Radio-Electronics®

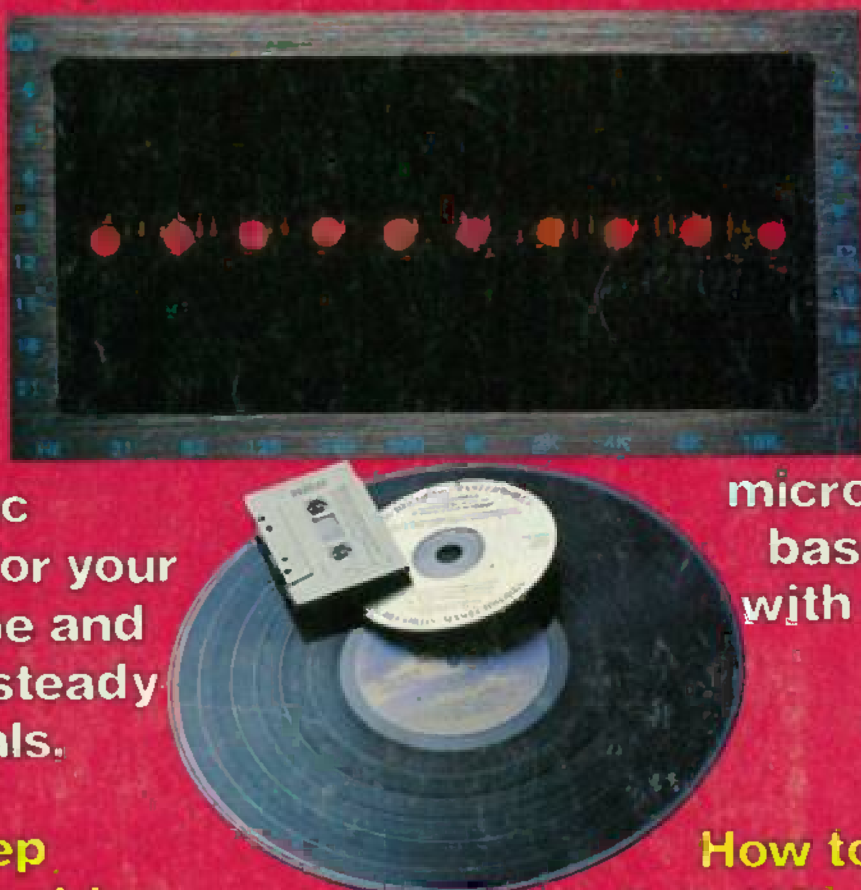
PUT A TELEPHONE IN YOUR CAR—CELLULAR TECHNOLOGY HAS ARRIVED!

$1.95 APR. 1985
IN CANADA $2.25

TECHNOLOGY - VIDEO - STEREO - COMPUTERS - SERVICE

Build R-E's real-time spectrum analyzer and match your hi-fi's response to your listening room.

How to improve your scanner's performance with a custom antenna you can build yourself.



Build R-E's add-on sync separator for your oscilloscope and view rock-steady video signals.

How to design your own microprocessor-based projects with easy to use single-IC computers.

Step-by-step guide to repairing videodisc players.

How to use CMOS digital IC's effectively.

Special 16-page tear-out section: COMPUTER DIGEST

A GERNSBACK PUBLICATION

PLUS:

★ Hobby Corner ★ Equipment Reports
★ Drawing Board ★ Service Clinic
★ New Idea ★ Antique Radios

TEK 2213A/2215A/2235 DUAL TRACE OSCILLOSCOPES

THE ANSWER BY ANY MEASURE

Now! Tek quality and expert advice are just a free phone call away!

100 MHz dual time base scope. Easy-to-read CRT; bright, full-sized 8x10 cm; 14 kv accelerating potential complete with BEAM FIND, separate A/B dual intensity controls, FOCUS and TRACE ROTATION.

Wide range vertical sensitivity. Choose from 2 mV/div (1x probe) to 50 V/div (10x probe); color-keyed for 1x and 10x probes, variable control increases scale factor by 2.5 to 1.

Two 100 MHz, high sensitivity channels. 3.5 ns risetime; dc to ≥ 100 MHz bandwidth from 5 V/div to 5 mV/div; extended sensitivity of 2 mV/div at ≥ 90 MHz.

A/B sweep selection. Calibrated A sweeps from 50 ns/div to 0.5 s/div; B sweeps from 50 ns/div to 50 ms/div; variable control for up to 2.5 to 1 reduction and 10x magnification for sweeps to 5 ns/div.

Dual time base measurements. Select either A or B sweeps, or both alternately with A intensified by B.

B trigger slope and level. Use B trigger level to select B-triggered or run-after-delay modes; use B TRIGGER SLOPE to select transitions.

Our direct order line gets you the industry's leading price/performance portables... and fast answers from experts! The 60 MHz single time base delay 2213A, the 60 MHz dual time base 2215A and the 100 MHz dual time base 2235 offer unprecedented reliability and affordability, plus the industry's first 3-year warranty* on labor and parts, CRT included.

The cost: just $1200 for the 2213A, $1450 for the 2215A, $1650 for the 2235.† Even at these low prices, there's no scrimping on performance. You have the bandwidth for digital and analog circuits. The sensitivity for low signal measurements. The sweep speeds for fast logic families. And delayed sweep for fast, accurate timing measurements. All scopes are UL Listed and CSA approved.

You can order, or obtain literature, through the Tek National Marketing Center. Technical personnel, expert in scope applications, will answer your questions and expedite delivery. Direct orders include comprehensive 3-year warranty*, operator's manual, two 10X probes, 15-day return policy and worldwide service backup.

Order toll free: 1-800-426-2200, Ask for Rick.

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VIDEO ACCESSORIES

■ Highest quality ■ Highest performance ■ Lowest prices

bp VIDEO-CINE CONVERTER

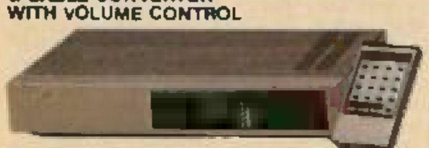
The BP Video-Cine Converter is an optical device that allows the easy transfer of slides, 8mm or 16mm movie film to VCR tape. The Video-Cine Converter's precision optics put the image from your movie or slide projector on a high-contrast, rear projection screen. Your video camera shoots that image, can color-correct faded pictures, add narration to other sound. Can be used with any video camera or slide projector. If your video camera lacks close-up capability, you will need a macro lens attachment.

MODEL V-1701 $34.95

FOR ULTIMATE VIEWING

TEKNIKA
WIRELESS REMOTE CONTROL TV TUNER & CABLE CONVERTER WITH VOLUME CONTROL

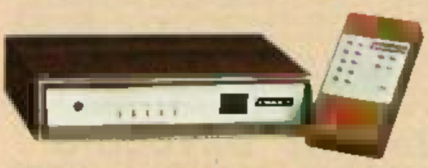
Model 6510 $169.95



Wireless remote control with volume for cable TV, VHF-UHF antenna systems upgrades any TV to 140 channel capability.
• Works with any TV set • Quick, easy installation • Off-air and cable compatible • Quartz frequency synthesizer tuning • Direct access/memory scan selector • Ultra-compact, hand-held wireless remote control

bp 61 CHANNEL WIRELESS REMOTE CONTROL

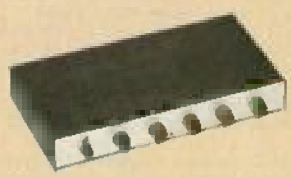
Model V7661 $79.95



Wireless remote control on/off, channel selection and fine tuning.
• Works with any TV • 61 channel capability
• Microcomputer controlled PLL operation
• Converter panel controllable for channel up, down, on/off, fine tuning. • LED display
• Compatible with CATV systems

bp STABILIZER/IMAGE ENHANCER/RF CONVERTER/VIDEO FADER/2-WAY DISTRIBUTION AMPLIFER

Model V1880 $99.95



Hook-up cable kit $11.75

The most versatile, all-in-one video processor. Can be used as a video guard remover for video tapes, enhancer, video to RF converter, professional video fade in and out and a dual output distribution amplifier.

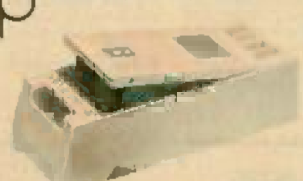
bp VIDEO SWITCH

Model V4804 $49.95

Record a pay channel while viewing a standard channel. You can also connect an antenna/cable, VCR, video disc player, home computer and video game.

bp VIDEO TAPE REWINDER

Model V7777 VHS $49.95
Model V7778 BETA $49.95



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NEW!

uniden®

Bearcat®

Rebates!

Communications Electronics,™ the world's largest distributor of radio scanners, celebrates 1985 with big savings on *Bearcat* scanners. Uniden Corporation of America, the manufacturers of *Bearcat* scanners is offering huge consumer rebates on their great line of scanners, when purchased from CE between February 1 and March 31, 1985.

Bearcat® 300-G

List price $549.95/CE price $344.00/$10.00 rebate
Your final cost is a low $334.00
7-Band, 50 Channel • Service Search • No-crystal scanner • AM Aircraft and Public Service bands. • Priority Channel • AC/DC
Bands: 32-50, 118-136 AM, 144-174, 421-512 MHz

The *Bearcat* 300 is the most advanced automatic scanning radio that has ever been offered to the public. The *Bearcat* 300 uses a bright green fluorescent digital display, so it's ideal for mobile applications. The *Bearcat* 300 now has these added features: Service Search, Display Intensity Control, Hold Search and Resume Search keys. Separate Band keys to permit lock-in/lock-out of any band for more efficient service search.

Bearcat® 20/20-G

List price $449.95/CE price $274.00/$5.00 rebate
Your final cost is a low $269.00
7-Band, 40 Channel • Crystalless • Searches AM Aircraft and Public Service bands • AC/DC Priority Channel • Direct Channel Access • Delay
Frequency range 32-50, 118-136 AM, 144-174, 420-512 MHz

Find an easy chair. Turn on your *Bearcat* 20/20 and you're in an airplane cockpit. Listening to all the air-to-ground conversations. Maybe you'll pick up an exciting search and rescue mission on the Coast Guard channel. In a flash, you're back on the ground listening as news crews report a last breaking story. Or hearing police and fire calls in your own neighborhood, in plenty of time so you can take precautions. You can even hear ham radio transmission, business phone calls and government intelligence agencies. Without leaving your easy chair. Because you've got a *Bearcat* 20/20 right beside it.

The *Bearcat* 20/20 monitors 40 frequencies from 7 bands, including aircraft. A two-position switch, located on the front panel, allows monitoring of 20 channels at a time.

Bearcat® 210XL-G

List price $349.95/CE price $209.00/$35.00 rebate
Your final cost is a low $174.00
6-Band, 18 Channel • Crystalless • AC/DC
Frequency range 32-50, 144-174, 421-512 MHz

The *Bearcat* 210XL scanning radio is the second generation scanner that replaces the popular *Bearcat* 210 and 211. It has almost twice the scanning capacity of the *Bearcat* 210 with 18 channels plus dual scanning speeds and a bright green fluorescent display. Automatic search finds new frequencies. Features scan delay, single antenna, patented track tuning and more.

Bearcat® 260-G

List price $399.95/CE price $274.00/$5.00 rebate
Your final cost is a low $269.00
8-Band, 16 Channel • Priority • AC/DC
Frequency range 30-50, 138-174, 406-512 MHz

Keep up with police and fire calls, ham radio operators and other transmission while you're on the road with a *Bearcat* 260 scanner. Designed with police and fire department cooperation, its unique, practical shape and special two-position mounting bracket makes hump mounted or under dash installation possible in any vehicle. The *Bearcat* 260 is so ruggedly built for mobile use that it meets military standard 810c, curve y for vibration rating. Incorporated in its rugged, all metal case is a specially positioned speaker delivering 3 watts of crisp, clear audio.

FREE Bearcat® Rebate Offer

Get a coupon good for a $35.00 rebate when you purchase a *Bearcat* 210XL, $30 rebate on model 201; $20 rebate on models 180 and 100; $10 rebate on models DX1000 or 300; $5 rebate on models 20/20 or 260. To get your rebate, mail rebate coupon with your original dated sales receipt from Communications Electronics and the *Bearcat* model number from the carton to Uniden. You'll receive your rebate in six to eight weeks. Offer valid only on purchases made between February 1, 1985 and March 31, 1985. All requests must be postmarked by April 15, 1985. Limit of one rebate per household. Special rebate coupon must accompany all rebate requests and may not be reproduced. Offer good only in the U.S.A. Void where taxed or prohibited by law. Resellers, companies and employees of Uniden, their advertising agencies, distributors and retailers are not eligible for this rebate. Please be sure to send in the correct amount for your scanner. Pay the listed CE price in this ad. *Do not* deduct the rebate amount since your rebate will be sent directly to you from Uniden. Orders received with insufficient payments will not be processed and will be returned. Offer subject to change without notice.

NEW! Bearcat® 201-G

List price $279.95/CE price $189.00/$30.00 rebate
Your final cost is a low $159.00
9-Band, 16 Channel • Crystalless • AC only Priority • Scan Delay • One Key Weather
Frequency range 30-50, 118-136 AM, 146-174, 420-512 MHz

The *Bearcat* 201 performs any scanning function you could possibly want. With push button ease, you can program up to 16 channels for automatic monitoring. Push another button and search for new frequencies. There are no crystals to limit what you want to hear.

NEW! Bearcat® 180-G

List price $249.95/CE price $164.00/$20.00 rebate
Your final cost is a low $144.00
8-Band, 16 Channel • Priority • AC only
Frequency range: 30-50, 138-174, 406-512 MHz

Police and fire calls. Ham radio transmissions. Business and government undercover operations. You can hear it all on a *Bearcat* 180 scanner radio. Imagine the thrill of hearing a major news event unfold even before the news organizations can report it. There's nothing like scanning to keep you in-the-know, and no better way to get scanner radio performance at a value price than with the *Bearcat* 180.

Bearcat® 100-G

The first no-crystal programmable handheld scanner.
List price $449.95/CE price $229.00/$20.00 rebate
Your final cost is a low $209.00
8-Band, 16 Channel • Liquid Crystal Display Search • Limit • Hold • Lockout • AC/DC
Frequency range: 30-50, 138-174, 406-512 MHz

The world's first no-crystal handheld scanner has compressed into a 3" x 7" x 1¼" case more scanning power than is found in many base or mobile scanners. The *Bearcat* 100 has a full 16 channels with frequency coverage that includes all public service bands (Low, High, UHF and "T" bands), the 2-Meter and 70 cm. Amateur bands, plus Military and Federal Government frequencies. Wow... what a scanner!

The *Bearcat* 100 produces audio power output of 300 milliwatts, is track-tuned and has selectivity of better than 50 dB down and sensitivity of 0.6 microvolts on VHF and 1.0 microvolts on UHF. Power consumption is kept extremely low by using a liquid crystal display and exclusive low power integrated circuits.

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® DX1000-G

List price $649.95/CE price $499.00/$10.00 rebate
Your final cost is a low $489.00
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.

Uniden® PC22-G

List price $159.95/CE price $99.00

The *Uniden* PC22 is a 40 channel AM remote mobile CB radio. It's the answer for today's smaller cars which don't always provide adequate space for mounting. Since all the controls are on the microphone, you can stash the "guts" in the trunk. The microphone has up/down channel selector, digital display, TX/RX indicator and external speaker jack. Dimensions: 5⅝" W x 7⅜" D x 1½" H. 13.8 VDC, positive or negative ground.

QUANTITY DISCOUNTS AVAILABLE

Order two scanners at the same time and deduct 1%, for three scanners deduct 2%, four scanners deduct 3%, five scanners deduct 4% and six or more scanners purchased at the same time earns you a 5% discount off our super low single unit price.

Uniden® PC55-G

List price $89.95/CE price $59.00

The *Uniden* PC55 40 Channel CB radio is a full featured transceiver that boasts a super-compact case and a front-panel mike. It has ANL, PA-CB, Channel 9 and RF Gain switches, LED "S"/RF meter, TX lite, PA & external speaker jacks. Dimensions: 6" W x 6" D x 1⅝" H. ±13.8 VDC. The *Uniden* PC55...now at a special low price.

Choose from many different models

OTHER RADIOS AND ACCESSORIES

RD55-G Uniden visor mount Radar Detector $119.00
RD95-G Uniden remote mount Radar Detector ... $139.00
FB-E-G Frequency Directory for Eastern U.S.A. $12.00
FB-W-G Frequency Directory for Western U.S.A. ... $12.00
BC-WA-G Bearcat Weather Alert™ $39.00
A60-G Magnet mount mobile antenna $35.00
A70-G Base station antenna $35.00
Add $3.00 shipping for all accessories ordered at the same time.
Add $3.00 shipping per scanner antenna.

