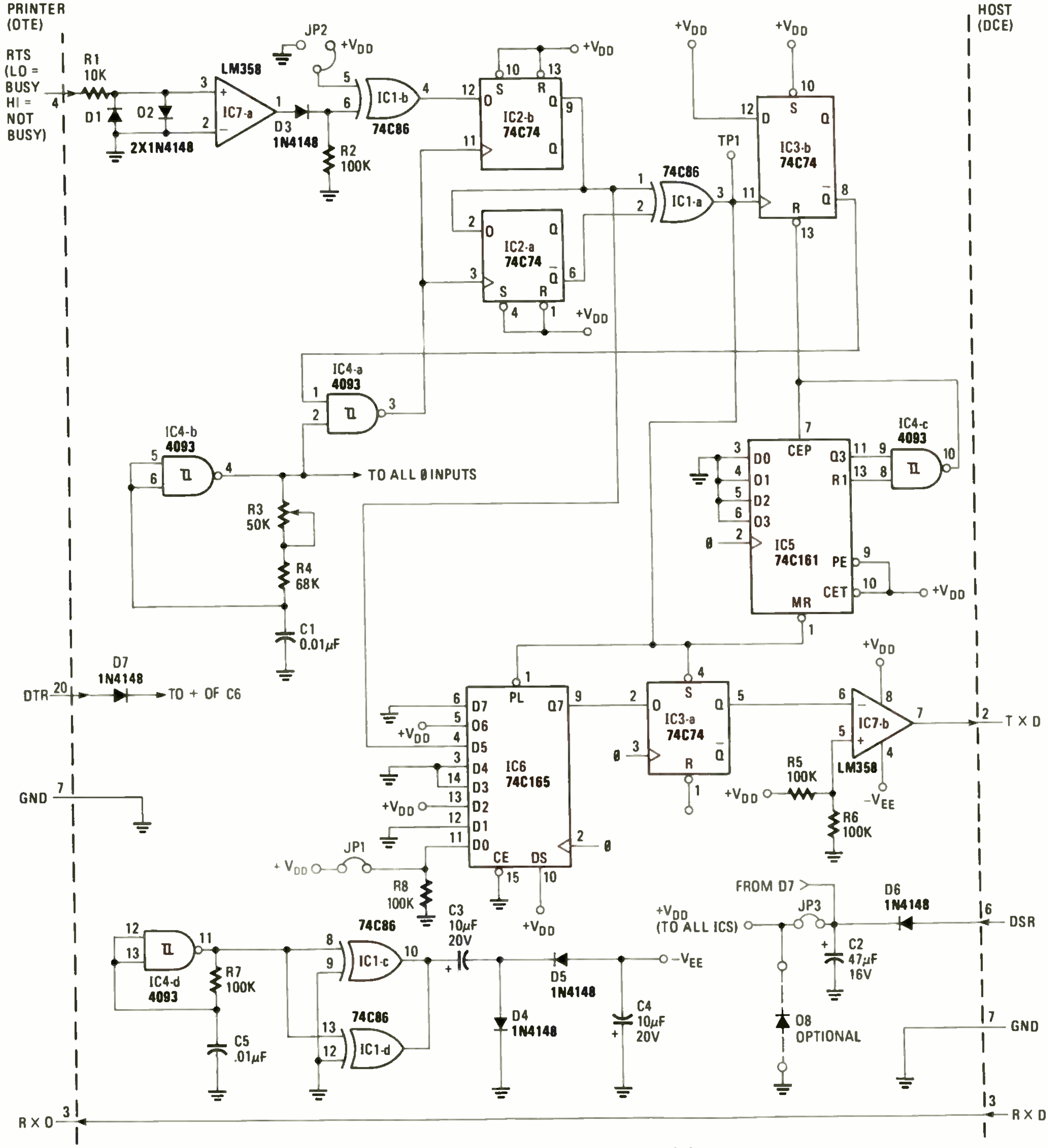
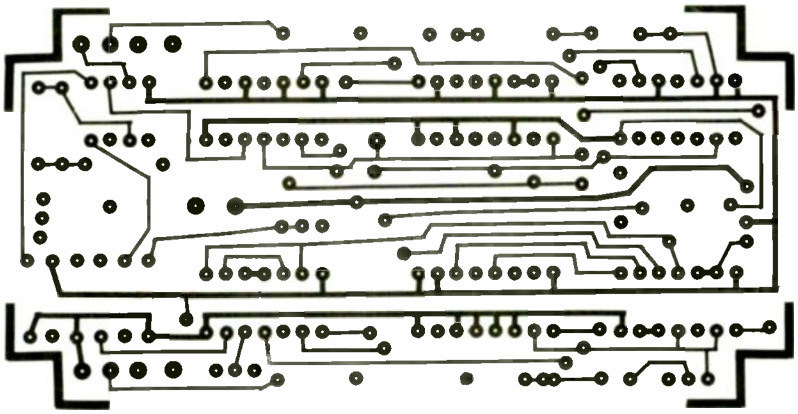


FIG. 2—SCHEMATIC DIAGRAM of converter. Note that the printer side is shown at left, the HOST at right. Text will clarify the schematic for you.

is accomplished in the converter. Serial data from the host is passed directly to the printer. The BUSY line from the printer is, however, first fed to the converter. The converter then sends the appropriate control code to the host unit, but only when there has been a change in the BUSY line state. The changes in states are detected by "remembering" the previous BUSY state and comparing it with the present BUSY state.

Now look at the schematic diagram, Figure 2, for the following detailed description. The power for this converter is derived from an active RS232 control line, the usual choices being DSR or DTR. D4, D5 and C3, C4 form a voltage inverter which is powered by the oscillator/driver combination of IC4d and IC1c and d. This generated negative supply voltage is used by the op amp IC7b, to drive the RS232 line to the host.

The baud rate clock is built using a Schmitt Trigger, IC4, making possible a simple and reliable oscillator with only a resistor and a capacitor. This eliminates the need for the more-expensive crystal and baud-rate generator chip. The baud rate clock was set to run at 2400Hz (2400 baud) in the prototype unit. This baud rate can be changed by using different values for R4 and C1. Just make sure to set the same baud rate on the



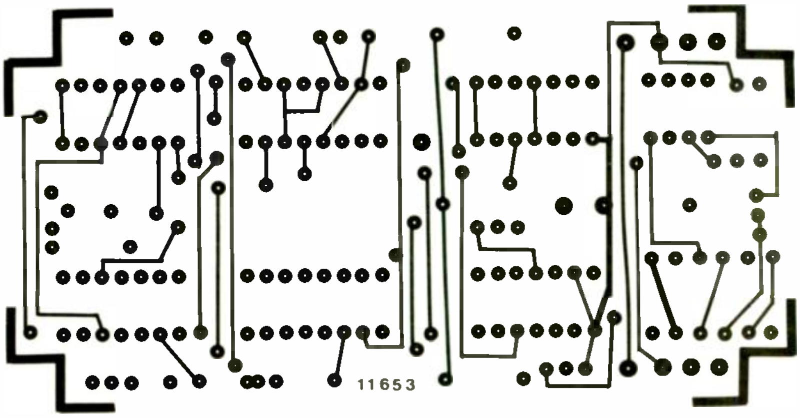


FIG. 3—THE PC BOARD is shown above (solder side, component side to left) full size for those who desire to fabricate their own boards. See parts list for name and address of source for completed circuit boards. Solder side is above, component side to the left.

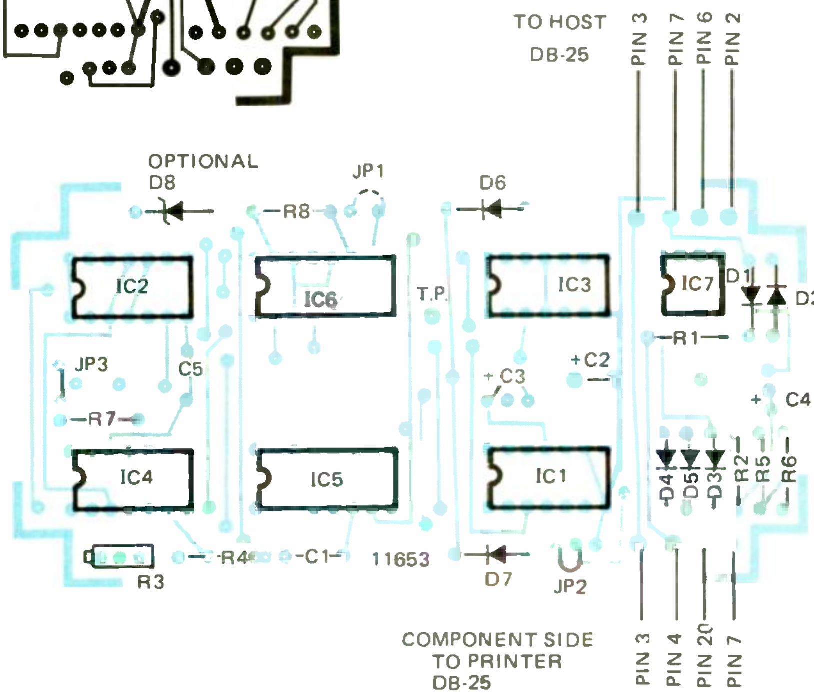


FIG. 4—PARTS PLACEMENT DIAGRAM, component side of board.

PARTS LIST

Semiconductors
D1-D7—1N4148 Diodes
D8—1N5236B Zener, 7.5V (optional)
IC1—74C86 XOR Gates
IC2, IC3—74C74 Flip-Flops
IC4—4093 Schmitt Triggers
IC5—74C161 Counter
IC6—74C165 Shift Register
IC7—LM358 Op Amps

Resistors
All resistors ¼ watt, 5% unless otherwise specified
R1—10,000 ohms
R2, R5-R8—100,000 ohms
R3—50,000 ohms, 10-turn potentiometer
R4—68,000 ohms

Capacitors
C1, C5—.01 µF, 50V
C2—47 µF, 16V
C3, C4—10 µF, 20V

Miscellaneous
PC board, hardware, wire, solder, Etc.
Plastic box (Radio Shack RS 270-221)

The following are available from Capulum Ltd., 814 Proctor Avenue, Ogdensburg, N.Y. 13669: printed circuit board, double sided with plated-through holes for $12. Assembled and tested unit, complete with connectors for $49. Add $2 for postage and handling. New York residents must add sales tax. Money order or Visa. (613) 726-1966.

host and the printer (while it is possible to transmit and receive at two different baud rates, nothing useful would be achieved here).

The "previous state" circuit is built using flip-flops and XOR gates. The BUSY line from the printer is sampled at each clock cycle. If it has changed from the previous time it was sampled, the output of IC1a XOR will go active low. This signal initiates the sequence necessary for transmission of X-on/X-off code. During these transmissions, the BUSY line is not sampled.

The parallel-to-serial circuitry is made up of shift register, binary counter and flip-flops. The shift register is loaded with either X-on (hex 13) or X-off (hex 11) ASCII code, depending on the present state of the BUSY line. The binary counter counts out 10 pulses (1 start, 7 data, and 2 stop bits) and upon completion, allows the "previous state" circuitry to be updated once again.

The RS232 receiver and driver are constructed using low power op amps. The op amp driver provides the bipolar output necessary to drive the host RS232 TxD input line.

Construction

The building of this converter is straightforward. There are no critical components. The prototype unit was built using a Scotchflex 3303 Breadboard Kit. However, use of the PC board is recommended to minimize construction errors and to save time. A layout for the printed circuit board is provided full size in Figure 3. See parts-placement diagram for location of components on the PC board (Figure 4).

Calibration

Connect the converter board to the host unit. Check the voltage level of +Vdd and −Vee. Note that the magnitude of the -Vee will be about 1.2V less than +Vdd, due to the two diode drops at the inverter circuit. Make sure the RS232 voltage levels do not exceed ± 15 volts; +15 being the recommended maximum voltage for operating the CMOS chips. Install a zener diode in the circuit if necessary. Check and adjust R3 for an oscillator frequency of 2400Hz. This frequency does not have to be very accurate, since each start bit synchronizes the receiver clock of the UART/ACIA in the host. Timing errors are thus non-cumulative.

Troubleshooting

If you have problems in making the converter work properly, the best way to troubleshoot is through a terminal program on the host. Install jumper JP1. This jumper will force bit 6 of the trnsmitted code high, which means that DC1/DC3 control codes will now be displayed as letters 'Q' and 'S'. Then, with the converter connected between the host and the printer, take the printer offline and send enough characters to fill the printer buffer (effectively generating a BUSY signal). You should then receive a DC3 code (now displayed as letter 'S') back in your terminal program. Take the printer back online. The printer should start printing and you should receive a DC1 code (letter 'Q') as soon as the buffer empties. If the order of the received codes is reversed, invert the BUSY signal by tieing jumper JP2 to ground instead of +Vdd. If you receive garbage characters, check the baud rate, word length, stop bits and parity. The host should be set up to accept baud rate of 2400, 7 data bits, 2 stop bits and no parity (same as 7 data bits, mark parity and 1 stop bit). If nothing is received at all when the printer is taken offline and online, then scope test test point TP1 on the converter. A negative-going pulse should be observed each time the printer goes busy or not-busy. Presence of pulses here indicates the fault to be in the shift register, counter, or RS232 driver circuitry. Absence of pulses here would suggest problems in the "previous state" flip-flop circuitry. Be sure to remove JP1 when you are finished. One final note: The frequency of the oscillator does change with the circuit voltage, so set the frequency at the voltage at which the converter will operate. Alternatively, you can install the optional zener diode D8, provided DSR or DTR line voltage is sufficient. This way, the frequency will not change with different line voltage. A current limiting resistor in place of jumper JP3 is needed if DSR or DTR line is powered by an external power supply and not by an RS232 line driver.

The author's manuscript was printed using WordStar with X-on/X-off protocol, the protocol converter and a lead control serial printer.

TOUCHSCREEN TECHNOLOGY

Something new has been added...

Marc Stern

■Based on surface acoustic wave (SAW) technology, the Zenith system relies on piezoelectric elements to generate SAWs. Acoustic reflector strips on each edge of the tube face send the SAWs across the screen and an invisible matrix of touchpoints is created. (See Fig. 1)

When the matrix is broken by a touch, an amplitude dip is created. The timing and depth of the dip indicates the location and pressure of the touch.

This concept was first developed in the early 1970s in a system which used a set of parallel SAW beams, in the same manner that infrared LED touch systems are used today. Rows of transducers are placed on opposite edges of a glass panel and are cycled; one transmit-receive set is turned on at a time. In this system, transmission attenuation on one of the possible paths determines the position of the touch.

The need for transducers along a minimum of two edges imposes a cost penalty. To reduce costs, Zenith rethought the concept and borrowed from reflective array technology to complete its acoustic touchscreen. The reason it proved attractive enough for Zenith's work is its good signal-to-noise ratio and the absence of spurious reflections or transducer ringing.

Using a single transducer in the upper left corner of the touchscreen panel, a short burst of SAWs is

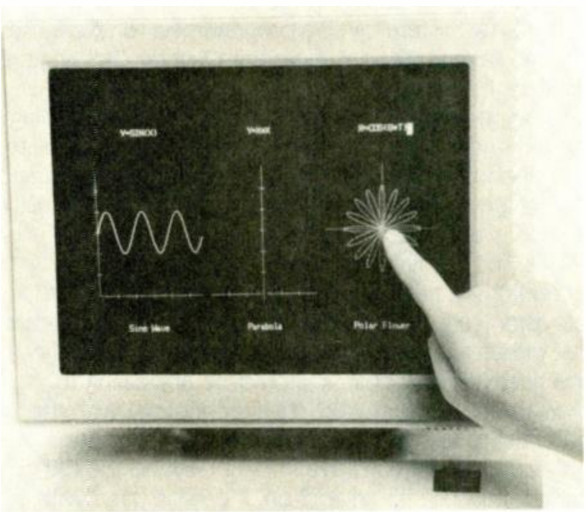


FIG. 1—THE ZENITH ACOUSTIC TOUCHSCREEN system is the first to offer three-dimensional touchpoints. It uses acoustic wave technology to create a matrix of inaudible soundwaves across the tube face, providing a depth coordinate as well as vertical and horizontal points.

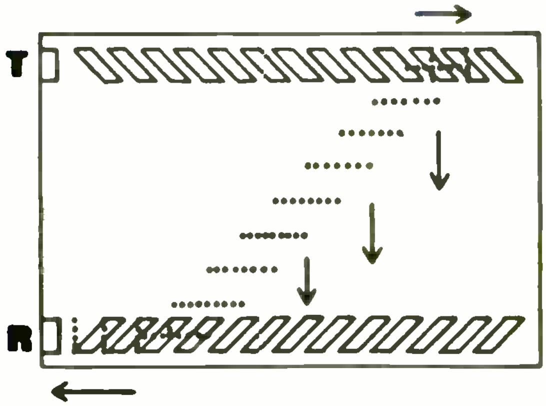


FIG. 2—USING ARRAY TECHNOLOGY, the Zenith system relies on a transmit transducer and an upside-down mirror image receiver to produce an acoustic wave system that bathes a CRT screen system with soundwaves. It is used in the horizontal and vertical plane.

emitted. Traveling along the top edge of the screen, the SAWs run into an array of partial reflectors, positioned 45 degrees to the direction of wave travel.