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To ***get the fastest delivery from CE*** of any product in this ad, send or phone your order directly to our Scanner Distribution Center.™ Michigan residents please add 4% sales tax or supply your tax I.D. number. Written purchase orders are accepted from approved government agencies and most well rated firms at a 10% surcharge for net 10 billing. All sales are subject to availability, acceptance and verification. All sales on accessories are final. Prices, terms and specifications are subject to change without notice. All prices are in U.S. dollars. Out of stock items will be placed on backorder automatically unless CE is instructed differently. A $5.00 additional handling fee will be charged for all orders with a merchandise total under $50.00. Shipments are F.O.B. Ann Arbor, Michigan. No COD's. Most products that we sell have a manufacturer's warranty. Free copies of warranties on these products are available prior to purchase by writing to CE. International orders are invited with a $20.00 surcharge for special handling *in addition* to shipping charges. Non-certified checks require bank clearance.

Mail orders to: Communications Electronics,™ Box 1045, Ann Arbor, Michigan 48106 U.S.A. Add $7.00 per scanner, radar detector or CB or $12.00 per shortwave receiver for U.P.S. *ground* shipping and handling in the continental U.S.A. For Canada, Puerto Rico, Hawaii, Alaska, or APO/FPO delivery, shipping charges are three times continental U.S. rates. If you have a Visa or Master Card, you may call and place a credit card order. Order toll-free in the U.S. Dial 800-USA-SCAN. In Canada, order toll-free by calling 800-221-3475. WUI Telex CE anytime, dial 671-0155. If you are outside the U.S. or in Michigan dial 313-973-8888. Order today.

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COVER 1

It never seems to fail: Those brand new speakers, that sounded so wonderful in the showroom, sound so disappointing when you set them up in your listening room. The explanation for that is simple: Your system has to be adjusted to accommodate your listening room. An equalizer can help, but only if it's adjusted properly to correct the response of the loudspeakers. That's where our real-time spectrum analyzer comes in. It can turn the job of adjusting an equalizer from a frustrating one to an easy one. Find out more about it, including how to build it, starting on page 43.

NEXT MONTH

ON SALE APRIL 11

COMPUTER-CONTROLLED ROBOT
Use a popular personal computer to operate a robot arm.

SERVICING CORDLESS PHONES
All about those devices and how to troubleshoot and repair them.

OPTOCOUPLERS
Learn how to use those versatile devices in your circuit designs.

STEREO POWER METER
More than a meter, it also disconnects your speakers from your system at the first sign of trouble.

AND LOTS MORE!

As a service to readers, Radio-Electronics publishes available plans or information relating to newsworthy products, techniques and scientific and technological developments. Because of possible variances in the quality and condition of materials and workmanship used by readers, Radio-Electronics disclaims any responsibility for the safe and proper functioning of reader-built projects based upon or from plans or information published in this magazine.

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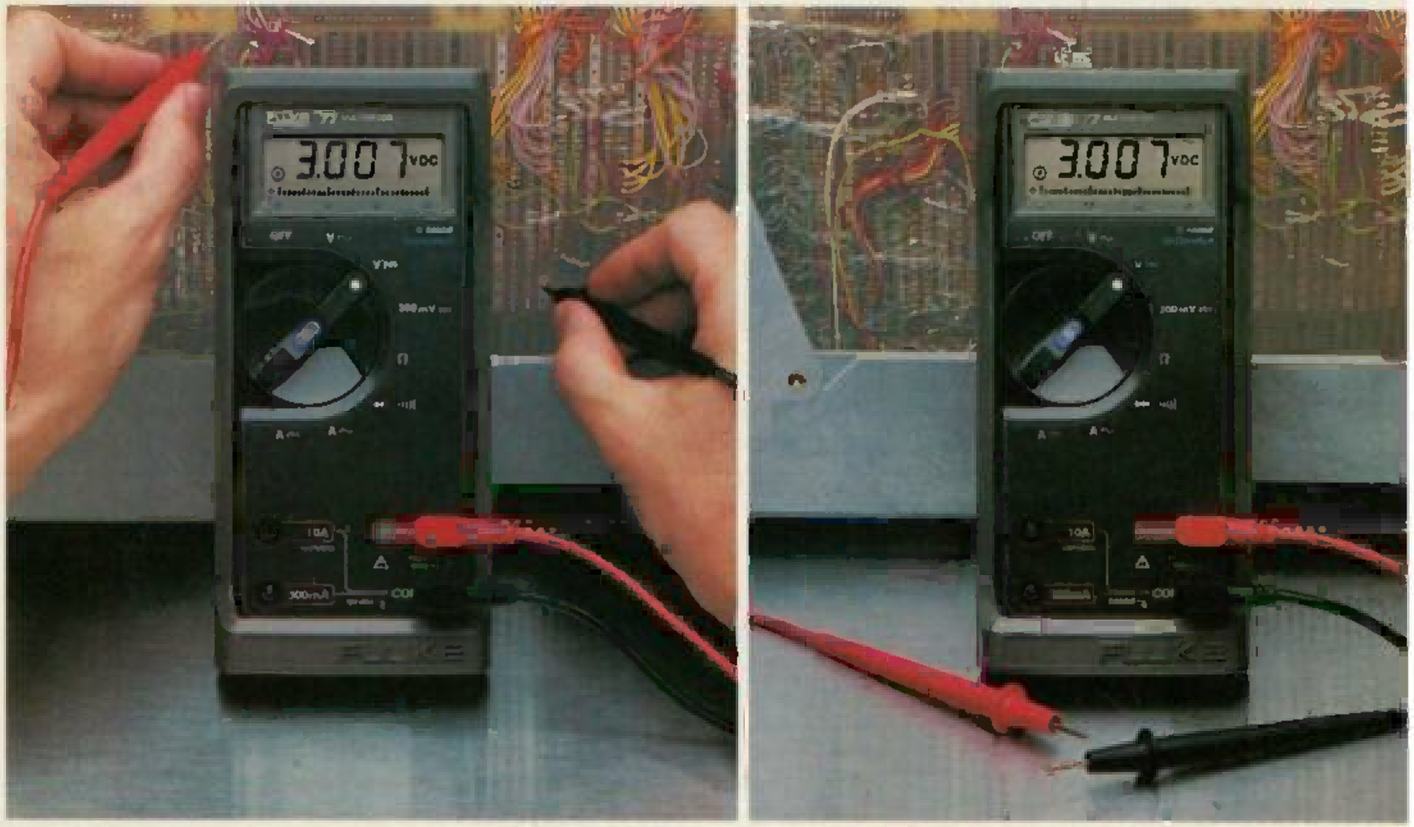

$129* gets you the world's first handheld digital/analog multimeter with "Touch Hold."

The Fluke 77

Its unique "Touch Hold"** function automatically senses and holds readings, leaving you free to concentrate on positioning test leads without having to watch the display.

Then, when you have a valid reading, it signals you with an audible beep.

The Fluke 77 is perfect for those test situations where accessibility is a problem, or when extra care is needed for critical measurements.

It's the top model in the world champion Fluke 70 Series line — the first industrial quality autoranging multimeters to combine digital and analog displays. These tough, American-made meters feature a three-year warranty and 2000+ hour battery life.

So call now for the complete story on the Fluke 77 with "Touch Hold." Because if you don't deserve the world's first, who in the world does?

For the name of your distributor or a free brochure, call our toll-free hotline anytime **1-800-227-3800, Ext. 229.**

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0.7% basic dc accuracy	Autorange/range hold	"Touch Hold" function
2000+ hour battery life	0.5% basic dc accuracy	Autorange/range hold
3-year warranty	2000+ hour battery life	0.3% basic dc accuracy
	3-year warranty	2000+ hour battery life
		3-year warranty
		Multipurpose holster

* Suggested U.S. list price, effective July 1, 1984
** Patent pending

FLUKE®

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WHAT'S NEWS

Comsat, Mitsubishi announce agreement

Comsat Technology Products (CTP), the equipment manufacturing arm of Comsat Satellite Corp, has signed a teaming agreement with Mitsubishi Electric Corp of Tokyo, Japan, to manufacture and market low-cost, small-aperture Ku-band earth stations for use in high-speed document distribution and private data-networks.

Mitsubishi will produce the RF portion of the terminals, and CTP will be responsible for making the digital, signal processing components, and for integrating and marketing the complete earth stations.

According to CTP president A.W. Perigard, the introduction of small-aperture, low-cost earth stations has led many U.S. companies to begin planning for large electronic mail and data networks to take advantage of the efficiencies of satellite communications. The combination of Mitsubishi's price-competitive microwave components and CTP's signal-processing equipment and system integration, he believes, should ensure the success of the venture.

New magnesium batteries hold promise for future

A dry cell with a shelf life of at least five years and a voltage output of 1.9 is promised as a result of research in magnesium battery design culminating in a recent patent application by ACR Electronics of Hollywood, FL. In addition, the new battery would have greater capacity for its size, lower internal resistance, and a higher peak discharge rate than present dry cells.

Magnesium's greater tendency toward chemical reaction—which is the cause of its higher voltage—also forms a protective layer on its surface when the battery is idle. This inhibits the "local action" or spontaneous internal discharge, that runs down a zinc-carbon battery when not in use. But this film, which so greatly increases shelf life, takes time to break down when the circuit is "turned on." The delay can last as much as a minute before the load breaks down the protective film and current rises to normal. A second problem is that the chemical reaction in the cell builds up gas, which must be vented.

Research by ACR has reduced or eliminated those problems. An improved electrolyte produces water instead of gas, and other improvements have reduced the "current-on" delay to less than 0.3 seconds.

A unique feature of the magnesium batteries is their "inside-out" construction. Instead of the negative zinc can, the carbon positive element is cast in one piece to serve both as container and positive center pole. The negative element is an extruded magnesium cylinder that fits concentrically between the center carbon electrode and "can." This positioning also reduces the length of the electrical paths in the cells, reducing internal resistance.

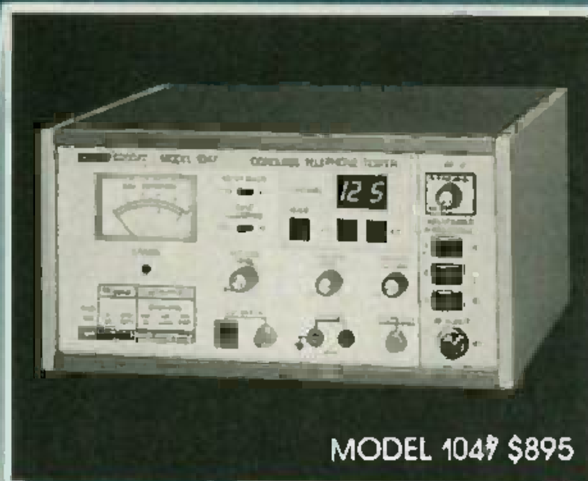
Although magnesium batteries have been used for some years in special applications, such as marine markers and rescue lights, and in several space programs, they are not yet quite ready for general consumer use. A number of problems remain—among which are adaption of radio equipment or flashlight bulbs to the 1.9-volt rating of the new cell. But it is reasonable to suppose that we will in time have a flashlight that can remain idle in the car for years and still supply top performance. R-E

NEW MAGNESIUM BATTERY features an "inside-out" construction. The positive element serves as both the center electrode and the battery can.

New from B&K-PRECISION, for telephone service, test and repair

COMPLETE TELEPHONE PRODUCT ANALYZER. A total self-contained system for diagnostic testing, servicing and calibration of corded and cordless telephones, answering machines and automatic dialers. Performs every test you'll ever need to test and repair any phone product including verification of pulse and touch-tone numbers, measurement of frequency error and modulation deviation. **MODEL 1050 $1695**

CORDLESS TELEPHONE TESTER. Provides full servicing and calibration capability for base and portable phone units. All rf test and measurement functions. Replaces expensive FM generators and modulation monitors, yet performs all tests required for cordless phone system analysis and repair, including full frequency testing and alignment. Generates all prior and recently approved frequencies. **MODEL 1047 $895**



TELEPHONE PRODUCT TESTER. For in-store consumer or service use. Tests handset cord, phone line cord, dial/redial functions, voice and dial number levels, ring function and voice quality of corded and cordless phones, answering machines and automatic dialers. **MODEL 1045 $395**

TELEPHONE LINE ANALYZER. Quickly identifies a problem as external or in the phone itself. Tests for condition of external phone line, phone line cord, ring and line voltage levels and polarity. Easy to use, no batteries or external power needed. **MODEL 1042 $19.95**

These test instruments cover every possible level of service required for telephone products. They are equally useful for training. The instruction manuals provided offer a comprehensive course of training for service personnel and students. Call your nearest B&K-PRECISION distributor for off-the-shelf-delivery or additional information—or contact B&K-PRECISION.

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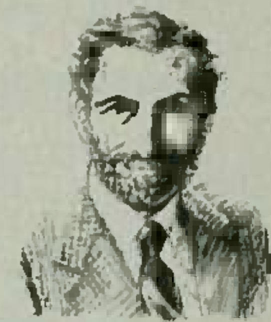
VIDEO NEWS



DAVID LACHENBRUCH
CONTRIBUTING EDITOR

• **Here comes Super Beta.** Around midyear, Sony and other Beta VCR manufacturers are scheduled to introduce "Super Beta," a new version of the Beta system, which is claimed to achieve a 20% increase in picture resolution. Super Beta recorders use standard Beta cassettes, but shift the carrier signal frequency upward by 800 kHz resulting in a wider luminance bandwidth for a sharper picture with more detail. In addition, the system has special video noise reduction and emphasis circuitry.

Super Beta produces a picture with more than 300 lines of horizontal resolution and about 45dB signal-to-noise, according to Sony estimates. Thus it falls short of the super-high-band VCR's mentioned previously in this column as being in the works. However, the picture is extremely good, and it particularly excels for home editing—demonstrations showed that a fourth-generation Super Beta tape was at least as good as a second-generation tape made on a standard Beta recorder. The Beta group claims complete compatibility—that is, tapes recorded on Super Beta can be played back on standard Beta recorders and standard tapes can be played on Super Beta machines.

• **More 8mm VCR's.** The first VCR's in the new 8mm video format to be sold here were combination camera-recorders, or camcorders, by Eastman Kodak, General Electric, and Polaroid. Now along come the first "separates"—tiny portable decks designed for use with miniaturized video cameras and with separate tuner-timers.

The little decks weigh about four pounds or so, including battery, and use the new 8mm cassettes. The Sanyo unit, priced at $1,100, including tuner-timer, has a two-speed switch to double the playing time of a 90-minute cassette. Canon's Canovision deck is priced at $900, the companion programmable tuner-timer at $300.

• **35-inch color tube.** The world's biggest direct-view color picture tube, a 35-inch model, will be introduced in the United States this fall in a new set by Mitsubishi. The TV console will sell for around $3,000, but the company promises future models at lower prices. The tube is 22.4 inches deep, weighs 110 pounds, has center brightness of 170 foot-lamberts with resolution comparable to Mitsubishi's best 26-inch—330 lines horizontally on broadcast TV, 400 on video input. Power consumption of the set will be 180 watts as compared with 160 watts for Mitsubishi's 25-inch models.

The largest picture tube in any set previously offered in the United States was 30 inches in a special Sony 35th Anniversary model console produced in a limited run of 1,000 sets, retailing at $10,000. The biggest tubes scheduled for production in the United States measure 27 inches diagonally and won't be available until 1986.

• **TV extenders.** Two new gadgets are designed to make it easy to add more TV sets to your home without having to string up cable. Rabbit, by Envision Systems, Santa Monica, Cal., connects to a VCR's video and audio outputs and puts them on an FM carrier for transmission to television sets throughout the house via the electrical wiring. One transmitter and one receiver cost $100, extra receivers are $40. Quantec International, Salt Lake City, offers a low-power transmitter that connects to the RF output of a VCR, game, computer, or videodisc player and is said to permit tuning on any rabbit-ear-equipped TV set up to 40 feet away. R-E

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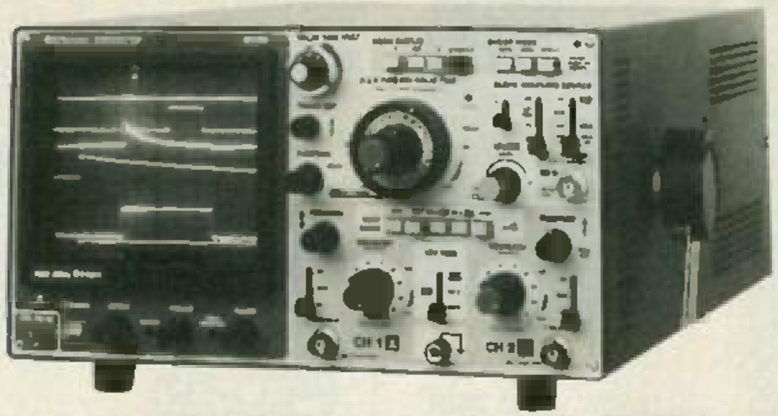

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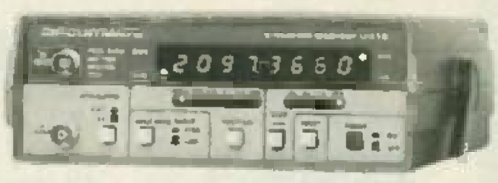

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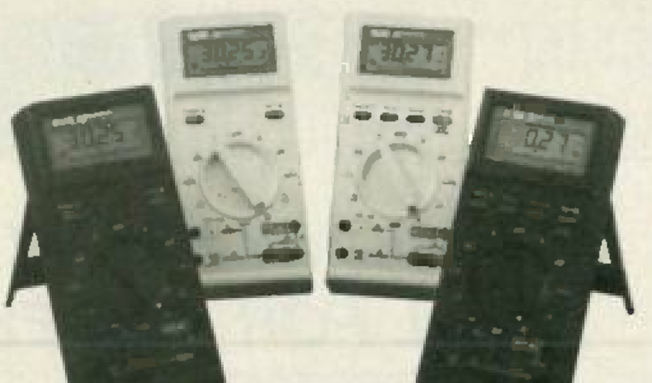

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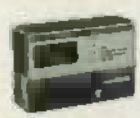

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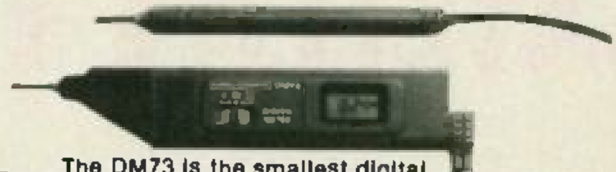

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SATELLITE TV

TVRO receivers and remote controls

BOB COOPER, JR.*
SATELLITE TV EDITOR

AS WE BEGAN TO SEE IN LAST MONTH'S column, the TVRO receiver of today has changed greatly over the past five years or so.