Wavelets

This array produces wavelets which travel vertically down the face of the screen. Because of the positioning of the reflectors, wavelets coming from reflectors farther to the right lag behind those which are reflected further to the left.

Eventually, this train of wavelets reaches an upside-down mirror image of the upper array at the bottom of the screen panel. The wavelets hitting the receive array are directed toward the receive transducer to the left. Note that the later wavelets produced to the right are further delayed by a longer return path. (See Fig. 2)

The planned delay of wavelets produces a continuous signal with a long rectangular envelope. The screen panel is covered by a continuous flow of wavelets with different transit times and each point on the time axis corresponds to a specific vertical path along the screen panel.

The attenuation dip caused by a touch appears in the output signal and indicates the position.

This system uses a fixed frequency in the 4 to 10 MHz range. The signal must be weighted so the amplitude of the signal remains constant across the screen panel, rather than decreasing exponentially over time. The designers, therefore, lowered the reflectivity of the array closest to the transmitter, where the signal is the strongest and used the highest reflectivity available at the other end.

Because of technical considerations, such as the SAW's velocity on soda-lime glass, it was found the optimum placement of the reflective elements is 0.75 mm, positioned at 45 degrees. In the perpendicular plane, spacing is 0.53 mm, or half a wavelength. A 50 percent duty factor means the strips should also be 0.27 mm wide. They are 5 microns thick. Therefore, the reflective elements can be screen printed on a panel.

Pressure dependable

A surface wave will be more deeply attenuated as a finger is pressed harder on a screen and thus the signal's dip is deeper.

Functions can be designed in which take advantage of it. To move a cursor a user might be instructed to press lightly and to make a program choice he might be instructed to press firmly.

In operation, the Zenith SAW system is three-dimensional. It generates the usual X and Y axis points, but also a pressure point. Available in one to 16 pressure levels, it can generate a maximum resolution of 50 touch points per inch. Thus, a 14-inch CRT can have a total of 512 by 384 touchpoints.

In the acoustic touch system, the piezoelectric elements can be mounted directly on the surface of the cathode ray tube or they can also be placed on a glass overlay. When they are excited electrically, they emit SAWs, which are reflected off the reflective strip arrays mounted along each edge of the tube surface. They send the SAWs across the screen and create the invisible matrix of touchpoints.

When a finger breaks the sound waves, two or more transducers sense it and a microprocessor locates the sources of the break at its horizontal and vertical crosspoints. And, because SAWs are affected by the amount of pressure applied, this system can not only generate the traditional X and Y information common to other forms of touch systems, but also a Z or third positional input that is based on pressure.

Three-dimensional

Because it can generate an extra dimensional input, it is possible for the SAW system to be more versatile than the standard touchscreen system. Most standard touchscreen systems can generate touchpoint resolutions from 1,024 by 1,024 to nearly 4,000 by 4,000, but these are only two-dimensional (X,Y) inputs which, while they do yield good positional inputs, fail to yield any other information. Adding the pressure or Z axis allows a company to build in more functionality because a system cannot only place the touchpoint in space, but it also has a pressure reference which can serve another function.

The resistive-membrane system is the more common type. It's been used for years and relies on a grid of resistive elements. When the elements are pressed a current corresponding to the X and Y axes is generated.

Generally transparent, the typical resistive or resistive-membrane touchscreen may have a layer of dots sandwiched in its construction. Although these dots are largely for show, they help a user locate where an input is generated. The resistive element is the important piece of the sandwich and it is a transparent layer of metallic material that has been included in the membrane's construction. When this comes in contact with a second element a current from a touchpoint is generated and a microprocessor senses the input.

The drawback with is that it cuts down on the visibility of a CRT because of the number of layers that are superimposed on the glass.

A resistive system relies on the current between a fingertip and the resistive element on glass. Since it

FIG. 3—THE SAW SYSTEM is highly versatile. It can be integrated with a graphics tablet to control a personal computer or terminal.

becomes part of the glass, it can be clearer than the traditional resistive-membrane system. It is less prone to damage from sharp instruments.

The second type of touchscreen technology works in a similar manner to the acoustic wave, except that it uses banks of LEDs and infrared detectors. In this system, LED transmitters are placed along the X and Y axis and receivers are placed opposite them. The LEDs transmit vertically and horizontally, from the bezel surrounding the CRT screen, and where a fingertip interrupts the LED beams input is generated.

This type of system will generated an X-Y position, but is incapable of generating a third dimension.

More flexibility

The Zenith system is important because of the added flexibility it gives to a touchscreen system. A system can be programmed to recognize the increased pressure and can then ask if a user would like to take a new or extra action. It can be programmed to ask a user if the action sought is the correct one.

The SAW system can be programmed to take a user through several steps in a program just by pressing the screen a little harder.

Finally, because it relies on transducers surrounding the CRT, there is no diminution of the screen's visibility and since only two piezoelectric sensors are used and a corresponding number of receivers, the system has few parts and should be trouble-free.

This isn't the first time Zenith has used SAW technology. It has used this technology for years in television sets. It's the novel approach in touchscreens that makes it interesting and because of its reliability and relatively low cost, it should be appealing to broad areas of the market. It's a technology with the potential to reshape the market in its own image.

Additionally, it will have impact beyond the CRT market. Because it's an add-on, it can be used with a wide variety of products. For example, it can become part of a graphics tablet package (See Fig. 3). This will allow the user fingertip control of a computer. It's just another use of this versatile technology.

COMMUNICATIONS CORNER

Amateur packet switching

HERB FRIEDMAN,
COMMUNICATIONS EDITOR

BECAUSE OF THE "CONGLOMERIZAtion" of most major manufacturing firms, few if any great technological breakthroughs are now made by hobbyists in basement workshops. Aside from the enormous expense involved, the development of a highly technical communications device or system often requires assistance from persons familiar with unrelated technologies—persons usually beyond the reach of the "crazy perfesser" working alone in a damp basement or a converted garage.

But there is still one source of manpower (personpower?) skilled in many conceivable technologies: amateur (ham) radio. From its vast pool of hundreds of thousands of technically-informed hobbyists you can come up with a handful of experts on just about any technology—people who are just itching to open up new frontiers in communications. It is that spirit of adventure that has transformed many specialized technologies and obscure laboratory phenomena into viable communications systems.

The latest contribution by the amateurs is something called "packet radio." Yes, you can say that there's nothing new about packet communications. And that's true. Packet communications is used by computer networks and some megabuck communications systems, but it's the hams who are making packet radio a very popular form of communications; packet may even replace SSB, RTTY, and even FM repeaters for anything but chit-chat.

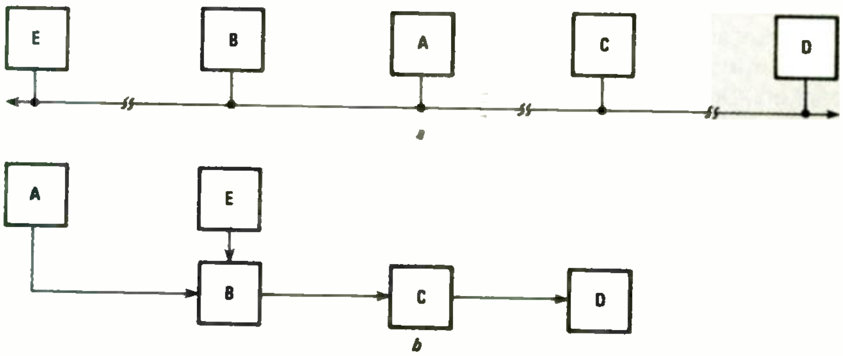


FIG. 1

How it works

The idea behind packet radio is shown in Fig. 1-*a*. For purposes of discussion, let's assume that data originates as entries on a keyboard, just as an actual message might originate. But that data could be chunks of a large database, programs, or just about anything else that can be represented in digital form.

Each station in a packet network is called a node, and two or more (possibly all) nodes are connected together by a simplex (single-wire) circuit. That circuit could be an actual wire, or it could be a line-of-sight radio link, a repeater, or even a satellite circuit. Or it could be any combination of those. The point is that in a simplex circuit stations send and receive on the same wire or frequency. Each node recognizes special protocol signals that switch the node from receive to transmit mode, that generate "busy" signals, etc.

For example, node *A* and node *D* might be across the room from each other, or they might be across the country from each other. In any case, to send data from node A to node D the computer at node A assembles data until it has a block of predetermined size. When the node senses that the communications line is clear it transmits an address—where the data is going to—and then the data.