Take the IF portion of the receiver, for example. The basic receiver must develop a significant "bulk gain" in the lowest IF segment—as much as 50 dB of gain at 70 MHz (in 1980). In the IF section, we also find single-channel filtering networks that eliminate (with bandpass filter sections) any signal energy on adjacent satellite channels. Up to 50% of the total receiver in 1980 was wrapped up with parts in the IF segment.

The 1984/85 TVRO receiver uses amplifier stages constructed from a few IC's; gone are the discrete transistors, and associated resistors and capacitors. The mixture of coils and capacitors that once made up elaborate bandpass filters have been replaced by SAW-filter devices. As a result, today's IF stages may have only a dozen (or fewer!) parts.

As we all know, fewer parts usually mean fewer dollars per receiver (in parts and labor). And any reduction in parts typically results in an improvement in mean-time-between-failures and, eventually, lower cost to the consumer. Before the end of 1985, we can expect to see a complete single IC that accepts the 70-MHz IF and "spits" out demodulated video and audio.

Enter remote control

The early TVRO terminals of 1979/80 not only lacked remote-control capabilities, but they were probably impossible to control even locally (manually)! At that time, all TVRO-system components (dish mover, receiver, etc.) were manufactured by different companies, who made no effort to make their respective products capable of communicating with the other components that made up the system.

* PUBLISHER, CSD MAGAZINE

FIG. 1

TVRO dealer "Starter Kit" available

Bob Cooper's *CSD Magazine* has arranged with a number of TVRO equipment suppliers to provide a single-package of material that will help introduce you to the world of TVRO dealership. A short booklet written by Bob Cooper describes the start-up pitfalls to be avoided by any would-be TVRO dealer, in addition, product data and pricing sheets from prominent suppliers in the field are included. That package of material is free of charge and is supplied to firms or individuals in the electronics service business as an introduction to the 1984/85 world of selling TVRO systems retail.

You may obtain your *TVRO Dealer Starter Kit* free of charge by writing on company letterhead, or by enclosing a business card with your request. Address your inquiries to: *TVRO STARTER KIT, P.O. Box 100858, Fort Lauderdale, FL 33310*. That kit *not* available to individuals not involved in some form of electronics sales and service.

That meant that every function was separate, requiring separate (unrelated) pieces of hardware to accomplish each task. For example: *Channel selection* was one function; *audio selection* was another (although the circuitry might have been located in the receiver cabinet); *fine tuning* was a separate function (within the basic receiver); *polarity selection* was another function, and *satellite selection*, yet another.

As TVRO systems progressed, synthesized tuning eliminated the need for a manual fine-tuning control, and memories made audio subcarrier tuning a thing of the past—you tuned it but once when the receiver was first set up. Polarization selection also went away when receivers were either "hard wired" or equipped with memory tied to the receiver's channel-selection switch. That allowed the correct polarization to be automatically selected when a new channel was tuned.

Now we're left with satellite selection and the basic channel selection. In many modern receivers, those two functions are combined into a single step; you tell the receiver what satellite you want and which transponder (channel) all in a series of strokes on a keypad. The receiver's memory, interfaced to the antenna drive unit, along with polarization switching does it all for the user. The system can be infrared controlled or (UHF) wireless or hard-wire controlled.

What's available

A number of receiver packages, like those from Arunta and Con-

ECG® LED Lamps

Philips ECG has LED lamps in shapes and sizes for virtually any application. They're available in round, rectangular, triangular and square shapes. They come in red, yellow, green, or even in two colors. And there's a choice of clear and diffused reds. Some have jewelled lenses. And some are even available as flashing LEDs with the flasher circuit built in.

In addition, long-life, shock-resistant, vibration-resistant, LED replacements for incandescent cartridge indicator lamps are also available in red, yellow or green.

Common applications: All LED indicator applications. LED cartridges are ideal replacements for cartridge-type incandescent lamps.

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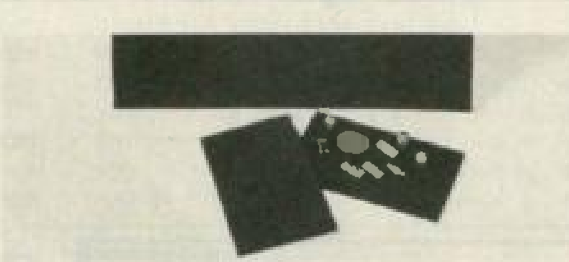


ECG® High-Voltage Rectifier and Voltage Divider Network

Philips ECG's ECG568 is a high-voltage rectifier used in Sanyo and Sears TV sets to supply high voltage to the picture tube. It also contains a voltage divider network which supplies focus voltage to the picture tube.

Common applications: For use in television service and repair.

CIRCLE 298 ON FREE INFORMATION CARD

EMF® Transient Voltage and RF Interference Suppressors

EMF transient voltage surge suppressors by Philips ECG clamp voltage spikes on 120 VAC line to levels safe for all electronic equipment. They can handle up to 40% greater surge current than other suppressors. Single outlet suppressors are available in both two- and three-prong versions.

The multiple outlet EMF315 incorporates both a spike suppressor and a PI filter to suppress RF interference on the AC line. RF interference causes audio and video degradation and causes digital equipment to function imperfectly.

Common applications: Electronic equipment such as hi-fi and television, stereo, computers or other line-operated electronic equipment subject to voltage surges and radio frequency interference from the AC line.

CIRCLE 299 ON FREE INFORMATION CARD

ECG® A-STAT Material

Philips ECG has two sizes of anti-static foam that will prevent damage to semiconductors from static electricity. The A-STAT 12 measures 12" x 12" and is perfect for bench use. The A-STAT 2 measures 3" x 5" and can be carried in the tool box. When semiconductors are kept in A-STAT foam, static electricity is shunted through the foam instead of into the semiconductor, where it could have caused damage.

Common applications: Essential for semiconductor protection on the workbench or in the field.

CIRCLE 271 ON FREE INFORMATION CARD

CIRCLE 68 ON FREE INFORMATION CARD

ifer, have the complete control system built into the basic receiver. Intersat and Arunta provide hand-held remote-units that allow full system control from your favorite easy-chair, or any other place within "sight" of the receiver.

The makers of the more sophisticated dish-mover systems, recognizing that not all receivers are equipped with remote-control capabilities, designed expandable dish-control units—like the *Tracker IV*, from Houston Tracker Systems—that offer remote control. (See Fig. 1.) Such units feature (UHF wireless) remote control over the antenna-drive system that, with dealer-installed interfacing, allow otherwise unavailable full system remote-control.

Like any relatively high-end package, such frills do not come in at low-end prices. And that has created a far broader marketplace for TVRO systems than existed back in 1979/80. Let's take a quick look at what you get in the various home TVRO-system price ranges—from low-end, no-frills packages to the more sophisticated high-end systems.

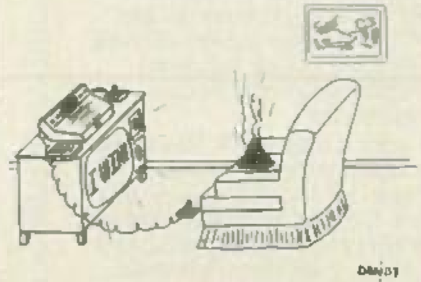
Price range

Starting with the least expensive *install-it-yourself* systems, the market starts off with packages that feature 4.5–6-foot antenna dishes, equipped with non-motorized mounts and simplistic electronics that retail for just under $1,000 ($995) in many sections of North America. Many marketing experts feel that such systems may be the wave of the future (offering 20 to 30 channels of satellite TV to the "average" user.)

The next sizable range of systems comes in at around $1995. These systems (usually dealer-installed) are simply slight upgrades of the no-frills packages. The system may contain a slightly larger antenna with polar-mount, and hand-operated dish mover. Dealers who know what they are doing seldom install the lower priced system.

Then we have the motor-driven systems—priced in the $2995 region—that feature higher-quality receivers, but few remote-control functions. An industry study in the late spring of 1984 showed the average system selling for just under $3000 nationwide.

Now we come to the high-end packages, selling for as high as $5995 in some parts of the country, that feature full remote control, receivers with memory, and stereo audio, with all the frills and do-dads that American and Japanese engineers have been able to create. Between the low-end and high-end price ranges ($995–$5995), there is an extremely wide selection of systems. Next time, we'll see how all of what has happened shapes up in the marketplace. **R-E**



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INTERFACING THE ZX81

This letter is in response to the article "Interfacing the ZX81," (Radio-Electronics September, 1984). The article makes the following statement in reference to interfacing a relay to a microprocessor system: "The disadvantage of this configuration is...mechanical relays that can be controlled with logic-levels signals typically can only handle loads up to 0.5 amp at 120 volts." While that is what I'd call a close guess (assuming you use a relay with a coil voltage of five volts), the following circuit may be helpful to readers who have a variety of relays available.

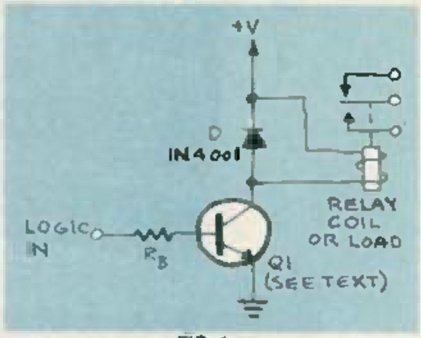

FIG. 1

In my area of the country there are many high current relays (3–10+ amps) available at surplus stores for peanuts. While it is true they do not all operate at five volts, by the circuit shown in Fig. 1, I have been able to control various relays with coils of 5–30 volts DC. That circuit will energize the relay (or other load) if a logic one is written to the base of Q1 via a 8155, 8755, etc.

The first step is to determine the collector current, I_C, required. That, of course, is simply the current needed to energize the relay. To be on the safe side, choose a value that is twice that for I_C. Pick an NPN transistor that will satisfy that requirement, and use that

transistor's base current, I_B, and beta, h_{fe}, to determine the value of R_B. That can be found from:

$$I_B = I_C/h_{fe}$$
$$R_B = V_L/I_B$$

where V_L is the worst case logic voltage. For TTL circuits, the value of V_L is 2.5 volts.
ROBERT PARENT
Boyceville, WI

EASY PC BOARD REPAIRS

"How to Repair PC Boards," by Robert Grossblatt, (**Radio-Electronics**, July 1984) was an interesting and helpful article on repairing damaged PC boards. However, preferably one should try not to damage a PC board, thereby avoiding the repair tasks outlined in your article. We have found, from experience, that a lot of damage to PC boards is caused by inconvenient desoldering methods, especially those that use an idling soldering iron and excessive temperature influence over a prolonged period of time while removing components.

A product that might be of help to your readers is desoldering braid. Desoldering braids, well known in industrial applications, and to do-it-yourself electronics hobbyists, do avoid many problems. The desoldering braids allow only a gradual increase of the temperature level when the desoldering operation is being made. The solder joint is "protected" by the original cold wick and the laminate therefore is not exposed to severe heat stress.
ERNEST SPIRIG, PRESIDENT
S.A.T. INC.
Agawarm, MA

ADDRESS CHANGE

The article "Build the Tele-Toll Timer", published in the November 1984 issue of **Radio-Electronics**, listed the address of Mendakota Products, Ltd., supplier of a kit of parts for the project, as PO Box 20HC, 1920 W. Commonwealth Ave., Fullerton, CA 92633. Readers may now write to Mendakota Products Ltd. at their new address: PO Box 2296, 1001 W. Imperial Highway, La Habra, CA 90631.—Editor

LONGER VCR WARRANTIES

There are a couple of interesting items in your November issue. One is the Editorial. The problem reminds me of the one some years ago with garage-door openers. That was solved by having an arrangement where an individual code was picked by each user. Application of that method to VCR's might be a little more difficult, but it can be done. That method could also solve another potential problem: If I have two VCR's in the same location, and they are of the same make, how can I select one of the two to the exclusion of the other? That would not be solved by standardization of codes, as you suggest, but might be if I could choose the codes myself.

The other item is in "Video News." The statement is made that the service record of VCR's already compares with that of color TV. If this is true, why aren't the manufacturers more generous with their warranties? Color TV's come with a one-year warranty on the set

continued on page 26

SS-5705, THE ALL-NEW 3-INPUT 6-TRACE 40 MHz OSCILLOSCOPE FROM IWATSU

- **H and V axes accurate to within ±2 %**
- **CRT with 12 kV accelerating voltage for bright traces**
- **Three input channels, six traces:** an enlarged delayed sweep waveform can be displayed for each channel for a total of 6 simultaneous traces. Each channel has its own position control.
- **Maximum delay jitter of 1/20,000**
- **Fastest sweep rate of 10 ns/div**
- **Jitterless circuitry** for stable high frequency signals observation.
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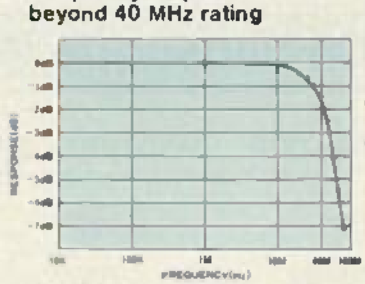
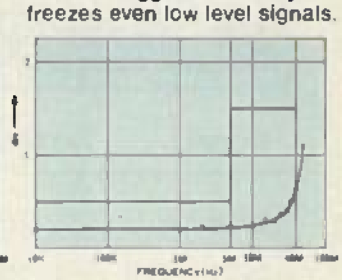
- **CH 1 signal output:** 50 mV/div (into 50 Ω)
- **High-stability calibrator** with frequency and voltage accurate to within ±1 %.
- **Stable observation of video signals possible**
- **Traces do not shift when the attenuator is switched**
- **Pushbutton controls** for easier operability and improved reliability.
- **Accuracy guaranteed** in temperatures ranging from 10 to 35°C (50 to 95°F).
- **Variable holdoff** for triggering when observing complicated waveforms.
- **FIX triggering**
- **Beam finder**

- **Frequency response extends beyond 40 MHz rating**



- **Superb trigger sensitivity** freezes even low level signals.



- **Single sweep:** essential if waveforms are to be photographed.
- **Trace rotation control** allows compensation for inclination of traces due to terrestrial magnetism.
- **Two probes provided as standard accessories:** both switchable between 10:1 and 1:1.
- **Wide range of optional extras** for more diverse applications.
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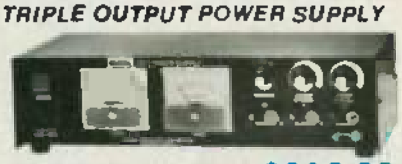

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- Fully automatic current limiting

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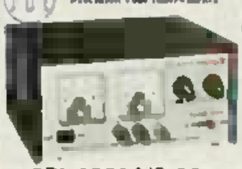

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MODEL 3002A/0-30 VDC/0-2A

B+K PRECISION TRIPLE OUTPUT POWER SUPPLY

MODEL 1650 **$319.00**

- Functions as three separate supplies
- Exclusive tracking circuit
- Fixed output 5 VDC, 5A
- Two 0 to 25 VDC outputs at 0.5A
- Fully automatic, current-limited overload protection
- + and − terminals of each output are fully isolated, in all modes
- All three outputs may be connected in series or parallel for higher voltage or current

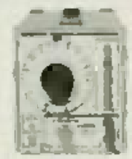
PROBE MASTER Oscilloscope Probes

MODEL	ATTENUATION	BAND WIDTH (MHZ)	PRICE
2904	10X	100	$35.00
2901	10X/1X	100/5	$39.00
2205	10X	250	$59.00
2960	10X	60	$30.00

LEADER Instruments Corporation

Audio Sine/Square Wave Generator

- Distortion from <0.03%
- 10 Hz to 1 MHz



$259.00 **LAG-120B**

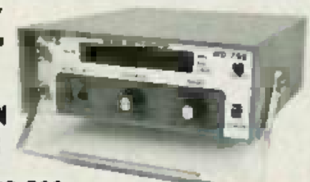
B+K PRECISION FUNCTION GENERATOR

$189.00

MODEL 3010

- Sine, square and triangle output
- Variable and fixed TTL outputs
- 0.1 Hz to 1 MHz in six ranges
- Typical distortion under 0.5% from 1 Hz to 100 KHz
- Variable DC offset
- VCO input for sweep tests

VIZ MULTI-FUNCTION COUNTER



MODEL WD-755 **$259.00**

- 5 Hz to 125 MHz
- 8 Digit LED Display
- Period Measurement 5 Hz to 2 MHz
- Totalizes to 99,999,999 Plus Overflow
- Frequency Ratio Mode
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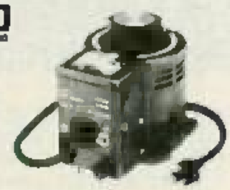
- Switchable Attenuator & Low Pass Filter

STACO ENERGY PRODUCTS CO
VARIABLE TRANSFORMER



$145.00

MODEL 3PN1010V

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- 3½ digit LCD display
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- 0.2% basic accuracy

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$139.00

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RAG ELECTRONICS, INC. / 21418 Parthenia Street / Canoga Park, CA 91304 / 1-818-998-6500

HHSmith HITACHI Hitachi Denshi, Ltd IET KEITHLEY LEADER Instruments Corporation ONEAC

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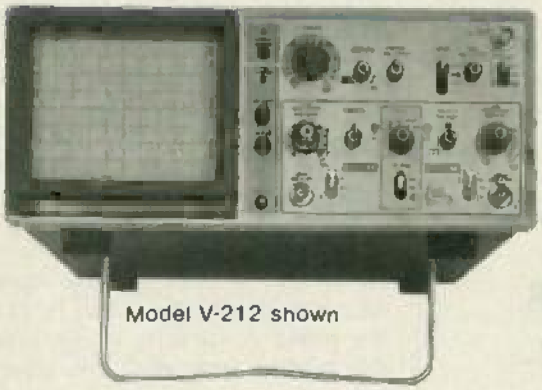
SCOPE SPECTACULAR

HITACHI Hitachi Denshi, Ltd. PORTABLE OSCILLOSCOPES



Model V-212 shown

Model V-1050F shown

MODEL V-212 **$461.00**
DC to 20 MHz, 1 mV/div, Dual Trace
Features 6" Rectangular CRT
Full 2 year parts and labor warranty (w/two X10 probes).

MODEL V-222 **$536.00**
DC to 20 MHz, 1 mV/div, Dual Trace. D.C. offset for DMM Output, Verticle Mode Trigger
6" CRT (w/two X1/X10 probes).

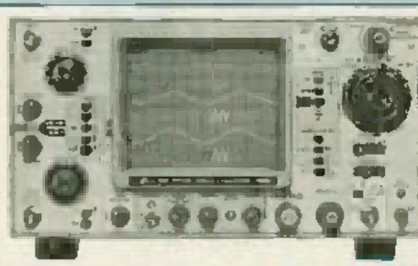
MODEL V-422 **$694.00**
DC to 40 MHz,
other features same as V-222 (w/two X1/X10 probes)

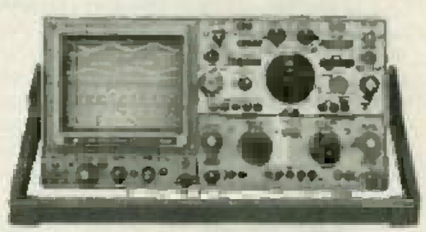
MODEL V-1050F **$1276.00**
DC to 100 MHz, .5 mV/div, Quad Trace, Delayed Sweep, Full T.V. Triggering, alternate time base (w/two X1/X10 probes)

MODEL V-650 **$956.00**
DC to 60 MHz, 1 mV/div, triple trace, delayed sweep, Full T.V. Triggering, variable trigger hold-off

CIRCLE 254 ON FREE INFORMATION CARD

IWATSU PORTABLE OSCILLOSCOPES





MODEL SS-5702 **$535.00**
DC - 20MHz, 5 mV/div
Dual trace
6 inch rectangular internal graticule CRT.
Includes 2 each x1/x10 probes and full factory warranty; 2 years on parts, labor and CRT.

MODEL SS-5705 **$899.00**
DC to 40MHz
Vertical and horizontal deflection accurate within ±2%. CRT acceleration voltage 12KV. 3 channels.
6 traces. High precision calibrator (±1%). Fastest sweep rate: 10 ns.
- High sensitivity 1 mv/div
- CH1 signal output
- Beam finder
- Delayed sweep
- Alternate time base
- 2 ea. X1/X10 Probes

MODEL 5711 **$1695.00**
DC to 100MHz (typically over 120 MHz), 5 mV/div. True 4 channel input, eight trace, Delayed sweep, alternate time base. CRT acceleration voltage 20 KV, (w/saddle bag, front cover, 2 ea X1/X10 probes).

MODEL 5711D **$2495.00**
(5711 with counter and DMM).

PROBE MASTER · Polaroid · Shimpo · Simpson · PRIMELINE A SOLITEC PRODUCT · STACO · VIZ

LETTERS

continued from page 22

and two years on the picture tube. Audio recorders also usually have a one-year warranty. That contrasts with the "generous" 90 day one for the VCR's. In recent years models that are programmable for three or more weeks with up to eight programs have become available. In fact, I believe some new ones claim one year. If the three-week capability is defective, the buyer cannot be sure in less than six or eight weeks, if he makes careful tests. Then there is the time spent in servicing, and then again time to test, as well as the need to check all the other functions. I don't believe most purchasers expect to spend a lot of time trying out the special features. It seems that a one-year warranty would be fairer.

DAVID C. HESS
Downers Grove, IL

ADDITIONAL BATTERY INFORMATION

As a Reliability Engineer for a minicomputer manufacturer who uses large quantities of lead-acid type rechargeable batteries, I enjoyed seeing the articles on "Rechargeable Batteries" (**Radio-Electronics**, September and October 1984). My experience has been with lead-acid "gell cell" and "sealed lead-acid" types, which are also manufactured by Globe-Union and Gates in addition to the sources you listed. I wish to contribute additional information.

Safety: First and foremost, those batteries have very high current capacity and, if shorted, will cause the shorting conductor to heat to the point of melting or ignition. The battery may melt the object across the terminals, may explode, or ignite any flammable materials nearby. Never use hot-melt glue, cardboard, or similar flammables to fabricate batteries from lead-acid cells. Use extreme care to protect exposed terminals from accidental contact across metal surfaces (including metal shelves and table tops.) Batteries or cells shorted in this manner are usually destroyed in seconds.

Shelf life: Shelf life is long on lead-acids, but not infinite. Our procedures call for six-month testing of shelf-stored batteries and recharging if the battery measures below 2.0 volts per cell (2.15 volts per cell is considered full charge and 1.5 volts after storage is unusable and will not recharge.) Shelf life is best insured by fully charging any battery prior to prolonged storage, generally at a 24-hour charging rate, and by maintaining a temperature suited to shelf storage. Six months is the shelf figure normally used at 75°F or room temperature. That figure is greatly extended at lower temperatures such as 40–50°F or reduced at elevated temperatures of 90–100°F.

Usage: Another point about lead-acids: If they are used in a deep-discharge cycle, recharging must begin within six hours of the discharge time. Most batteries held in deep discharge for longer periods cannot be recharged and must be replaced.

JAMES V. GREER
Perkin-Elmer *Oceanport, NJ* **R-E**

EQUIPMENT REPORTS

Alden Model 9321 Weatherchart Recorder

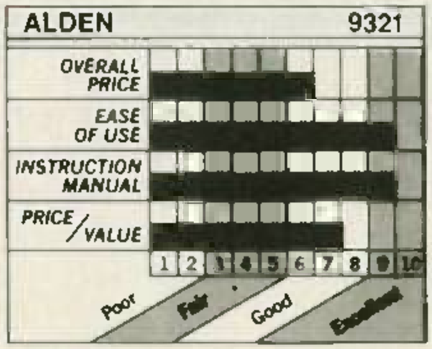
Keep an eye on the weather with this chart recorder. It's available in kit form, too.

CIRCLE 5 ON FREE INFORMATION CARD

DOES YOUR MIND COME TO ATTENTION when you hear weather reports of storms brewing at sea? If you are an avid sailor, or you're just into weather forecasting as a hobby, you need to know all there is to know about what's happening "out there."

One way to keep track of the ocean's surface weather, ice formations, the condition of the Gulf Stream, or anything else having to do with the "big ponds," is through the Alden model 9321 Weatherchart Recorder (Alden Electronics, Washington St., Westborough, MA 01581.)

The Alden Weatherchart Recorder is a facsimile printer specifically designed to recreate the charts broadcast on shortwave frequencies by marine radiofacsimile stations throughout the world. The North and South Atlantic and Pacific oceans, the Indian ocean, the Antarctic, the Red Sea, the Persian Gulf, and coastal waters are all served by the radiofacsimile broadcasts.



The charts are broadcast on many different frequencies, from 4 MHz to approximately 20 MHz. (A directory of the stations, frequencies, and time of operation is supplied with the recorder.) The facsimile signals, which are easily recognized by their distinctive ding-dong sound, can be received on any shortwave receiver capable of upper-sideband reception. The tones are converted to hard-copy printouts by the Alden Weatherchart Recorder.

The chart recorder is housed in a plastic cabinet that measures 17$\frac{1}{16}$ × 3$\frac{5}{8}$ × 10$\frac{1}{4}$ inches. It weighs a shade over 10 pounds. It is powered by 117-volts AC. The input to the recorder is 600 ohms balanced, available at a terminal strip located on the rear. An accessory matching transformer is provided for unbalanced receiver outputs, such as a headphone jack. However, we connected the recorder's 600-ohm input directly to a receiver's 4-ohm headphone output and had no difficulty of any kind in driving the recorder. It is possible that some receivers might require the matching transformer, but we tried several, ranging from a budget-priced "shortwave radio" to a top-of-the-line communications receiver, and always got good results without the matching transformer.

The top of the recorder has the main power switch, the start switch, two LED's that serve as tuning indicators, and a framing switch that centers the pictures on the paper.

The charts are created on a roll of 11-inch wide electrosensitive paper that is supplied in a cylindrical cassette that mounts near the front of the machine. (You tear off the charts as needed.) Motor-driven rollers located in front of the cassette feed the paper out. The image is traced on the paper by a stylus assembly located between the cassette and the rollers that "burns" the image into the paper. As you would expect from the method of creating the image, the paper is damp because it contains a conductive fluid. The electric current representing the image passes through the paper and the stylus, causing a burn where they touch.

The recorder responds to FSK

(*F*requency *S*hift *K*eying) frequencies of 1500 Hz ("white") and 2300 Hz ("black"). While the machine can be started and stopped manually, it also operates under tone control, broadcast from the radiofacsimile stations.

How it works

The receiver is first pretuned to the desired station by adjusting the receiver's tuning control until the "white" tuning indicator flickers most of the time and the "black" indicator flickers occasionally. The actual tuning adjustment isn't critical; as long as the tuning indicator lights appear to be "in the ballpark" the recorder works properly. Once the tuning is set for a particular station, it does not have to be readjusted because the recorder can accommodate a rather broad receiver drift. (We got excellent results from a low-cost receiver.) Prior to broadcasting weather charts, the radiofacsimile station transmits an automatic start signal that shifts 1500 Hz and 2300 Hz at a 300 Hz rate for 5 seconds. The recorder starts, prints the chart, and is automatically stopped when the station broadcasts the same tones, but at an alternating rate of 450 Hz for 5 seconds.

Part of the initial setup procedure requires adjusting the framing so the picture is "centered" on the paper, thereby avoiding loss of part of the picture. That is done by observing the print as it is made by the stylus and pressing the FRAME switch until the chart is centered on the paper. The FRAME switch causes the framing to change in small discrete increments, and we found about five to seven increments was all it normally took to center the chart.

Once the chart is framed, the framing procedure does not have to be repeated as long as the same station is received.

The recording rate is 120 spm (*S*cans *P*er *M*inute). It takes approximately 15 minutes to receive a 10- × 12-inch chart. A station might broadcast several charts followed by an "end" tone, which stops the recorder. The cycle will be repeated the next time a chart is broadcast.

The Alden Weatherchart Recorder (which is also available in kit form) is supplied with two paper cassettes, three spare stylus belts, the audio matching transformer, two spare fuses, and a selection of notably good manuals. The operator's manual is superb; it is clear, concise, unwordy, and is well illustrated. Also supplied is a directory of worldwide facsimile stations, a guide to understanding radiofacsimile weather charts, and a technical manual that includes the step-by-step kit assembly.

Like all other professional equipment, the Alden Weatherchart Recorder doesn't come cheap. The kit version is priced at $995, the wired version (the model we tried) sells for $1995. This is such highly specialized equipment that its value can only be judged in terms of its necessity. But, if you're into weather studies for business or a hobby it's worthwhile looking into. **R-E**

MFJ Enterprises MFJ-989 Antenna Tuner

Get peak performance at almost any frequency with almost any antenna, feedline combination.

CIRCLE 6 ON FREE INFORMATION CARD

AS ANY RADIO AMATEUR OR SHORTwave listener knows, for best performance, the antenna-feedline system and receiver or transmitter must be matched as perfectly as possible. If you operate at only a single frequency, that does not present that much of a problem, as an antenna can be cut and tuned for peak performance at that frequency.

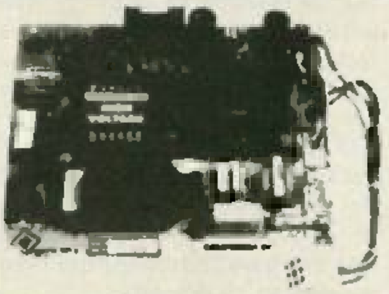
But if you operate over a wide variety of frequencies, or worse, several bands, things prove to be a bit more difficult. Antennas may be cut for use over an entire band of frequencies, such as 40 meters, but such an antenna will only provide peak performance over a narrow range of frequencies, with performance dropping off markedly at the ends of the band. That effect is even more pronounced if a trapped multi-band antenna is used.

Those problems can be minimized through the use of an antenna tuner. Those devices let you tune almost any type of antenna system to maximum efficiency. One such tuner is the *MFJ-989* Versa-Tuner V, from MFJ Enterprises, Inc. (921 Louisville Rd., Starkville, MS 39759).

The *MFJ-989*

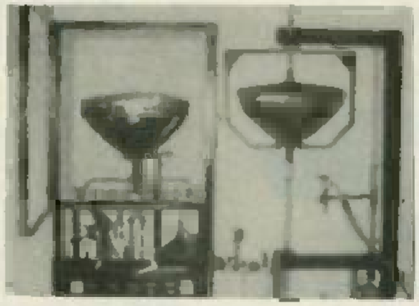
The unit is intended for amateur radio use, but could also be used by the SWL who demands top performance from his receiving setup. A match for today's smaller transceivers, the unit measures 10.5 ×

Radio-Electronics mini-ADS

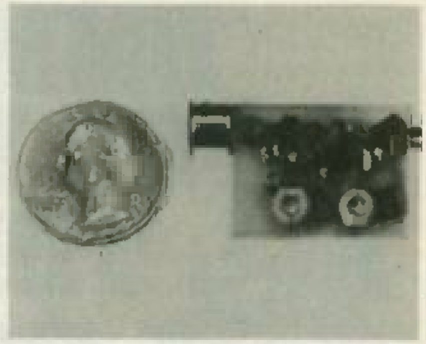


CALIFORNIA-DC REGULATED SWITCHING POWER SUPPLY +5v dc @ 5 amp +12v dc @ 2.8 amp +12v dc @ 2 amp −12v dc @ .5 amp 115-230v ac input. fused. EMI filtered. Removable DC Power Harness and Schematics included. 7.4" × 6.2" × 1.7" ht. Visa/MC/M.O./check; when clears. $37.50 ea. (Free shipping in U.S.) 1-800-327-7182/305-830-8886. **POWER PLUS,** 130 Baywood Ave., Longwood. Fl. 32750. (Call for quantity price).

CIRCLE 125 ON FREE INFORMATION CARD



ONE MAN CRT FACTORY, easy operation. Rebuild CRT's for tv's, bus. machines, monitors, scopes, etc. Color, b&w, 20mm, foreign or domestic. 3×6 ft. space required. Profits??? Average CRT rebuilding costs—$5. Sell for $100 = $95 profit; × 5 CRT's = $475 daily; × 5 days = $2375 weekly profit. Higher profits overseas. Investigate this opportunity today. We service the entire world. Contact: **CRT FACTORY,** 1909 Louise St., Crystal Lake, Il. 60014. (815) 459-0666.



THE MOST EXCITING KIT YOU WILL EVER BUILD The model WAT-50 miniature FM transmitter uses a 4-stage circuit NOT to be confused with a simple wireless microphone. Up to 1 mile range. So sensitive, it will pick-up a whisper 50 feet away! Use with any FM radio. Complete kit only $29.95 tax incl. FREE SHIPPING. **DECO INDUSTRIES,** Box 607, Bedford Hills, NY 10507.