If data must be echoed through a repeater in order to reach its destination, other nodes pick it up and pass it along. As shown in Fig. 1-*b*, the signal might travel through nodes *B* and *C* before they actually reach node *D*. Obviously, then, nodes *B* and *C* must be smart enough to know that they have to pass the signal on.

Since all nodes share a single circuit something must untangle their transmissions. Again, that is part of the protocol. When *A* is finished transmitting to *B*, *B* attempts to retransmit that packet to *C* However, suppose that, at the very moment *B* is ready to transmit, *C* sends a packet of data to *D*. *B* then gets a "busy" when it polls *C*, so it waits until the circuit is clear. Depending on the system, *D* might transmit through *C* and *B* to *E* even while *B* was storing data that is to be passed through *B*.

(Things *do* get complex and might get a bit confusing at first, so reread the preceding paragraph if you find it necessary.)

While all that is going on, *A* is assembling the next block of data, which it will transmit to *B* as soon as the circuit is clear. As you can see, the data is handled in small packets which are put on the system one at a time. The destination node assembles the packets in its memory into a single file, document, or whatever. When it receives a signal that it has received the last packet, it feeds the entire file into the user's computer where it can be saved for use when needed.

As you can see, at any given time there may be bits and pieces (packets) of various data files passing through various nodes. For example, while *B* is waiting for *C* to "unbusy" so it can transmit a packet to *D*, *B* might be transmitting a packet from *E* to *A*. Since the communications protocol prevents more than one node from transmitting at a time, for all practical purposes packet communications multiplexes a simplex communications path.

While data packets are usually a predetermined size (e. g., 256 bytes), message packets are usually a typed line; that is, all characters up to the carriage return. If you type a line and enter a carriage return, the node accepts that as a packet. If you type three lines and then a carriage return the node accepts all characters in those lines as a single packet.

The protocol includes checksum and ACK (*ACK*nowledge) signals which ensure that packets are received error-free. The checksum is a value that is a mathematically determined by the data in the packet. Every packet is transmitted with a checksum value. Each receiving node in the signal path calculates a checksum from the data it receives and compares that value with the checksum transmitted by the originating node. If that checksum matches the transmitted checksum, the receiving node sends an ACK signal to the originating node. That signal informs the originating node that the packet has been properly received and that the next packet can be transmitted.

On the other hand, if something caused a reception error, the received checksum will not match the transmitted checksum, so an ACK will not be sent to the originating node. It therefore knows that it must repeat the transmission. The originating node will continuously repeat the transmission as long as necessary until it receives an ACK, or an abort signal from the receiving node. That's the way communications integrity is maintained through many nodes, thousands of miles of wire, and geographically-distant radio circuits.

Right now, hobbyist packet equipment is expensive. But, as is common in this industry, someone will probably figure out a way to put a complete node on two VLSI IC's that cost less than $29.95. And we'll be happy to see that happen! **R-E**

DRAWING BOARD

continued from page 85

a low, our circuit is addressing one of the soft switches. The two least significant bits of the address bus (A7 and A8) will determine which bank of our memory system to enable.

Since we only want to enable one bank at a time, the second part of our circuit has to be a one-of-four decoder. There are several IC's we could use, but it's always a good idea to keep the idea of system expansion in mind. The 4051 shown in Fig. 3 is a one-of-eight switch that we've used here before. It's a CMOS analog switch that can handle either analog or digital signals; the digital mode is selected by tying pin 7 low. The data presented to the D input at pin 3 is transferred to the output selected by the AØ–A2 inputs (pins 9–11). Since we're decoding four banks of memory with two inputs, we'll use the most significant select line (A2) to enable the IC.

The last part of the circuit is a latch. The 4042 is a four-bit latch with a really neat feature. We can make it latch data on either a high or a low trigger by tying the POLARITY input (pin 6) high or low. The signal from the NAND gate is active low, so we'll tie the POLARITY pin low. So, whenever a low is presented to the STORE input (pin 5), the data at the latch's inputs will be stored. They'll also appear at the latch's outputs.

The circuit works like this: When one of our soft-switch addresses shows up on the system address bus, the output of the NAND gate goes low. That allows the 4051 to transfer that signal to the output selected by address lines A7 and A8. Since a low is also presented to the STORE input of the 4042, the state of the four 4051 outputs are latched and transferred to the memory enable lines. The result: the selected bank is enabled and the other three banks are disabled.

Caveats

There are a few considerations you should keep in mind when using that arrangement, or a similar one, to control a banked memory system. First, you'll notice that there's no way of predicting which states the latch's output lines will be in when the system is first powered up. Zero, one, or even several of the memory banks could be enabled when you first apply power. That last possibility exists because the 4051 can have an illegal output state—more than one high output—if much noise is present at power up.

Previously, when we were faced with that sort of problem, we used an RC network to generate a quick-and-dirty reset pulse to make sure that things were set up the way we wanted them. But if you examine our circuit, you'll see that it is, unfortunately, too complicated for that type of reset. A simple reset pulse just won't work since there are so many variables involved. A hardware reset would have to control all the circuit elements, so it would be very difficult to design.

But there are other ways to solve that problem.

However, we're out of space for now, so we'll have to wait till next time to see the solution, and also wrap up our discussion of memory management. **R-E**

A $10,000 Challenge To Escort

Let's cut through the Radar Detector Glut. We challenge Escort to a one on one Distance and Falsing 'duel to the death' on the highway of their choice. If they win, the $10,000 check pictured below is theirs.

By Drew Kaplan

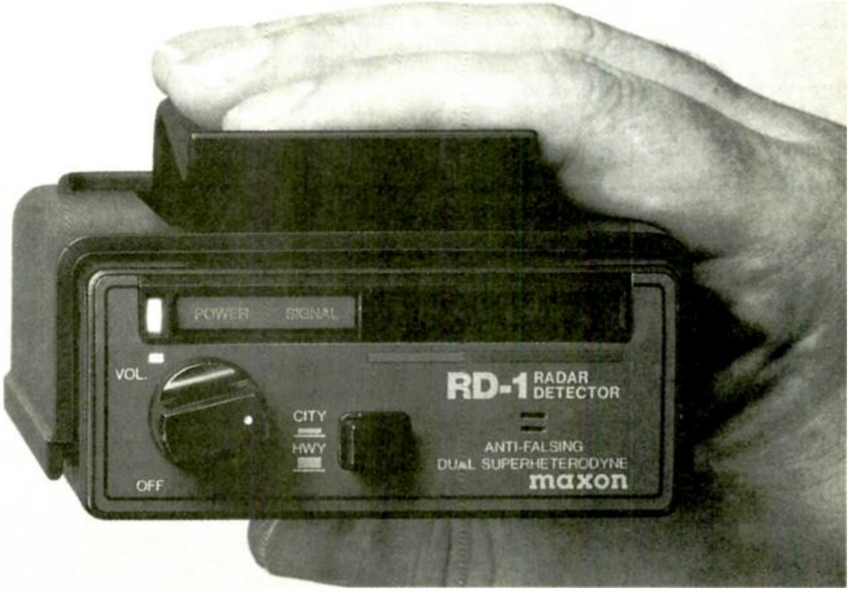
We've put up our $10,000. We challenge Escort to take on Maxon's new Dual Superheterodyne RD-1 $99^{90} radar detector on the road of their choice in a one on one conflict.

Even Escort says that everyone compares themselves to Escort, and they're right. They were the first in 1978 to use superheterodyne circuits and they've got a virtual stranglehold on the magazine test reports.

But, the real question today is: 1) How many feet of sensing difference, if any, is there between this top of the line Maxon Detector and Escort's? And 2) Which unit is more accurate at interpreting real radar versus false signals?

So Escort, you pick the road (continental U.S. please). You pick the equipment to create the false signals. And finally, you pick the radar gun.

Maxon and DAK will come to your highway with engineers and equipment to verify the results. And oh yes, we'll have the $10,000 check (pictured) to hand over if you beat us by more than 10 feet in either X or K band detection.



BOB SAYS MAXON IS BETTER

Here's how it started. Maxon is a mammoth electronics prime manufacturer. They actually make all types of sophisticated electronic products for some of the biggest U.S. Electronics Companies. (No, they don't make Escort's).

Bob Thetford, the president of Maxon Systems Inc., and a friend of mine, was explaining their new RD-1 anti-falsing **Dual** Superheterodyne Radar detector to me. I said "You know Bob, I think Escort really has the market locked up." He said, "Our new design can beat theirs".

So, since I've never been one to be in second place, I said, "Would you bet $10,000 that you can beat Escort?" And, as they say, the rest is history.

By the way, Bob is about 6'9" tall, so if we can't beat Escort, we can sure scare the you know what out of them. But, Bob and his engineers are deadly serious about this 'duel'. And you can bet that our $10,000 is serious.