CIRCLE 263 ON FREE INFORMATION CARD

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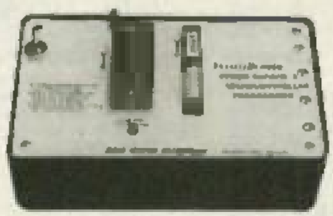
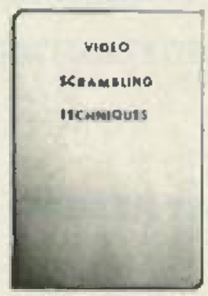
CIRCLE 264 ON FREE INFORMATION CARD



IntelliBurner EPROM-EEPROM & MICRO-CONTROLLER programmer $299 Communicates through the serial port of any personal computer. Use your PC's modem software to read, verify, or program all popular EPROMs, EEPROMs and 87xx series micro controllers. Custom software included for IBM, CP/M or Radio Shack PCs. Other programmers from $149. Bare PC boards with software from $39. **ROSS CUSTOM ELECTRONICS,** 1307 Darlene Way #A12, Boulder City, NV 89005. 702-293-7426.

CIRCLE 266 ON FREE INFORMATION CARD



SUBSCRIPTION TV MANUAL. This information packed book details the methods used by subscription TV companies to scramble and descramble video signals. Covers the Sinewave, Gated Pulse, SSAVI system, and the methods used by most cable companies. Includes circuit schematics, theory, and trouble shooting hints. Only $12.95 plus $2.00 first class P&H. **ELEPHANT ELECTRONICS INC.,** (formally Random Access) Box 41770-R, Phoenix, AZ 85080.

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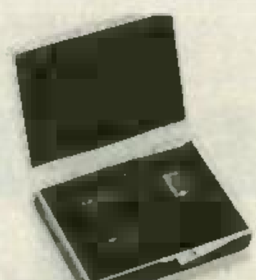
CIRCLE 118 ON FREE INFORMATION CARD

SATELLITE TELEVISION RECEIVER SEMIKIT with dual conversion downconverter. Features Infrared remote control tuning, AFC, SAW filter, RF or video output, stereo output. Polorator controls, LED channel & tuning indicators. Install six factory assembled circuit boards to complete. Semikit $400.00. Completed downconverter add $100. Completed receiver and downconverter add $150. **JAMES WALTER SATELLITE RECEIVER,** 2697 Nickel, San Pablo, CA 94806. Tel 415-724-0587.

CIRCLE 124 ON FREE INFORMATION CARD



TELTONE'S TRK-957 KIT makes breadboarding a low-power, central office quality DTMF detection system easy and inexpensive. The included M-957 receiver decodes 12 or 16 digits and operates from 5 to 12V dc. Its sensitivity, wide dynamic range, noise immunity, and low power consumption are ideal for telephone switching, computer and remote control applications. Only $24.75. To order, call: **TELTONE,** 1-800-227-3800, etx. 1130.

CIRCLE 122 ON FREE INFORMATION CARD

CONSUMER CORNER

New solid state and digital TV sets, stereos, and videorecorders are tougher to repair than old-fashioned tube type sets and require special training for the service technician who works on them.

Only a few states have laws requiring competency tests for licensing technicians who repair consumer electronics, but fifteen years ago the International Society of Certified Electronic Technicians (CET) began its own certification program to qualify these technicians and those in industry. To carry the CET designation, technicians must have four years experience and pass a rigid examination on general electronics and a specific area of expertise such as audio or radio-TV.

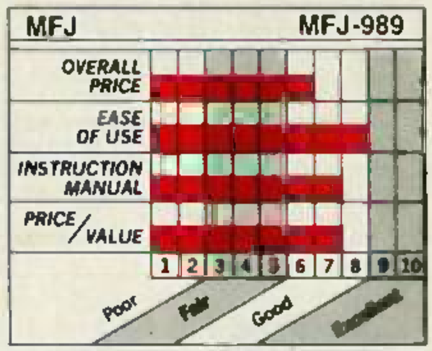
Many consumers look for a Certified Electronic Technician in the shop when they need any electronic item repaired.

Free Consumer Checklist

A consumer checklist for selecting a service shop is available free by sending a stamped, self-addressed envelope to: Checklist, ISCET, 2708 West Berry, Fort Worth, TX 76109. The list reminds consumers to check such items as "Does the business have the parts for your particular brand?", "Did you get an estimated price?", and "Did you check this company with the Better Business Bureau?"

Modern electronic equipment such as digital TVs or stereos should be repaired by specially trained people.

4.75 × 14.5 inches and uses a 99-turn roller inductor. That 36-μH inductor is made of 14-gauge plated wire with a silver-plated roller contact. The balance of the tuning circuit is made up of two 250-pF variable capacitors. That circuit will allow you to tune an antenna for top performance at just about any frequency in the HF amateur or SW bands. The components are rated to handle transmitter output powers to 3 kilowatts.



The *MFJ-989* is housed in a sturdy aluminum box. The capacitors and roller inductor are all set from the front panel. The inductor features a turns indicator.

The unit can handle 50-ohm coaxial cable and balanced 300-ohm feedlines, as well as end-fed longwire antennas. The type of feed or antenna is selected by a front-panel switch. That switch also allows you to bypass the tuning circuit, if so desired.

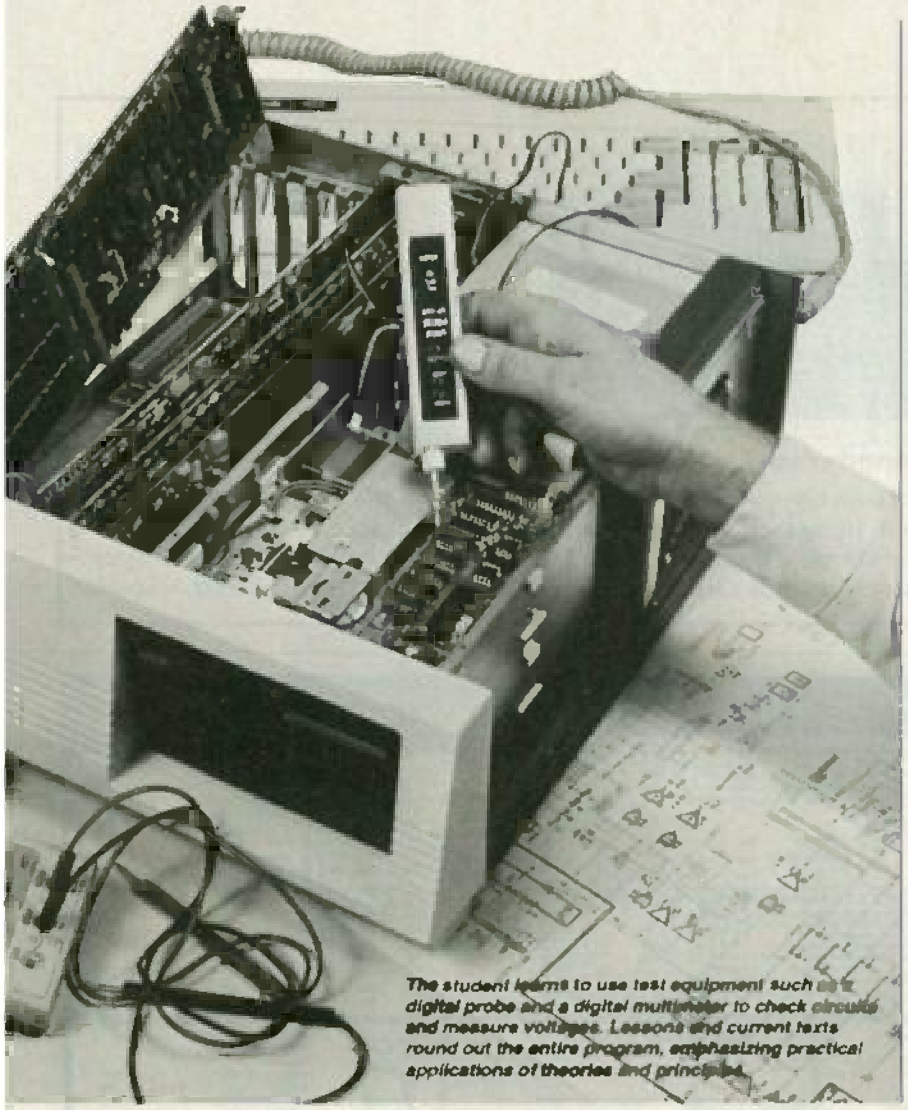
Also built into the unit is a 300-watt, 50-ohm dummy load. That dummy load is rated at 300-watts for 30 seconds and 100 watts for 1.5 minutes.

The unit also features an accurate VSWR/power-meter. That meter can be user-calibrated via two controls on the front panel.

Overall, we have found the unit to be an excellent performer. It will tune an antenna system for peak performance for both transmission and reception. In all fairness, the unit seems a bit pricey at $329.95, but the quality of construction seems equally high.

One last note, MFJ's documentation appears brief, but it is readable and provides you with more than enough information about the unit. It even provides you some brief operating hints, as well as some theory of operation. R-E

INTO PC SERVICING A MICROCOMPUTER



The student learns to use test equipment such as a digital probe and a digital multimeter to check circuits and measure voltages. Lessons and current texts round out the entire program, emphasizing practical applications of theories and principles.

Installing the disk-drive in the PC is one of the final stages in the assembly of the microcomputer. Learning the use of test equipment to check circuits is an integral part of the training which, with field experience, develops invaluable career skills.

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If card is missing, simply write to the address shown below stating the course you are interested in. A FREE color catalog with all details will be sent to you by return mail.

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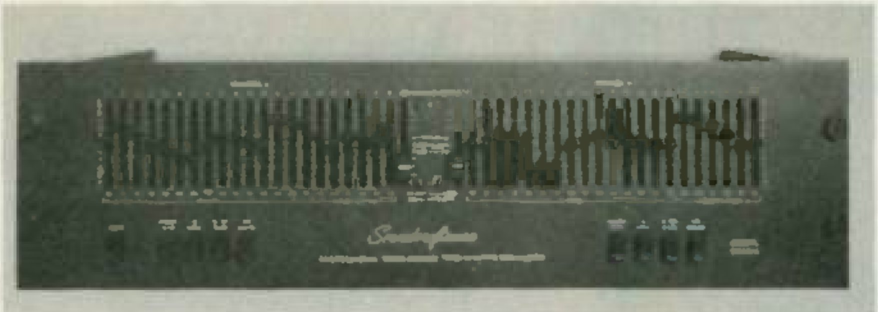


CIRCLE 11 ON FREE INFORMATION CARD

THIRD-OCTAVE STEREO EQUALIZER, is designed to handle the problem of balancing in-out signal levels, which is especially important with compact discs because of their increased dynamic range. The stereo equalizer minimizes phase shift and assures that there is no degradation of the tonal qualities of the music.

The same balancing requirement extends to Direct-to-Disc recordings, where the dynamic range is substantially higher than FM broadcasts and ordinary records and tapes. The new equalizer is also suited for use with dbx and other types of expander/compander accessories, where dynamic range is increased, thus making the signal-level balancing function so critical.

The *Third-Octave Stereo Equalizer* is priced at \$599.00.—Sound-

CIRCLE 73 ON FREE INFORMATION CARD

craftsmen, 2200 So. Ritchey, Santa Ana, CA 92705.

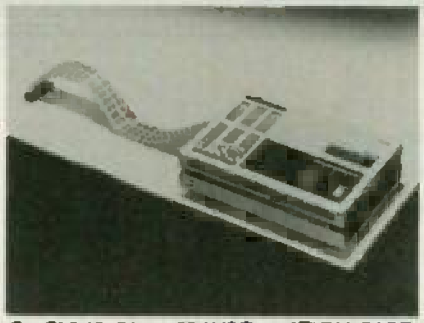
VHF PORTABLE RADIO, model *70-152*, is a 2-way FM portable radio with an RF power output of 5 watts (switchable to 2 watts). It has a one-piece molded 500-mAH battery pack and an earphone jack. The radio measures 6¹³⁄₁₆ inches high × 2⅜ inches wide × 1⅝ inches deep and weighs approximately 24 ounces with battery pack and 6-inch helical antenna.

CIRCLE 12 ON FREE INFORMATION CARD

Operating over a frequency range of 150–174 MHz, the model *70-152* is available with optional tone-coded squelch, leather carrying case, and optional 3-inch "stubby" helical antenna. A vehicular charger is available in addition to one-unit, two-unit, and eight-unit desktop chargers.

The model *70-152* is priced at less than $350.00.—**Midland International Corp.**, 1690 N. Topping, Kansas City, MO 64120.

IN-CIRCUIT EMULATOR, the model *ICD-178 8048* is a stand-alone device and emulates the entire 8048 family in one unit (to 11 MHz). It has 4K of emulation memory, a 2K × 32-bit real-time trace buffer, three hardware and eight software breakpoints, a built-in PROM programmer for the 8748 and 8749, an external event probe

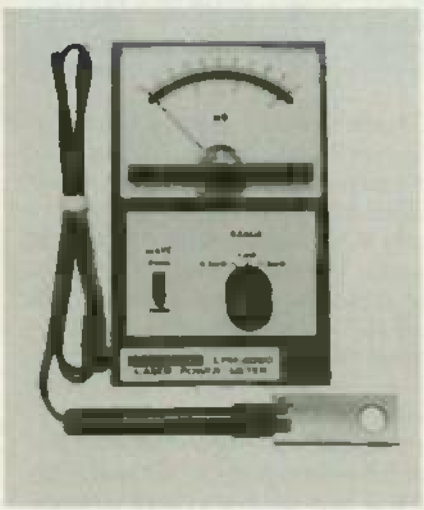


CIRCLE 13 ON FREE INFORMATION CARD

for triggering logic analyzers, and an external breakpoint probe for TTL signals. It can also be connected to the IBM *PC* with an optional software package that turns the *PC* into a complete development system for the 8048 family.

The model *ICD-178 8048* is priced at $4995.00.— **ZAX Corporation**, 2572 White Road, Irvine, CA 92714.

LASER POWER METER, model *LPM-8000* provides a fast, convenient method of measuring the power output from laser devices used in many compact audiodisc and videodisc players.



CIRCLE 14 ON FREE INFORMATION CARD

Two wavelength and three power-measuring ranges are available on the model *LPM-8000*, giving the instrument versatility. This laser power meter, which consists of a main body and a sensor connected by cable, is small-size, light-weight, and battery-operated for portability. It is priced at $225.00.—**Leader Instruments Corporation**, 380 Oser Ave., Hauppauge, LI, NY 11788. R-E

NEW IDEAS

Making electronic music—automatically!

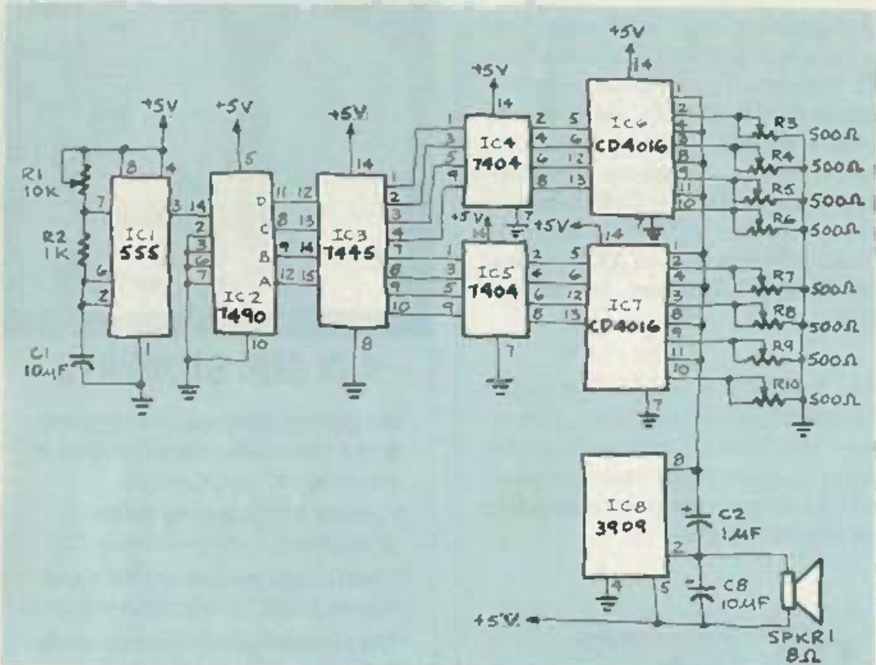


FIG. 1

BUILDING ELECTRONIC CIRCUITS TO produce musical notes and tones is fast becoming a favorite pastime of electronics hobbyists. Such circuits are have gained popularity among school-aged children for class projects, as well.

Figure 1 shows a circuit you can build "from scratch" using any construction method you choose. It's made of several IC's and a few discrete components, and none of the parts used should prove hard to come by.

How it works

IC1, a 555 timer, is set up as an astable multivibrator to produce the signal that triggers IC2, a 7490 decade counter. That IC, in turn, produces a BCD output that is fed to IC3, a 7445 BCD-to-decimal decoder/driver. Because IC3's output is positive, it's necessary to invert the signal before feeding it to the rest of the circuit. That's handled by two hex inverters, IC4 and IC5.

Note that the eight outputs of IC3 are divided evenly between the two 7404's. Since there are six inverters in each package, there will be four left over for you to play with. What you do with them is up to you. The outputs of IC4 and IC5 are input to control pins on IC6 and IC7 (CD4016 CMOS quad bilateral switches). As those switches open and close, different resistances (as set by potentiometers R3–R10) are inserted into the sound-generating circuit made up of IC8 and its associated components. Note that IC8, which is a 3909 LED flasher also makes a fine sound generator.