We ask only the following. 1) The public be invited to watch. 2) Maxon's Engineers as well as Escort's check the radar gun and monitor the test and the results.

3) The same car be used in both tests. 4) We do this test during the summer when it's warm. (I'm from California, and anything below 80° will do me in.)

5) We'd like an answer from Escort no later than June 1, 1986 and 30 days notice of the time and place of the conflict. And, 6) We'd like them to come with a $10,000 check made out to DAK if we win.

SO, WHAT'S DUAL SUPERHETERODYNE?

Ok, so far we've set up the conflict. Now let me tell you about the new dual superheterodyne technology that lets Maxon leap ahead of the pack.

It's a technology that tests each suspected radar signal 4 separate times before it notifies you, and yet it explodes into action in just 1/4 of one second.

Just imagine the sophistication of a device that can test a signal 4 times in less than 1/4 of one second. Maxon's technology is mind boggling.

But, using it isn't. This long range detector has all the bells and whistles. It has a separate audible sound for X and K radar signals because you've only got about 1/3 the time to react with K band.

There's a 10 step LED Bar Graph Meter to accurately show the radar signal's strength. And, you won't have to look at a needle in a meter. You can see the Bar Graph Meter with your peripheral vision and keep your eyes on the road and put your foot on the brake.

So, just turn on the Power/Volume knob, clip it to your visor or put it on your dash. Then plug in its cigarette lighter cord and you're protected.

And you'll have a very high level of protection. Maxon's Dual Conversion Scanning Superheterodyne circuitry combined with its ridge guide wideband horn internal antenna, really ferrets out radar signals.

By the way Escort, we'll be happy to have our test around a bend in the road or over a hill. Maxon's detector really picks up 'ambush type' radar signals.

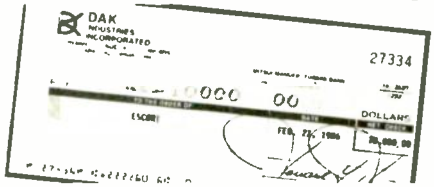
And the key word is 'radar', not trash signals. The 4 test check system that operates in 1/4 second gives you extremely high protection from signals from other detectors, intrusion systems and garage door openers.

So, when the lights and X or K band sounds explode into action, take care, there's very likely police radar nearby. You'll have full volume control, and a City/Highway button reduces the less important X band reception in the city.

Maxon's long range detector comes complete with a visor clip, hook and loop dash board mounting, and the power cord cigarette adaptor.

It's much smaller than Escort at just 3½" Wide, 4¾" deep and 1½" high. It's backed by Maxon's standard limited warranty. Note from Drew: 1) Use of radar detectors is illegal in some states.

2) Speeding is dangerous. Use this detector to help keep you safe when you forget, not to get away with speeding.



CHECK OUT RADAR YOURSELF RISK FREE

Put this detector on your visor. When it sounds, look around for the police. There's a good chance you'll be saving money in fines and higher insurance rates. And, if you slow down, you may even save lives.

If you aren't 100% satisfied, simply return it in its original box within 30 days for a courteous refund.

To get your Maxon, Dual Superheterodyne, Anti-Falsing Radar Detector risk free with your credit card, call toll free or send your check for just **$99^{90}** ($4 P&H). Order No. 4407. CA res add tax.

OK Escort, it's up to you. We've got $10,000 that says you can't beat Maxon on the road. Your answer, please?

Escort is a registered trademark of Cincinnati Microwave.

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26 ($74.10)	27 ($76.95)	28 ($79.80)	29 ($82.65)	30 ($85.50)
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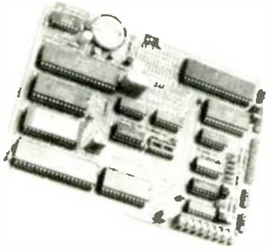

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RADAR SIGNAL DETECTOR

continued from page 52

power, background noise should be heard. You may want to vary the value of R1 slightly to get a pleasant ringing frequency. Then adjust the threshold control (R5 in Fig. 1; R2 in Fig. 2) so that received signals are just above the $1/f$ noise background.

You can test the detector on the workbench by generating a millimeter-wave microwave signal. You don't need a fancy signal generator—just "arc" a small inductor (say 500 mH) across a nine-volt battery. A properly-functioning detector should ring loudly when a signal is generated in that manner fifty feet from the detector. You may want to experiment with different inductors at different distances from the detector.

PARTS LIST—ECONOMY MODEL

All resistors ¼-watt, 5%.
R1—1.1 megohm
R2—27,000 ohms
R3, R4—100,000 ohms
R5—100,000 ohms, panel-mount potentiometer
Capacitors
C1—0.22 µF
C2—0.0 µF
C3—100 µF 16 volts, electrolytic
Semiconductors
IC1—1458 dual op-amp
Other components
S1—SPST switch
Piezo-electric transducer

PARTS LIST—DELUXE MODEL

All resistors ¼-watt, 5%.
R1—2.2 megohms
R2—10,000 ohms, trimmer potentiometer
R3—4700 ohms
R4, R6, R7—100,000 ohms
R5—25,000 ohms, panel-mount potentiometer
Capacitors
C1—0.22 µF
C2, C5—0.05 µF
C3—220 µF, 10 volts, electrolytic
C4—10 µF, 6 volts, electrolytic
Semiconductors
IC1—1458 dual op-amp
IC2—LM386 audio power amplifier
Other components
S1—SPST switch
SPKR—8–100 ohm miniature speaker

Conclusions

Both circuits pick up low-level pulsed-RF signals. The detector responds to very short pulses and will continue to ring for several milliseconds. But the circuit will respond only to the beginning and the end of a CW (continuous-wave) signal. Using either circuit, you'll soon be able to recognize various signal sources by their "signatures." Microwave towers, for example, provide lots of varied output.

Either circuit could be used for purposes other than radar detection. For example, you could use one to detect a hidden radio transmitter (provided the transmitter is a pulsed type). The detector could be used as a leakage detector at a microwave tower. The detector could also be used to detect leakage or arcing in home power lines, as well as outdoor power-transmission lines. In fact, the uses to which this circuit may be put are limited only by your imagination! **R-E**


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74S85	1.49	74S287*	1.69
74S86	.35	74S288*	1.69
74S124	2.75	74S373	1.69
74S174	.79	74S374	1.69
74S175	79	74S472*	3.49

74ALS

74ALS00	.35	74ALS138	.89
74ALS02	.35	74ALS174	.89
74ALS04	.39	74ALS175	.89
74ALS08	.35	74ALS240	1.79
74ALS10	.35	74ALS244	1.79
74ALS27	.39	74ALS245	2.49
74ALS30	35	74ALS373	1.95
74ALS32	.39	74ALS374	1.95
74ALS74	.55	74ALS573	1.95

74F

74F00	.59	74F139	1.29
74F04	.65	74F157	1.29
74F08	59	74F193	4.95
74F10	.59	74F240	2.49
74F32	.65	74F244	2.49
74F74	.69	74F253	1.79
74F86	.89	74F373	2.95
74F138	1.19	74F374	2.95

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CD4001	.19	CD4081	.25
CD4011	.19	CD4082	.25
CD4013	.35	CD4093	.39
CD4016	.29	CD4094	1.49
CD4017	.49	CD40103	2.95
CD4018	.69	CD4503	.49
CD4020	.59	CD4510	.69
CD4024	.49	CD4511	.69
CD4027	.39	CD4515	1.39
CD4030	.39	CD4518	.79
CD4040	.65	CD4520	.79
CD4049	.29	CD4522	.79
CD4050	.29	CD4538	.89
CD4051	.65	CD4541	.89
CD4052	.65	CD4543	.99
CD4053	.65	CD4553	4.95
CD4059	3.49	CD4555	.89
CD4060	.89	CD4566	1.95
CD4066	.29	CD4583	1.19
CD4069	.25	CD4584	.59
CD4070	.29	CD4585	.75
CD4071	.25	MC14411	9.95
CD4072	.25	MC14490P	4.49
CD4076	.89	MC14572	.89

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*Specs Available @ $1.50 ea.		*6567VIC-II	~~44.95~~ 19.95	NOTE: 82S100 = U17 (C-64)	

MOTOROLA

MC68701-Microcomputer with EPROM

The MC68701 is an 8-bit single chip microcomputer unit (MPU) which significantly enhances the capabilities of the MC6800 family of parts. On-chip resources include 2048 bytes of EPROM, 128 bytes of RAM, Serial Communications Interface (SCI), parallel I/O, and a three function Programmable Timer.