The frequency at the outputs of IC6 and IC7 are adjusted to various rates, using potentiometers R3–R10, to produce the desired tones. Capacitors may be placed in series with the potentiometers to produce a sloping sound instead of a straight tone.

Two other tones may be added using the pin 5 and pin 6 outputs of IC3. To do so, simply route those two outputs through inverters and switches as done with the other eight. If you include the extra outputs, it will be necessary to add another CD4016 bilateral switch with potentiometers connected in the same way as the others.

The negative-going output signals of IC6 and IC7 are fed through a common bus to pin 8 of IC8. Filtering for the input signal is provided by capacitor C2. Capacitor C3, connected across the output at pin 2 and the supply controls the speaker output. C3 may be replaced by a potentiometer if desired—*Artur Manhica*

NEW IDEAS

This column is devoted to new ideas, circuits, device applications, construction techniques, helpful hints, etc.

All published entries, upon publication, will earn $25. In addition, for U.S. residents only, Panavise will donate their *model 333*—The Rapid Assembly Circuit Board Holder, having a retail price of $39.95. It features an eight-position rotating adjustment, indexing at 45-degree increments, and six positive lock positions in the vertical plane, giving you a full ten-inch height adjustment for comfortable working.

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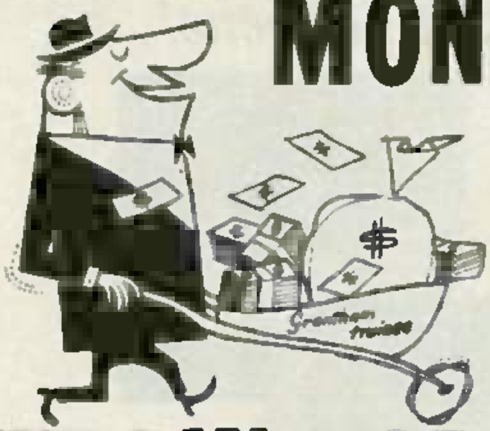

TRAIN FOR ELECTRONICS

Do You REALLY Want to Make More Money?

Yes it does take *work* and a few sacrifices to climb up the electronics ladder to where the bigger money is. But, if that's where you want to be, then that's what you must do — *work* harder at learning and getting the right credentials, even if it takes a few sacrifices. A *B. S. degree* and the knowledge that rightly goes along with it can give you powerful ladder-climbing equipment in your search for *success in electronics.*

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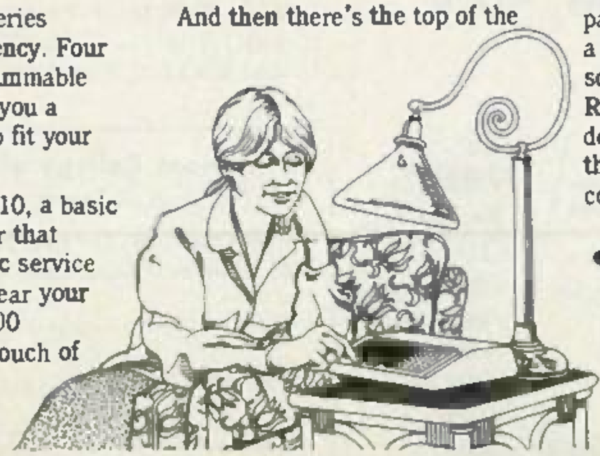

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CIRCLE 268 ON FREE INFORMATION CARD

Real-Time Spectrum Analyzer for your Hi-Fi

Once you can see the response of your stereo system, you can control it better with your equalizer and flatten your speaker response.

ROGER COTA and LLOYD ADDINGTON

AFTER YOU SET UP AND LISTEN TO YOUR stereo speakers in your living room, you realize that they don't give the full, just-right sound that you were hoping for. They don't sound nearly as good as they did in the stereo showroom. That situation has become a much-repeated one because your stereo system requires help in obtaining a correct response depending on the room in which it's placed.

That's why the equalizer has become a standard component of the audio system. But the equalizer isn't of any help unless it's adjusted properly to correct the response of the loudspeakers. Adjusting the equalizer for maximum performance can be a tedious and frustrating job. But it doesn't have to be. Proper equalizer adjustment can be done easily in the stereo listening room by using a real-time analyzer.

We'll show you how to build an audio-spectrum analyzer that displays a picture of any audio signal spectrum in 10 octaves. It is an economical, lab-style measuring tool capable of calibrating a wide variety of levels. For those of you with rack-mounted systems, rest assured that the PC board fits into a 19-inch rack-mountable chassis.

Why use an analyzer?

The addition of the real-time audio analyzer to your stereo system, PA, or recording console allows you to see what you're hearing. You can use it as a tool when taping: to match tapes with the original source, or to discover the playback characteristics of a tape machine. Because it reveals the spectral content of the music played, it can be used as an educational, entertaining, and colorful display.

Total system/environment control can be realized by using the analyzer with an equalizer. Analyzing the frequency response of your listening area and adjusting your equalizer is simplified because the ten octave filters are tuned to the standard ISO center frequencies that are used in most equalizers. Music can be analyzed, tape copies can be compared to originals, and equalization of live vocal or instrumental sound can be optimized. Because unwanted extraneous noise will be displayed, it can be removed. When using a microphone with a known frequency response, the built-in diagnostic signal generator provides a visual display of the reproduction characteristics in the listening environment.

The analyzer, with its several input connectors and selectable input mode, allows a variety of hookup options. For example, you can use it with a receiver, preamp, tape recorder/player, equalizer, microphone, compact disc player, home satellite receiver, mixing board or recording console. The 81-LED display forms a picture of any audio signal over a 21-dB range of energy in 3-dB steps in each of the ten standard ISO octaves.

The basics of our analyzer

Figure 1 is a block diagram of the analyzer. As you can see, there are two possible input sources, line and microphone. (As we'll soon see, there is really a third possible input source that can be selected by a front-panel rotary switch.

In the LINE mode, the analyzer will accept standard line-level (1-volt nominal) signals from devices such as preamps, receivers, tape machines, consoles, etc. In the MIC mode, the analyzer accepts the output of a dynamic microphone, which is fed into the built-in preamp. We'll see how and when to use that input shortly.

The front-panel LEVEL control sets the level of the input signal so that the highest-level signal is still in the range of the LED display. The input signal is amplified by the input driver and separated into the ten octaves by the analog bandpass-filter networks. The signals are then rectified and filtered so that the RMS amplitudes can be determined. Next the signals are multiplexed together by the diode analog multiplexer, amplified, and fed to an analog-to-digital (A/D) converter.

Logic circuitry is used to control both the diode multiplexer and the multiplexed display driver. The control logic consists of a timer, a divider, and a 1-of-10 decoder.

The A/D converter takes the analog voltage and drives the 80-LED display. Each LED-step vertically represents a gain in amplitude of 3 dB. The horizontal axis of the LED matrix represents frequency. When a signal in any frequency range drives the device higher than the 21-dB range, the OVERSCALE LED lights. When that happens, simply use the LEVEL control to bring the signal back into the range of the analyzer

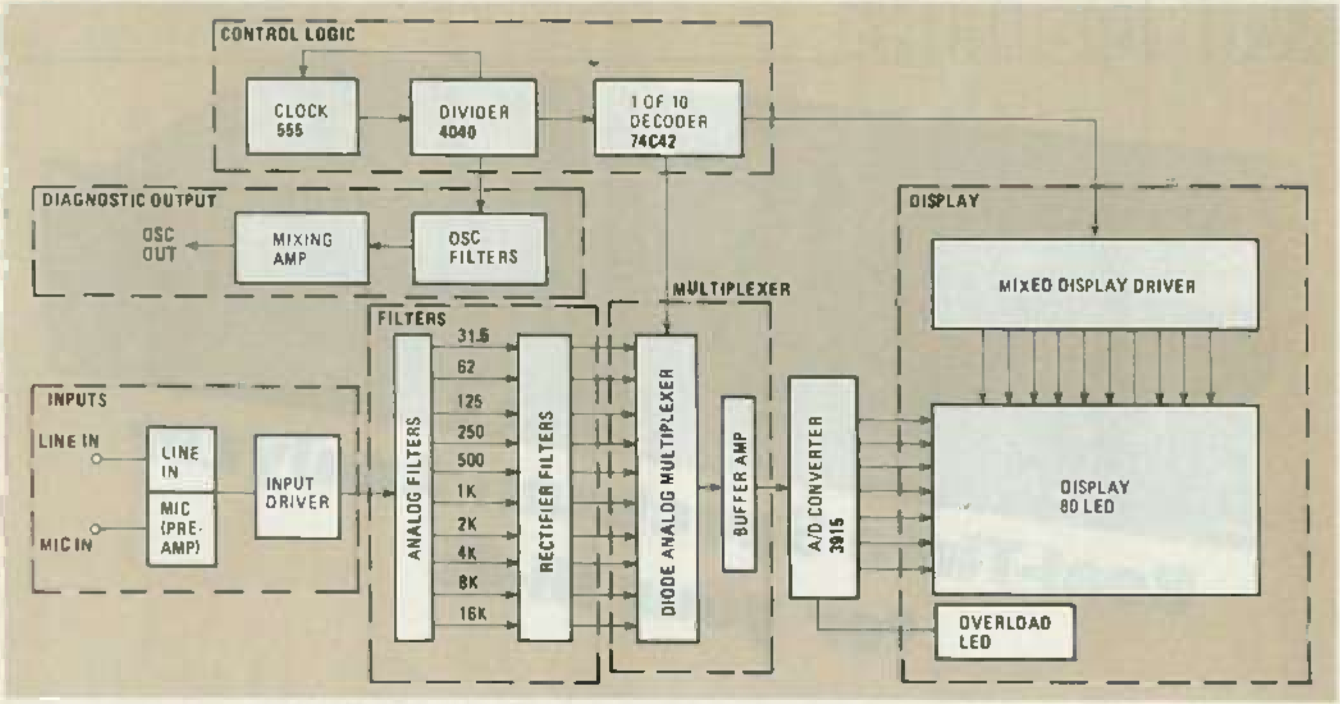


FIG. 1—AUDIO ANALYZER BLOCK DIAGRAM. The diagnostic output can also be used as an input to the analyzer for calibration purposes.

A *diagnostic sweep signal*, which is used to calibrate the equalizer, is controlled by the clock and the divider. A 555 timer is used as an oscillator, which is filtered to obtain frequencies for testing at all 10 octaves. The generated signals are mixed together, filtered, and then sent to the oscillator output. That output can be fed to speakers (via the stereo system) and picked up by a microphone in order to calibrate the equalizer. That diagnostic signal can also be chosen as an input by the front-panel mode switch. That lets you view the response of the analyzer as all the frequencies are swept.

How the circuit works

Figure 2 is the schematic of the analyzer. As you can see there, a three-position rotary switch, S1, selects the appropriate input. The LINE input is configured to allow either separate right- and left-channel inputs or a balanced input. In other words, the input can be the right channel and ground, the left channel and ground, or the right plus left for balanced line in. In either case, the input signal goes into a line buffer or mixing amplifier made up of R11–R15, C6, C7, and IC1-*b*.

A microphone input is also included for low-impedance dynamic microphones. Since the output of a dynamic microphone is at a very low level, the signal must be preamplified. The microphone preamp section is made up of R2, R3, R8, R9, C2, C56, IC1-c, and IC1-d. If you want to use a condenser microphone, then you'll have to add R1, R4, R5 and C1, as shown in the dashed box in Fig. 2.

The 100K front-panel LEVEL control, R113, sets the input level for the input driver stage (which consists of R16, R18, R19, C13, and IC4-a.) That stage supplies a low-impedance signal source for the analog filters. Each basic filter has the same configuration, but the frequency is selected by the value of the capacitors. Figure 3 shows the basic filter, while Table 1 gives the values of C and corresponding filter frequencies.

The rectifier filters and the diode multiplex network are identical for all frequencies. The output of the analog filter op-amp is rectified by a small-signal diode in series with a 10K resistor and a 1-µF capacitor connected to the negative supply. For the 30-Hz frequency, for example, the rectifier filter is D5, R52, and C14. The diode multiplexer buffer amp IC4-b is driven by the diode networks and consists of R17, R20, R21, and IC4-b.

The control logic determines which frequency's signal is presented to the multiplexer buffer amp. The 555 timer, IC8, is controlled by R74, R75, and C44 to operate as a 16-kHz oscillator, triggered and reset on the trailing edge of each pulse.

The output of the 555 feeds IC5, a 4040 12-stage ripple-carry binary counter. As the counter counts up, resets and repeats, the output pin 1 is fed back through R80 and C3 to the frequency-modulating pin 5 of IC8. That causes the oscillator's output to warble up and down about 1/2 octave. The output pins of IC5 (pins 2, 3, 4, and 13) are fed to IC6, a 74C42 BCD-to-decimal decoder. The 74C42 converts the signal at its A, B, C, and D inputs to a logic zero on the appropriate output from 0–9.

Those outputs are connected both to the diode multiplexer and the display multiplexing network. As the 74C42 counts from 0-9 it enables each of the frequencies in turn to feed through the multiplexer buffer amp, thereby presenting each octave's analog voltage to IC7, an A/D converter. Resistors R77 and R78 form a voltage divider to provide IC7 with a reference voltage; the IC senses the analog voltage input and fires the output LED corresponding to that voltage. Each output corresponds to a 3 dB step in a 21 dB range.

At the same time, the 74C42 enables the particular octave to be sensed by the A/D, it also enables the display driver for that frequency. The multiplexed display driver consists of PNP transistors Q2–Q11, which are biased by R81–R90.

Overscale is indicated by Q1, R76, and D36. The base of Q1 is enabled by the 4040 (IC5), and the collector is connected to the output of the A/D converter corresponding to the highest analog level. When that output is activated the transistor is forward biased and turns on D36, the OVERSCALE LED.

The diagnostic sweep signal is generated and controlled by the logic circuitry as well. Ten oscillator filters are formed by R91–R110 and C26, C29, C32, C35, C38, C41, C45, C48, C51, C54. Those filters convert the squarewave outputs of IC5 to ramp waves. Table 1 shows the relationship between filter capacitance and frequency.

The 555 timer fires and pulses a signal to the first filter then, as the counter counts, the 16 kHz is divided down to produce a center oscillating frequency for all the octaves. The resulting signals are presented to the mixing amp formed by

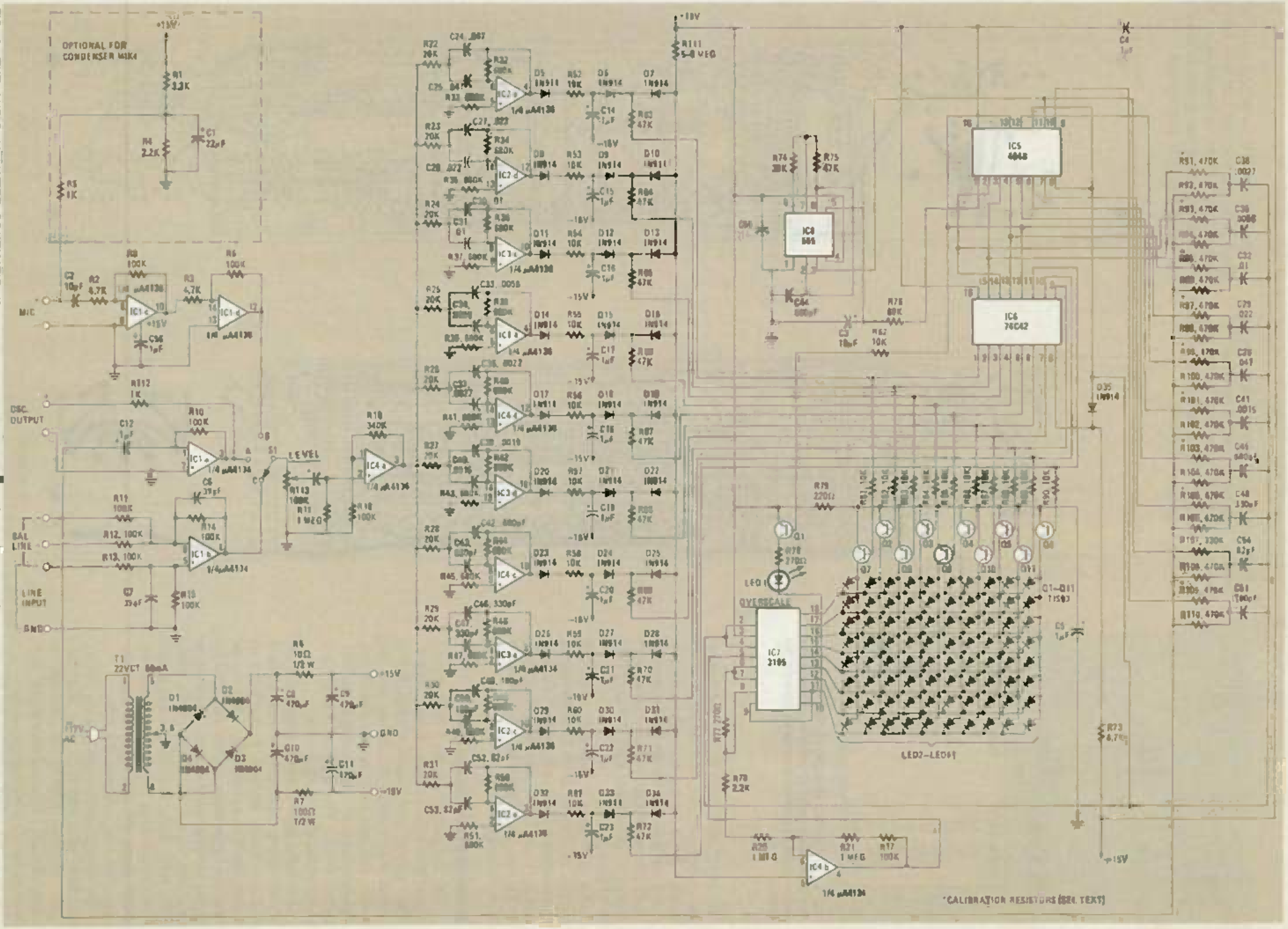
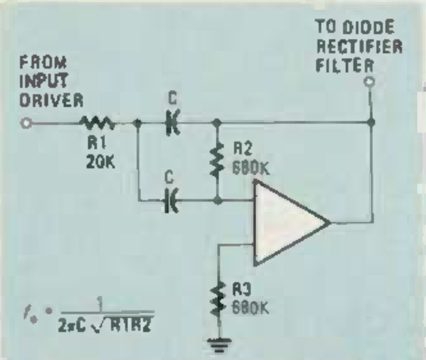


FIG. 2—THE AUDIO ANALYZER SCHEMATIC. If you want to use a condenser (or electrostatic) microphone, the components shown in the dashed box must be installed.