MC68701 .... $24.95

MICROPROCESSOR COMPONENTS

MICROPROCESSOR CHIPS Part No.	Price	6500/6800/68000 Cont. Part No.	Price	8000 SERIES Cont. Part No.	Price
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CDP1802CE	6.95	6845	4.95	8243	2.49
2661-3	6.95	6850	1.95	8250A	6.95
Z80, Z80A, Z80B, SERIES		6852	4.75	8250B (For IBM)	7.25
Z80	1.75	68000L8	9.95	8251A	2.25
Z80-CTC	1.79	68661	8.95	8253-5	2.25
Z80-DART	4.95	**8000 SERIES**		8254	9.95
Z80-PIO	1.79	8031	6.95	8254-2	11.95
Z80A	1.85	80C31BH	19.95	8255A-5	2.25
Z80A-CTC	1.89	8035	1.95	8257-5	2.49
Z80A-DART	5.25	8073N	29.95	8259-5	2.49
Z80A-PIO	1.95	8080A	3.95	8272	4.95
Z80A-SIO/0	5.25	8085A	2.75	8279-5	2.95
Z80B	3.95	8086	8.95	8741	8.95
Z80B-CTC	4.95	8086-2	10.95	8748	7.95
Z80B-PIO	4.95	8087(5MHz)	129.95	8749	9.95
6500/6800/68000 SER.		8087-2(8MHz)	159.95	8751	29.95
6502	2.75	8088	7.95	8755	14.95
6520	2.95	8088-2	9.95	**DATA ACQUISITION**	
6522	4.95	8116	8.95	ADC0804	3.49
6532	6.49	8155	2.75	ADC0808	8.95
6551	6.95	8155-2	3.95	ADC0809	3.95
6800	1.95	8156	2.75	ADC0816	14.95
6802	4.95	8202	9.95	ADC0817	8.95
6810	1.95	8203	29.95	DAC0808	1.95
6821	1.95	8212	1.95	DAC1008	7.95
6840	6.75	8224	2.25	AY-3-1015D	4.95
		8228	3.49	AY-5-1013A	3.95

Part No.	Function		Price
DYNAMIC RAMS			
4116N-15	16,384 x 1	(150ns)	.89
4128	131,072 x 1	(200ns)	5.95
4164N-150	65,536 x 1	(150ns)	1.39
4164N-200	65,536 x 1	(200ns)	1.19
TMS4416-12	16,384 x 4	(120ns)	4.95
MM5280	4096 x 1	(200ns) 2107	1.95
8118	16,384 x 1	(120ns) (+5V Only Required)	.99
41256-150	262,144 x 1	(150ns)	3.95
50464-15	65,536 x 4	(150ns) (4464) (41464)	7.95
STATIC RAMS			
TMM2016-12	2048 x 8	(120ns)	1.69
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	1.79
HM6116LP-3	2048 x 8	(150ns) LP CMOS	1.85
HM6264P-12	8192 x 8	(120ns) CMOS	4.69
HM6264LP-12	8192 x 8	(120ns) LP CMOS	4.79
HM6264P-15	8192 x 8	(150ns) CMOS	4.49
HM6264LP-15	8192 x 8	(150ns) LP CMOS	4.59
6514	1024 x 4	(350ns) CMOS (UPD444C)	4.49
PROMS/EPROMS			
1702A	256 x 8	(1 µs)	5.95
TMS2516	2048 x 8	(450ns) 25V	4.95
TMS2532	4096 x 8	(450ns) 25V	5.95
TMS2564	8192 x 8	(450ns) 25V	9.95
2708	1024 x 8	(450ns)	3.95
TMS2716	2048 x 8	(450ns) 3 voltage	9.95
2716	2048 x 8	(450ns)	4.95
2716-1	2048 x 8	(350ns) 25V	5.95
27C16	2048 x 8	CMOS	9.95
2732	4096 x 8	(450ns)	4.75
2732A-20	4096 x 8	(200ns) 21V	4.95
2732A-25	4096 x 8	(250ns) 21V	4.49
2732A-45	4096 x 8	(450ns) 21V	4.25
27C32	4096 x 8	CMOS	7.95
2758	1024 x 8	(450ns) Single +5V	5.95
2764-20	8192 x 8	(200ns) 21V	4.49
2764-25	8192 x 8	(250ns) 21V	4.25
2764A-25	8192 x 8	(250ns) 12.5V	4.49
2764-45	8192 x 8	(450ns) 21V	3.95
27C64	8192 x 8	CMOS 21V	5.95
27128-25	16,384 x 8	(250ns) 128K 21V	4.49
27128A-25	16,384 x 8	(250ns) 12.5V	5.95
27256-25	32,768 x 8	(250ns) 256K (12.5V)	7.95
27C256-25	32,768 x 8	(250ns) 256K (CMOS) (12.5V)	10.95
68764	8192 x 8	(450ns) 25V	15.95
68766	8192 x 8	(350ns) 25V	16.95
74S387	256 x 4	PROM O.C.	1.69
74S471	256 x 8	PROM T.S.	4.95
82S123	32 x 8	PROM T.S.	2.95
82S129	256 x 4	PROM T.S.	2.95

LOW PROFILE (TIN) SOCKETS

Part No.	1-9	10-99	100-up
8 pin LP	13	.12	.11
14 pin LP	.15	13	.11
16 pin LP	.17	.15	.13
24 pin LP	31	.30	.29
28 pin LP	39	.37	.35
40 pin LP	.49	.46	.43

WIRE WRAP SOCKETS (GOLD) LEVEL #3

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
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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
MM54104	Processor Chip	$12.95

DT1057-Expands the DT1050 vocabulary from 137 words to over 250 words. Includes two (2) ROMs and specs.

DT1057 .... $11.95

INTERSIL

Part No.	Price	Part No.	Price
FE0202D	12.95	7207AEV/Kit	8.49
FE0203D	12.95	7211IPL (TTL)	7.95
7106CPL	8.95	7211MIPL (Micro)	8.49
7106EV/Kit	46.95	7217IJI	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

74C—CMOS

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
74C32	.35	74C374	1.95
74C74	.49	74C912	7.95
74C85	1.19	74C915	1.19
74C86	.29	74C920	9.95
74C89	3.95	74C921	9.95
74C90	.89	74C922	3.95
74C154	2.95	74C923	3.95
74C173	.89	74C925	4.95

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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
LF347N	.99	XR2207	2.49
LM348N	.69	XR2211	2.95
LF351N	.49	LM2907N	1.95
LF353N	.59	LM2917N (8 pin)	1.55
LF355N	.89	LM3900N	.59
LF356N	.89	LM3905CN	1.19
LM358N	.49	LM3909N	.89
LM360N	2.19	LM3914N	1.95
LM361N	1.59	LM3916N	1.95
LM380CN	1.09	NE5532	.99
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LM387N	.99	75477	1.19
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2102L-2	1024x1	(250ns)(LP)	1.45
2112	256x4	(450ns)	2.99
2114	1024x4	(450ns)	.99
2114L-4	1024x4	(450ns)(LP)	1.09
2114L-2	1024x4	(200ns)(LP)	1.49
2114L-15	1024x4	(150ns)(LP)	1.95
TMS4044-4	4096x1	(450ns)	1.95
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HM6116-3	2048x8	(150ns)(CMOS)	1.49
HM6116LP-4	2048x8	(200ns)(CMOS)(LP)	1.49
HM6116LP-3	2048x8	(150ns)(CMOS)(LP)	1.59
HM6116LP-2	2048x8	(120ns)(CMOS)(LP)	2.95
HM6264P-15	8192x8	(150ns)(CMOS)	3.89
HM6264LP-15	8192x8	(150ns)(CMOS)(LP)	3.95
HM6264LP-12	8192x8	(120ns)(CMOS)(LP)	4.49

LP=Low power

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4116-200	16384x1	(200ns)	.69
4116-150	16384x1	(150ns)	.89
4116-120	16384x1	(120ns)	1.49
MK4332	32768x1	(200ns)	6.95
4164-200	65536x1	(200ns)(5v)	1.19
4164-150	65536x1	(150ns)(5v)	1.29
4164-120	65536x1	(120ns)(5v)	1.95
MCM6665	65536x1	(200ns)(5v)	1.95
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5v=Single 5 Volt Supply   REFRESH=Pin 1 Refresh

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2716-6	2048x8	(650ns)	2.29
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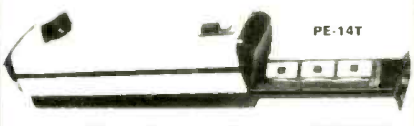
2716-1	2048x8	(350ns)(5V)	3.95
TMS2532	4096x8	(450ns)(5V)	3.95
2732	4096x8	(450ns)(5V)	3.89
2732A	4096x8	(250ns)(5V)(21V PGM)	3.95
2732A-2	4096x8	(200ns)(5V)(21V PGM)	4.25
27C64	8192x8	(250ns)(5V)(CMOS)	5.95
2764	8192x8	(450ns)(5V)	3.49
2764-250	8192x8	(250ns)(5V)	3.95
2764-200	8192x8	(200ns)(5V)	4.25
TMS2564	8192x8	(450ns)(5V)	8.95
MCM68766	8192x8	(350ns)(5V)(24 PIN)	17.95
27128	16384x8	(250ns)(5V)	4.25
27C256	32768x8	(250ns)(5V)(CMOS)	12.95
27256	32768x8	(250ns)(5V)	7.49

5V=Single 5 Volt Supply   21V PGM=Program at 21 Volts

SPECTRONICS CORPORATION EPROM ERASERS



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

8000

8035	1.49
8039	1.95
8080	2.95
8085	2.49
8087-2	169.95
8087	129.00
8088	6.95
8088-2	9.95
8155	2.49
8155-2	3.95
8748	7.95
8755	19.95
80286	129.95
80287	199.95

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8203	29.95
8205	3.29
8212	1.49
8216	1.49
8224	2.25
8237	4.95
8237-5	5.49
8250	6.95
8251	1.69
8251A	1.89
8253	1.89
8253-5	1.95
8255	1.69
8255-5	1.89
8259	1.95
8259-5	2.29
8272	4.95
8279	2.49
8279-5	2.95
8282	3.95
8284	2.95
8286	3.95
8288	4.95

Z-80

Z80-CPU	1.69
4.0 MHz	
Z80A-CPU	1.79
Z80A-CTC	1.89
Z80A-DART	5.95
Z80A-DMA	5.95
Z80A-PIO	1.89
Z80A-SIO 0	5.95
Z80A-SIO 1	5.95
Z80A-SIO 2	5.95
6.0 MHz	
Z80B-CPU	3.75
Z80B-CTC	4.25
Z80B-PIO	4.25
Z80B-DART	14.95
Z80B-SIO 0	12.95
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6500

1.0 MHz	
6502	2.79
65C02 (CMOS)	12.95
6507	9.95
6520	1.95
6522	4.95
6526	26.95
6532	6.95
6545	6.95
6551	5.95
6561	19.95
6581	34.95
2.0 MHz	
6502A	2.95
6520A	2.95
6522A	5.95
6532A	11.95
6545A	7.95
6551A	6.95
3.0 MHz	
6502B	6.95

6800

1.0 MHz	
6800	1.95
6802	4.95
6803	9.95
6809	5.95
6809E	5.95
6810	1.95
6820	2.95
6821	1.95
6840	6.95
6843	19.95
6844	12.95
6845	4.95
6847	11.95
6850	1.95
6883	22.95
2.0 MHz	
68B00	4.95
68B02	5.95
68B09E	6.95
68B09	6.45
68B21	3.50
68B45	6.75
68B50	3.95
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7220	19.95
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1797	12.95
2791	19.95
2793	19.95
2797	29.95
6843	19.95
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IM6403	9.95
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76489	8.95
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AY3-8910	12.95
AY3-8912	12.95
SP1000	39.00

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1.8432	2.95
2.0	1.95
2.097152	1.95
2.4576	1.95
3.2768	1.95
3.579545	1.95
4.0	1.95
4.032	1.95
5.0	1.95
5.0688	1.95
6.0	1.95
6.144	1.95
6.5536	1.95
8.0	1.95
10.0	1.95
10.738635	1.95
12.0	1.95
14.31818	1.95
15.0	1.95
16.0	1.95
17.430	1.95
18.0	1.95
18.432	1.95
20.0	1.95
22.1184	1.95
24.0	1.95
32.0	1.95

CRYSTAL OSCILLATORS

1.0MHz	5.95
1.8432	5.95
2.0	5.95
2.4576	5.95
2.5	4.95
4.0	4.95
5.0688	4.95
6.0	4.95
6.144	4.95
8.0	4.95
10.0	4.95
12.0	4.95
12.480	4.95
15.0	4.95
16.0	4.95
18.432	4.95
20.0	4.95
24.0	4.95

MISC.

TMS99531	9.95
TMS99532	19.95
ULN2003	.79
3242	7.95
3341	4.95
MC3470	1.95
MC3480	8.95
MC3487	2.95
11C90	13.95
2513-001 UP	6.95
AY5-2376	11.95
AY5-3600 PRO	11.95

74LS00

74LS00	.16	74LS165	.65
74LS01	.18	74LS166	.95
74LS02	.17	74LS169	.95
74LS03	.18	74LS173	.49
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	.59	74LS259	1.29
74LS48	.69	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
74LS136	.39	74LS624	1.95
74LS138	.39	74LS640	.99
74LS139	.39	74LS645	.99
74LS145	.99	74LS669	1.29
74LS147	.99	74LS670	.89
74LS148	.99	74LS682	3.20
74LS151	.39	74LS683	3.20
74LS153	.39	74LS684	3.20
74LS154	1.49	74LS688	2.40
74LS155	.59	74LS783	22.95
74LS156	.49	81LS95	1.49
74LS157	.35	81LS96	1.49
74LS158	.29	81LS97	1.49
74LS160	.29	81LS98	1.49
74LS161	.39	25LS2521	2.80
74LS162	.49	25LS2569	2.80
74LS163	.39	26LS31	1.95
74LS164	.49	26LS32	1.95

HIGH SPEED CMOS

A new family of high speed CMOS logic featuring the speed of low power Schottky (8ns typical gate propagation delay), combined with the advantages of CMOS: very low power consumption, superior noise immunity, and improved output drive.

74HC00

74HC: Operate at CMOS logic levels and are ideal for new, all-CMOS designs.

74HC00	.59	74HC148	1.19
74HC02	.59	74HC151	.89
74HC04	.59	74HC154	2.49
74HC08	.59	74HC157	.89
74HC10	.59	74HC158	.95
74HC14	.79	74HC163	1.15
74HC20	.59	74HC175	.99
74HC27	.59	74HC240	1.89
74HC30	.59	74HC244	1.89
74HC32	.69	74HC245	1.89
74HC51	.59	74HC257	.85
74HC74	.75	74HC259	1.39
74HC85	1.35	74HC273	1.89
74HC86	.69	74HC299	4.99
74HC93	1.19	74HC368	.99
74HC107	.79	74HC373	2.29
74HC109	.79	74HC374	2.29
74HC112	.79	74HC390	1.39
74HC125	1.19	74HC393	1.39
74HC132	1.19	74HC4017	1.99
74HC133	.69	74HC4020	1.39
74HC138	.99	74HC4049	.89
74HC139	.99	74HC4050	.89

74HCT00

74HCT: Direct, drop-in replacements for LS TTL and can be intermixed with 74LS in the same circuit.

74HCT00	.69	74HCT166	3.05
74HCT02	.69	74HCT174	1.09
74HCT04	.69	74HCT193	1.39
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
74HCT32	.79	74HCT257	.99
74HCT74	.85	74HCT259	1.59
74HCT75	.95	74HCT273	2.09
74HCT138	1.15	74HCT367	1.09
74HCT139	1.15	74HCT373	2.49
74HCT154	2.99	74HCT374	2.49
74HCT157	.99	74HCT393	1.59
74HCT158	.99	74HCT4017	2.19
74HCT161	1.29	74HCT4040	1.59
74HCT164	1.39	74HCT4060	1.49

74F00

74F00	.69	74F74	.79	74F251	1.69
74F02	.69	74F86	.99	74F253	1.69
74F04	.79	74F138	1.69	74F257	1.69
74F08	.69	74F139	1.69	74F280	1.79
74F10	.69	74F157	1.69	74F283	3.95
74F32	.69	74F240	3.29	74F373	4.29
74F64	.89	74F244	3.29	74F374	4.29

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TERMS: Minimum order $10.00. For shipping and handling include $2.50 for UPS Ground and $3.50 for UPS Air. Orders over 1 lb. and foreign orders may require additional shipping charges - please contact our sales department for the amount. CA. residents must include applicable sales tax. All merchandise is warranted for 90 days unless otherwise stated. Prices are subject to change without notice. We are not responsible for typographical errors. We reserve the right to limit quantities and to substitute manufacturer. All merchandise subject to prior sale.