FREQUENCY	CAPACITANCE
31.5 Hz	.047 μF
62 Hz	.022 μF
125 Hz	.01 μF
250 Hz	.0056 μF
500 Hz	.0022 μF
1000 Hz	.0015 μF
2000 Hz	680 pF
4000 Hz	330 pF
8000 Hz	180 pF
16000 Hz	82 pF

FIG. 3—THE BASIC ANALOG FILTER configuration is the same for all frequencies. However, the values of the capacitors change as shown in the table.

R10, R112, C12, and IC1-a, and then to the output terminals and the input-select switch. Since the top-octave frequency is being warbled, all the octave frequencies warble, giving a diagnostic signal with energy across the audio band from 25 Hz to 19 kHz.

The 1081 uses a standard ± 15 volt supply. A 22-volt, 50-mA center-tapped transformer is used to step down the line voltage to a useable value that is rectified by D1–D4, and filtered by C8–C11 along with R6 and R7.

Building the audio analyzer

The foil pattern for the "component" side of the circuit board is shown in Fig. 4. The "solder" side is shown in Fig. 5. It is not entirely correct to call one side the solder side and the other the circuit side because each side has components soldered to it. The display LED's are mounted on the "solder" side.

Since the parts count is high and parts are very close together be *very careful* not to cause solder bridges. It also helps to install the lower-profile parts first to be sure the larger parts are not damaged by trying to solder around them. However, at this time, do not install R91, R93, R95, R97, R99, R101, R103, R105 and R109. You can put them in position, but do not solder them. We will return to those devices when we calibrate the unit.

We should remind you that the 74C42 and 4040 (IC6 and IC5) are CMOS devices. Because CMOS devices can be easily damaged by static discharges, they must be handled with proper care.

A parts-placement diagram for the audio-analyzer circuit board is shown in Fig. 6. Note that the LED's are mounted on the "solder" side of the circuit board so that they'll be seen from the front of the cabinet. As with any diodes, be sure to install them in the proper direction.

Note that you'll be installing some off-board jacks such as the line and microphone inputs and the oscillator output. Be sure that the wires you mount in the circuit-board holes are long enough!

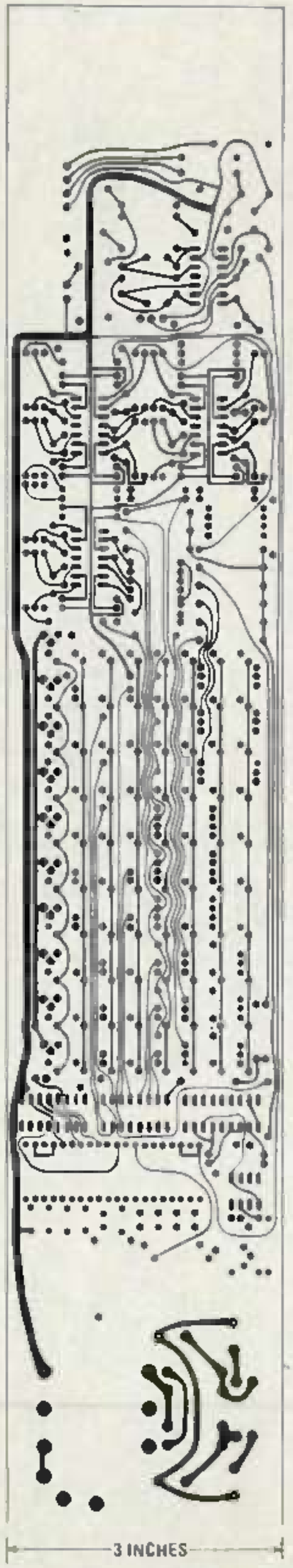


FIG. 4—THE COMPONENT SIDE of the analyzer circuit board is shown here half-sized.

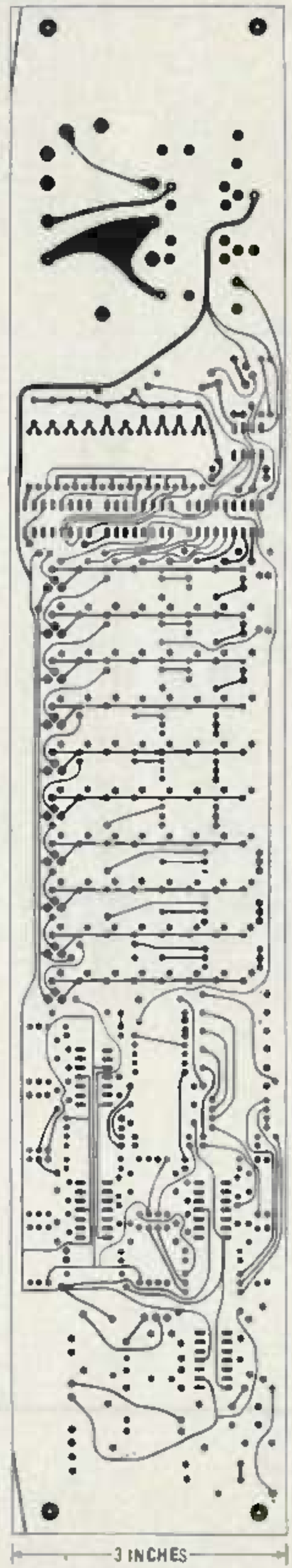


FIG. 5—THE SOLDER SIDE of the analyzer circuit board is shown here half-sized.

PARTS LIST

All resistors are ¼ watt, 5% carbon-film types unless otherwise indicated.

R1—3300 ohms (Optional)
R2, R3, R73—4700 ohms
R4—2200 ohms (Optional)
R5—1000 ohms (Optional)
R6—10 ohms, ½ watt, 5%
R7—100 ohms, ½ watt, 5%
R8–R17—100,000 ohms
R18—390,000 ohms
R19–R21—one megohm
R22–R31—20,000 ohms
R32–R51—680,000 ohms
R52–R62, R81–R90—10,000 ohms
R63–R72, R75—47,000 ohms
R74—39,000 ohms
R76, R77—270 ohms
R78—2200 ohms
R79—220 ohms
R80—6800 ohms
R91, R93, R95, R97, R99, R101, R103, R105, R109—Put in 470,000-ohm units but do not solder them! These are calibrating resistors. See the text for details.
R92, R94, R96, R98, R100, R102, R104, R106, R108, R110—470,000 ohms
R107—330,000 ohms
R111—5.6 megohms
R112—1000 ohms
R113—100,000 ohms, linear potentiometer

Capacitors

C1—22µF, optional
C2, C3—10µF
C4, C5, C12–C23, C56—1µF, 50 volts, electrolytic
C6, C7—39 pF, ceramic disc
C8–C11—470 µF, 35 volts, electrolytic
C24, C25, C26—0.047 µF, Mylar
C27, C28, C29—0.022 µF, Mylar
C30, C31, C32—0.01 µF, Mylar
C33, C34, C35—0.0056 µF, Mylar
C36, C37, C38—0.0027 µF, Mylar
C39, C40, C41—0.0015 µF, Mylar
C42, C43, C44, C45—680 pF, ceramic disc
C46, C47, C48—330 pF, ceramic disc
C49, C50, C51—180 pF, ceramic disc
C52, C53, C54—82 pF, ceramic disc
C55—0.1 µF, ceramic disc

Semiconductors

IC1–IC4—µA4136 quad op-amp (Fairchild, or Exar XR4136)
IC5—4040 ripple-carry binary counter
IC6—74C42—4- to 10-line decoder
IC7—3915 dot/bar display driver
IC8—555 timer
Q1–Q11—TIS93 (ECG159)
D1–D4—1N4004
D5–D35—1N914
D36–D116—miniature red LED

Other components:

S1—2 pole, 3 position rotary switch
T1—transformer, 22 volts, 50 mA center-tapped

The following are available from COTA, 3314 H Street, Vancouver, WA 98663 (206) 693-3834: Circuit board and 28 page manual, $38.50. All orders should add $4.50 shipping and handling.

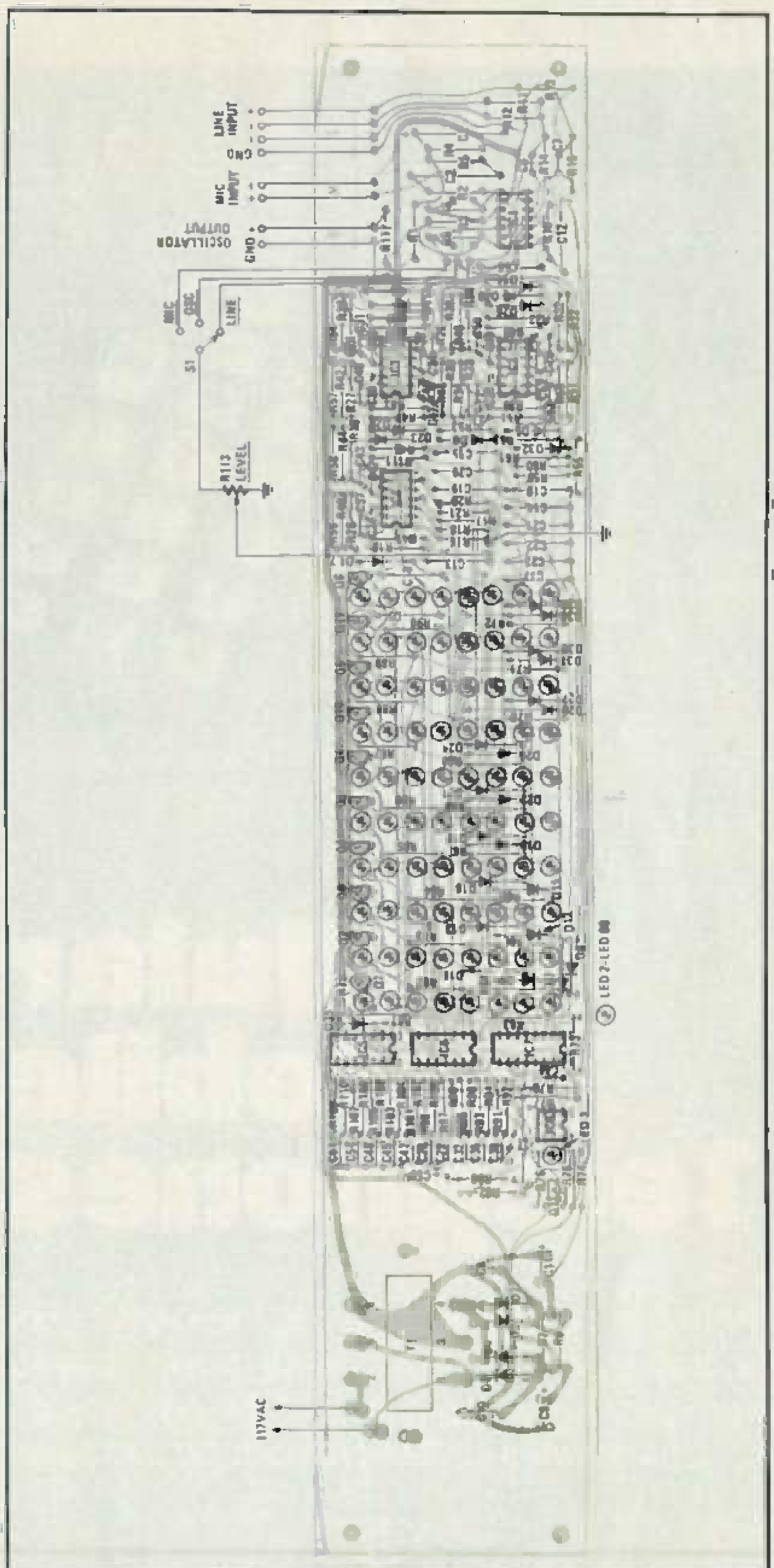


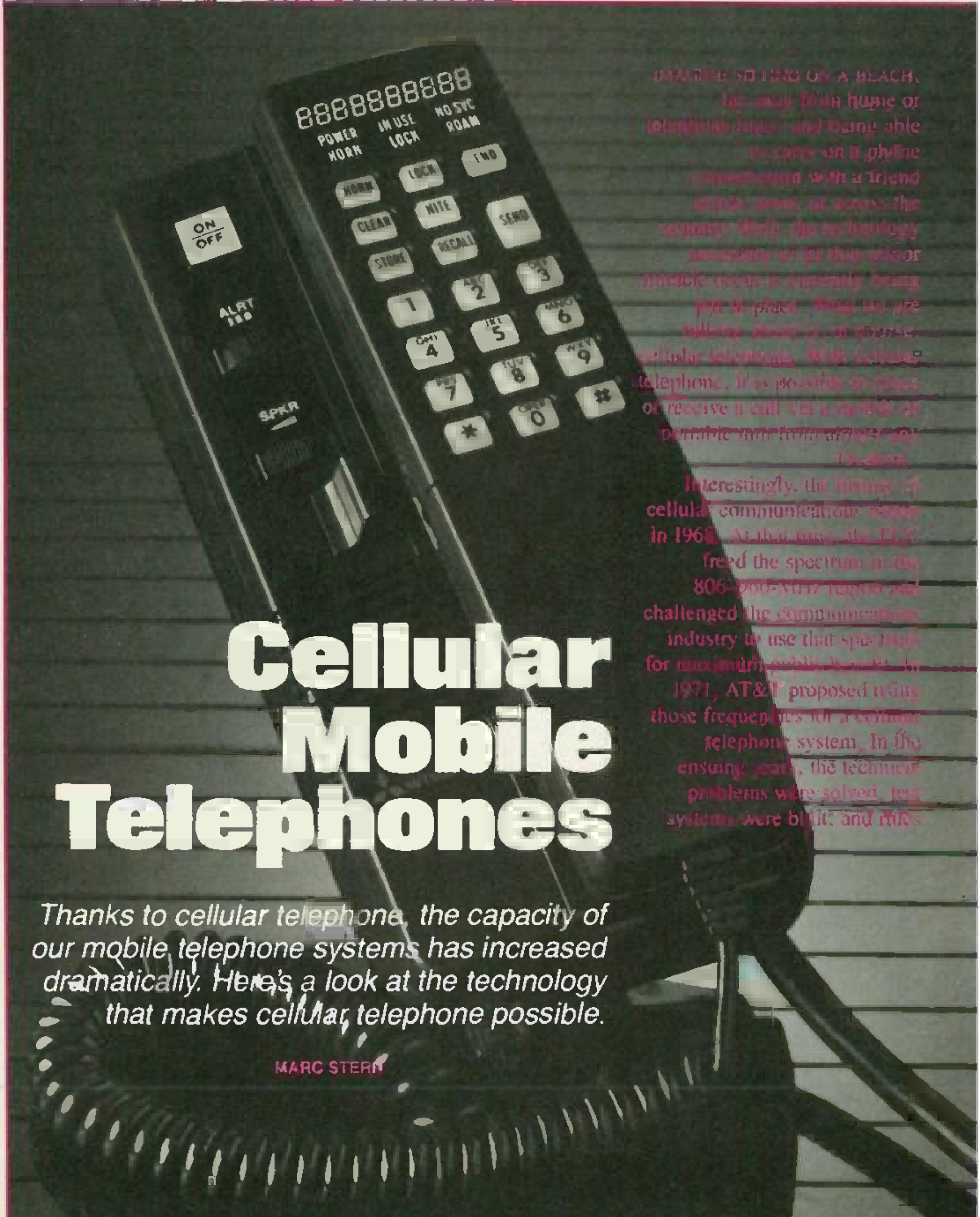
FIG. 6—PARTS PLACEMENT DIAGRAM. Note that the LED's are mounted on the solder side of the board so they can be seen when it is mounted in a cabinet.