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CMOS

4001	.19	14419	4.95
4011	.19	14433	14.95
4012	.25	4503	.49
4013	.35	4511	.69
4015	.29	4516	.79
4016	.29	4518	.85
4017	.49	4522	.79
4018	.69	4526	.79
4020	.59	4527	1.95
4021	.69	4528	.79
4024	.49	4529	2.95
4025	.25	4532	1.95
4027	.39	4538	.95
4028	.65	4541	1.29
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	1.75
4069	.19	74C240	1.89
4076	.59	74C244	1.89
4077	.29	74C374	1.99
4081	.22	74C905	10.95
4085	.79	74C911	8.95
4086	.89	74C917	8.95
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	.35	74S196	1.49
74S30	.29	74S197	1.49
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	1.39	7905K	1.49
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	3.75
LM322	1.65	XR2211	2.95
LM323K	4.79	XR2240	1.95
LM324	.49	MPO2907	1.95
LM331	3.95	LM2917	1.95
LM334	1.19	CA3046	.89
LM335	1.40	CA3081	.99
LM336	1.75	CA3082	.99
LM337K	3.95	CA3086	.80
LM338K	3.95	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	4.60	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

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-
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	1.95	1.49
ST SOLDERTAIL		
8 PIN WW	.59	.69
14 PIN WW	.69	.52
16 PIN WW	.69	.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-WIRE WRAP		
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

IDCEN36/F	RIBBON CABLE	7.95
CEN36PC	RT ANGLE PC MOUNT	4.95

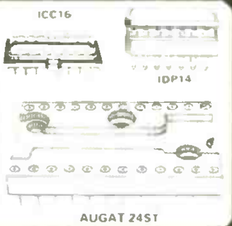
INTERSIL

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

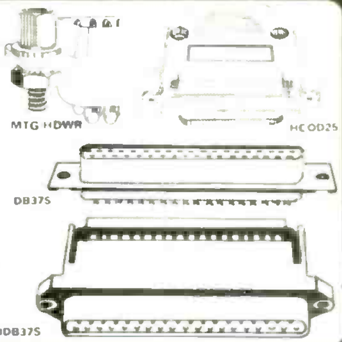
1N751	.25	4N26	.69
1N759	.25	4N27	.69
1N4148	25/1.00	4N28	.69
1N4004	10/1.00	4N33	.89
1N5402	.25	4N37	1.19
KBP04	.55	MCT-2	.59
KBU8A	.95	MCT-6	1.29
MDA990-2	.35	TIL-111	.99
2N2222	.25	2N3906	.10
PN2222	.10	2N4401	.25
2N2905	.50	2N4402	.25
2N2907	.25	2N4403	.25
2N3055	.79	2N6045	1.75
2N3904	.10	TIP31	.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

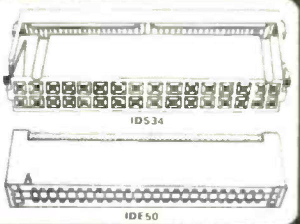
DIFFUSED LEDS

		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

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



SWITCHES

SPST	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
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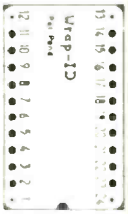

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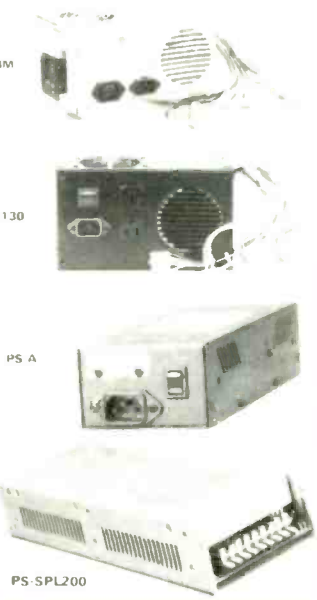

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22	50V	.05	.001µf	50V	05
27	50V	.05	.0022	50V	05
33	50V	.05	.005	50V	05
47	50V	.05	.01	50V	07
68	50V	.05	.02	50V	07
100	50V	.05	.05	50V	07
220	50V	.05	.1	12V	.10
560	50V	.05	1	50V	12

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4.7	50V	15	22	16V	14
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47	35V	18	100	35V	.25
100	16V	18	220	25V	30
220	35V	.20	470	50V	.50
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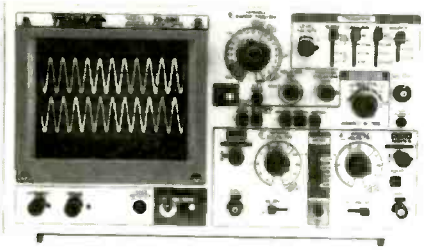

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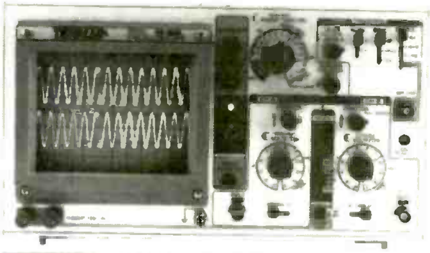

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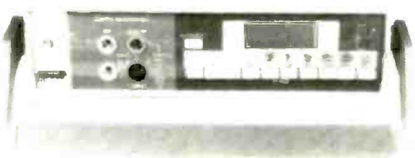

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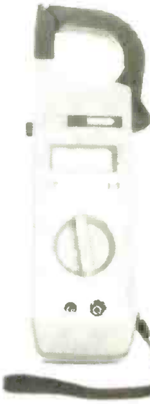

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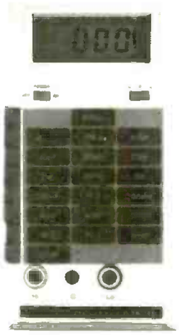

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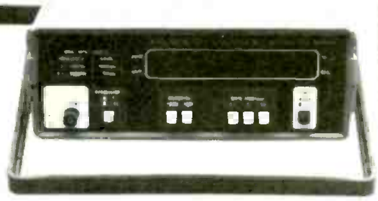

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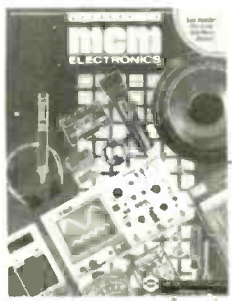

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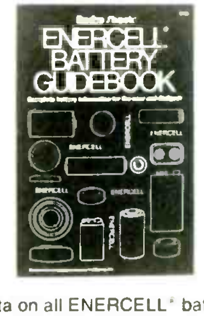

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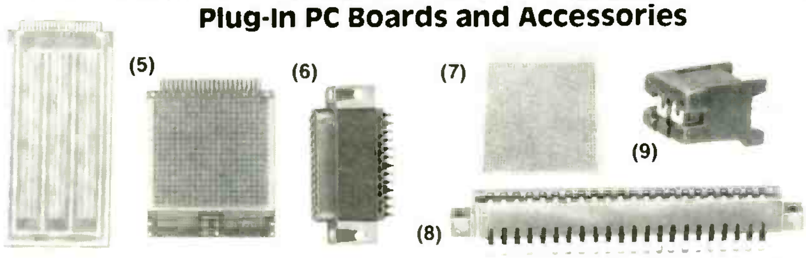

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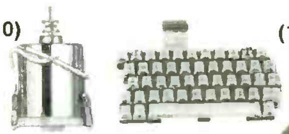

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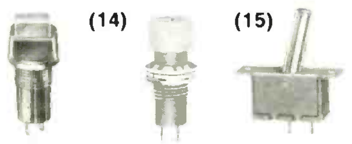

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2.2	35	272-1435	59
10	16	272-1436	69
22	16	272-1437	79

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047	250	272-1052	49
1	250	272-1053	59
1 0	250	272-1055	89

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Decade Counter/Divider	4017	276-2417	1 49
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Description	Type	Cat No	Each
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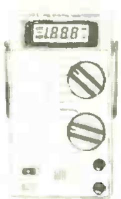
Micronta® Test Instruments



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(16)

Tests In Or Out Of Circuit

14⁹⁵

(17)

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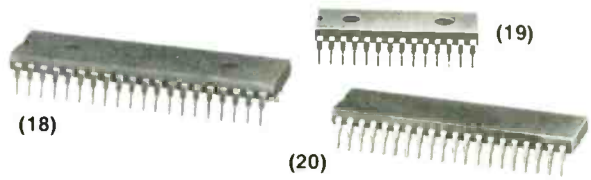

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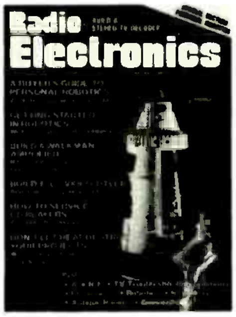

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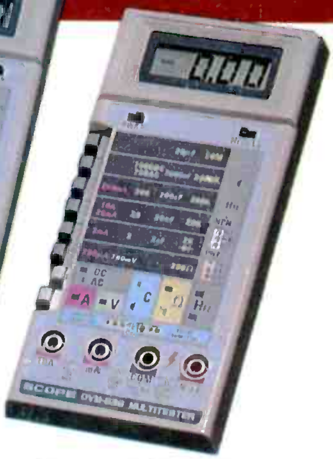

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