The front-panel components, such as the mode switch and level potentiometer also have to be wired. All the details are shown in the parts-placement diagram of Fig. 6. The same is true for the connections to switch S1.

The circuit board bolts onto a chassis using the same type of bolts that hold the faceplate on a standard 3½" × 19" rack mount chassis. Since everything but the select switch and level control are circuit-

continued on page 93

HOW IT WORKS



Cellular Mobile Telephones

Thanks to cellular telephone, the capacity of our mobile telephone systems has increased dramatically. Here's a look at the technology that makes cellular telephone possible.

MARC STERN

IMAGINE SITTING ON A BEACH, far away from home or telephone lines, and being able to carry on a phone conversation with a friend across town, or across the country. Well, the technology necessary to do that minor miracle is currently being put in place. We are talking about cellular telephones. With a cellular telephone, it is possible to place or receive a call with a mobile or portable unit from almost any location.

Interestingly, the history of cellular communications began in 1968. At that time, the FCC freed the spectrum in the 806–890-MHz region and challenged the communications industry to use that spectrum for maximum public benefit. In 1971, AT&T proposed using those frequencies for a cellular telephone system. In the ensuing years, the technical problems were solved, test systems were built, and rules for the cellular industry were issued. In 1983, the first commercial cellular system started operation.

The cellular telephone system

To understand how cellular telephone works, it is necessary to discard some long-held ideas about mobile telephone. In conventional mobile telephone systems, a single central base-station is used to transmit a powerful signal over an area of up to 50 miles (see Fig. 1). In that system, only a single conversation may be held over a given frequency or channel in the service area.

In cellular systems, several low-power transmitters, with their associated receivers, are scattered about an area. Each transmitter operates at a power level sufficient only to cover a small area, called a cell (hence the name). If cells are sufficiently far apart, they can simultaneously use the same set of frequencies. (To ensure proper separation, adjacent cells are assigned different sets of frequencies.) Thus, where only one conversation could occur at a time over a given frequency in a service area, now hundreds could take place over the same coverage area.

Also, instead of using fairly high-powered mobile units—25 watts or more—to carry on conversations, each cellular mobile unit is lower powered ranging from 0.6 to 3 watts. In addition, the cellular system makes handheld portable phones both practical and possible.

Finally, the last notion that must be discarded about traditional mobile-phone systems is a low number of users. In traditional VHF-based radiotelephone systems, due to the low number of conversations that are possible at a time, the saturation level for the system is about 1,200 mobile units. That means that there are few people who can actually use the mobile phone system, and there is usually a long waiting list in any urban area. With cellular telephone, though, as many as 100,000 can make use of the system.

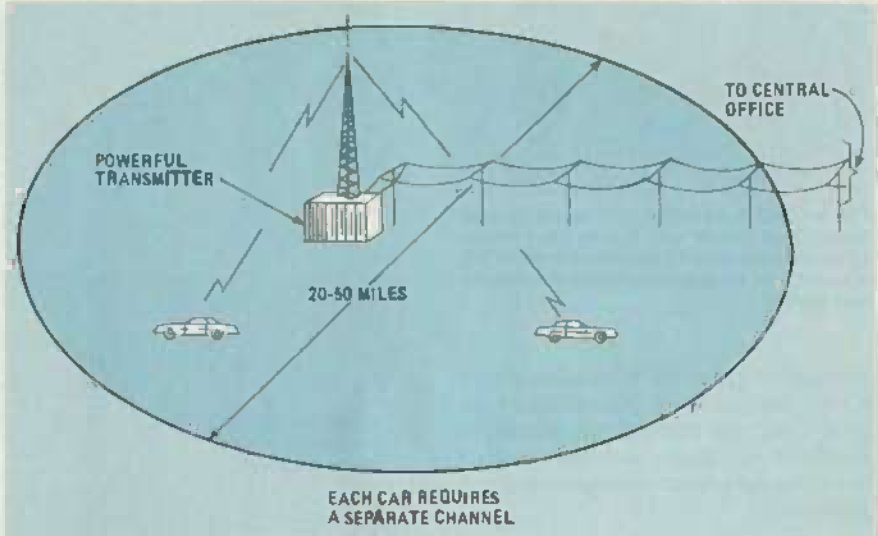


FIG. 1—CONVENTIONAL MOBILE TELEPHONE SERVICE uses one central base station to transmit a powerful signal over an area of up to 50 miles in diameter. Only one two-way conversation at a time can be held over a given channel in the coverage area and the number of channels is limited.

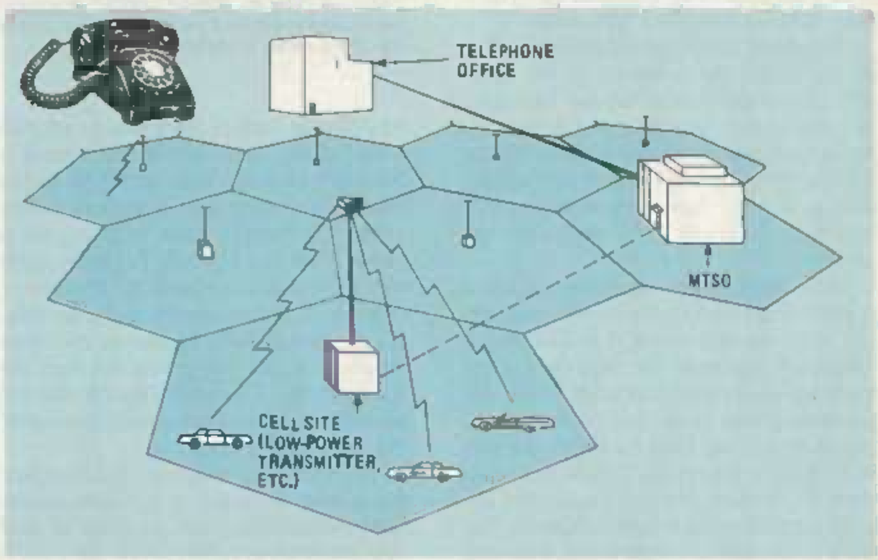


FIG. 2—CELLULAR MOBILE TELEPHONE SERVICE is provided through a system that is composed of three major elements: cell sites, a mobile telephone switching office (MTSO), and dedicated interconnecting circuits. In the cellular system, the coverage area is divided into small areas called cells, hence the name.

A Cell Is Born

Central to the cellular radiotelephone system is the concept of a cell. That is the service area of one transmitter/receiver and it is just one part of a larger network. As shown in Fig. 2, at the center of the cell is the *cell site*, which consists of a low-power transmitter, a receiver, and an electronic switching center that links the cell to the rest of the cellular system. Each of those cell sites, in turn, is linked to a *M*obile *T*elephone *S*witching *O*ffice (MTSO), which is the ultimate arbiter of the entire cellular network. The MTSO, in turn, links the cellular system with the wire telephone system run by the local phone company.

The electronics that makes the cellular system possible is located at the cell site. In addition to the transceiver (transmitter-receiver) needed for the cellular system, at each site is a sophisticated computer system that not only controls the transceiver, but also the mobile units—in conjunction with the mobile unit's internal microprocessor and circuitry—as well as the local switching operation to the MTSO.

For the cellular system to work, when a car moves from cell to cell, there must be an orderly transition; communications must be transferred cleanly from cell to cell, and the mobile unit must only communicate via one cell site at a time. To achieve that aim, each cell site is assigned a set-up channel, which only handles data signals, in addition to a given number of voice channels. The set-up channel, which is used by all of the mobile units in the cell, is used to initiate calls and assign a user to a voice channel. The receiver in a subscriber's mobile unit scans all of the set-up channels in a system and selects the one that is the strongest. Communications then commence via that cell site and only that cell site.

Transitions between cell sites (see Fig. 3) are handled by the cell site electronics. The mobile unit monitors the voice channel for a "hand-off" signal. That signal is sent by the cell site when the signal strength at the cell site drops below a certain level and it has been determined that another cell site is receiving a stronger signal (each cell site has a scanning receiver for that purpose). The hand-off signal instructs the mobile unit to change frequencies. During the change, the audio

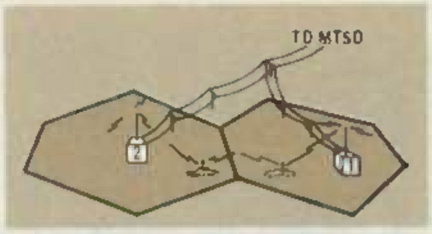


FIG. 3—CELLULAR HAND-OFF occurs as a car moves from cell to cell. During the transfer, which is coordinated by equipment in the MTSO, the user sees no apparent change in transmission quality.

is muted for 150 to 400 milliseconds: such a time interval is not perceptible to the user. Once the mobile unit exchanges handshaking signals with the new cell site, communications resume on the new frequencies.

A closer look

Let's look more closely at the cellular radiotelephone system to see how all the electronics and computers do their tasks. And what better way to look at the system than walking through a typical call?

To initiate a call, all a mobile user has to do is lift the handset of his radiotelephone and dial the number he wants. At that time, the microprocessor-controlled unit sends a brief burst of digital information to the transceiver, alerting the cell site that the user wants to make a call and that it is present in the site's coverage area.

Next, the cell site equipment sends a digital signal back to the mobile unit telling it to standby while it is assigned a frequency pair from the frequency allotment assigned to the central site. (Cellular phones operate in the full-duplex mode, which means that both the caller and person called can hear and talk at the same time. To do that, discrete frequencies are used for transmission and reception. The typical frequency separation between transmit and receive is 45 MHz. Spacing between channels is 30 kHz and there are 666 duplex channels in all.)

Continuous contact

One of the interesting capabilities of the cellular radiotelephone system is its ability to provide continuous coverage across a large geographic expanse.

In order to do that as a mobile station moves from one area to another, the entire cellular system must know the exact location of that mobile system and it must be ready to enable a hand-off of that mobile between cell sites—all without the user being aware of it.

To do that requires some interesting computerized gyrations. Look at a cell site tower, such as the one used in the Motorola system and shown in Fig. 4, and you will see something interesting—the transmit and receive antennas are located on different parts of the tower. In a typical installation, such as the ones used in Motorola systems, there are six 60-degree directional receiving antennas spaced around the tower, each with a gain of about 17 dB (see Fig 4-*b*). Diversity reception techniques are used. In diversity reception, signal strengths at the antennas are monitored, with the one receiving the strongest signal being used for the communications. Computers handle the task of analyzing the signal strengths and making the antenna selection.

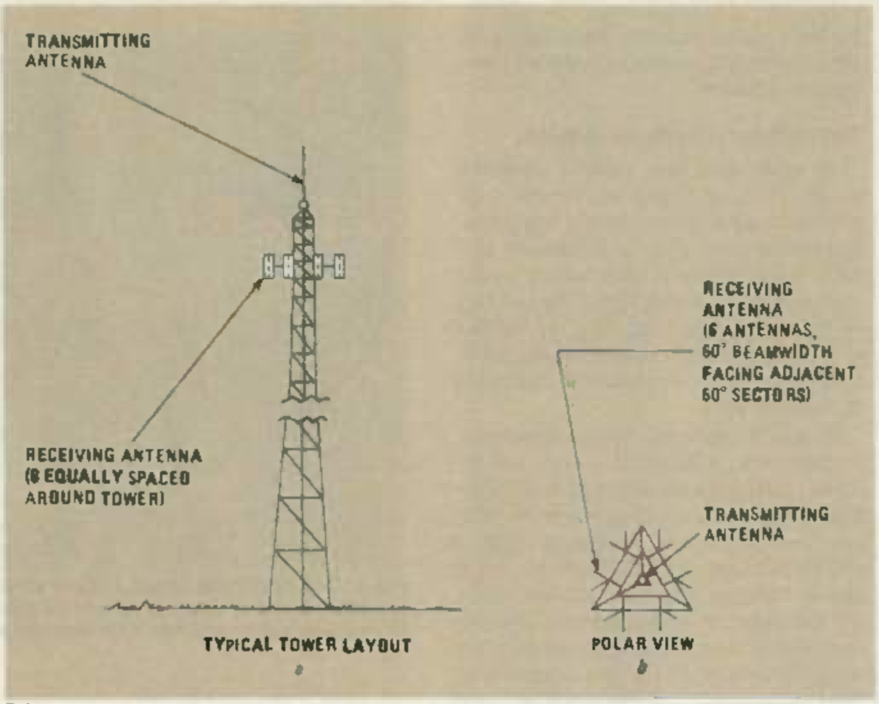


FIG. 4—A TYPICAL TOWER LAYOUT is shown in *a*. Note that the transmitting and receiving antennas are located at different parts of the tower. The arrangement of the receiving antennas, as seen from the top of the tower, is shown in *b*.

The receiving antennas and computer equipment also team up to handle another task—determining the position of each communicating mobile unit in the cell. To do that, the computer samples the received signal strength at each antenna, and uses a special direction-finding algorithm to determine the exact location of the mobile unit.

Monitoring continuously, that information is constantly updated and is fed back to the master computer at the MTSO. The computer at the MTSO is the arbiter that takes the information on the location of the mobile unit and if the signal strength falls below a certain level—about 17 dB (carrier-to-interference-and-noise)—the MTSO decides its time for a hand-off between cells.

While all of that is going on, the computer in the MTSO is also polling nearby cell sites, asking them which one is receiving the mobile unit the strongest. The cell sites, in turn, look for the signal and reply. Using the information received from the cell sites, the MTSO orders the call to be switched to the most appropriate cell. At the same time, the mobile unit switches frequencies to a pair that is available in the new cell site. The frequency pair in the old cell site is then freed.

Monitoring the received signal strength is not only important in determining the location of the mobile unit, but it is also important in keeping the power levels within the cellular system down. Signal strength is monitored by the cell site, and when it exceeds a certain level, the cell site orders the mobile unit to cut back on the output power. Thus, the potential for interference is very small.

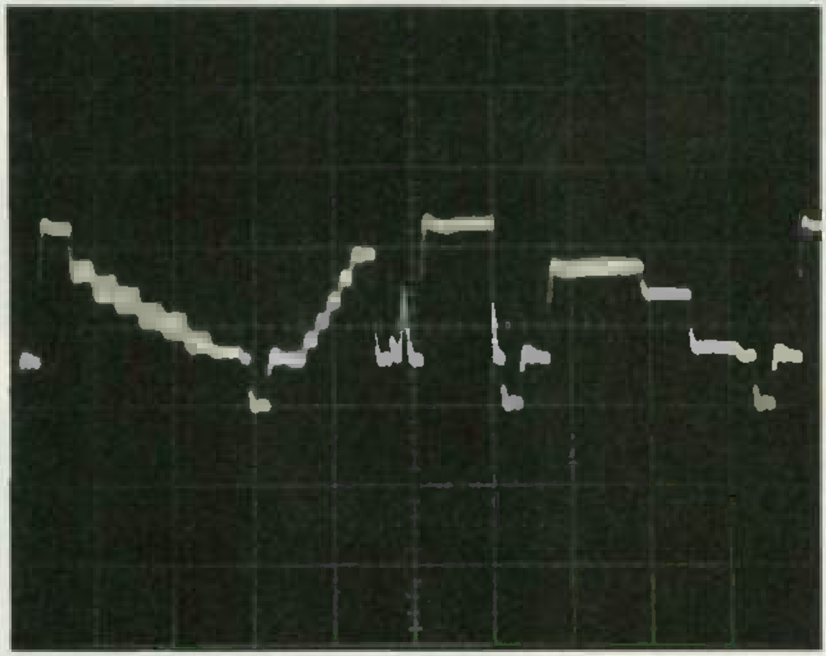
Cost

At the moment, cellular service isn't inexpensive. Most units are selling in the $2000–$3000 range, though prices for equipment will likely drop as more and more units come on the market. As you might expect at that price, most cellular telephones are loaded with bells and whistles. Multi-phone-number memories, last number redial, digital readouts, horn alert (used to alert the user to a call while he is out of the car), and LED status lights used to indicate such things as no service in a particular area are all found on typical cellular phones. As to monthly charges, including access charges and time on the system, those are currently averaging out at about $150.

Overall, cellular radio is an exciting concept whose time has come. It promises truly portable telecommunications, which will keep anyone in touch wherever they go. **R-E**

BUILD THIS

VIDEO SYNC SEPARATOR FOR YOUR OSCILLOSCOPE



STEVE PENCE

With this oscilloscope upgrade, you can stabilize your display of video signals and see what they really look like.

IF YOU'VE EVER WORKED WITH TELEVISIONS or video recorders, you know how difficult it can be to trigger an oscilloscope to provide a really stable display—especially if you want to examine one line of video. And what's even more frustrating is that when you do finally obtain a good display, the part of the waveform you want to examine seems to be just beyond reach. It seems that no combination of position control, sweep rate, and expansion will get you just where you want to be.

If you own a triggered-sweep oscilloscope, there is a solution! We'll show you how to add a video-sync separator and delayed-trigger capability to your oscilloscope. With your upgraded oscilloscope, you'll *really* get to see those video signals.

The circuit can be broken down into four major sections:

- Input buffer/amplifier and video clamp circuit.
- Video-sync separator.
- Digital vertical-pulse separator.
- Trigger-delay section.

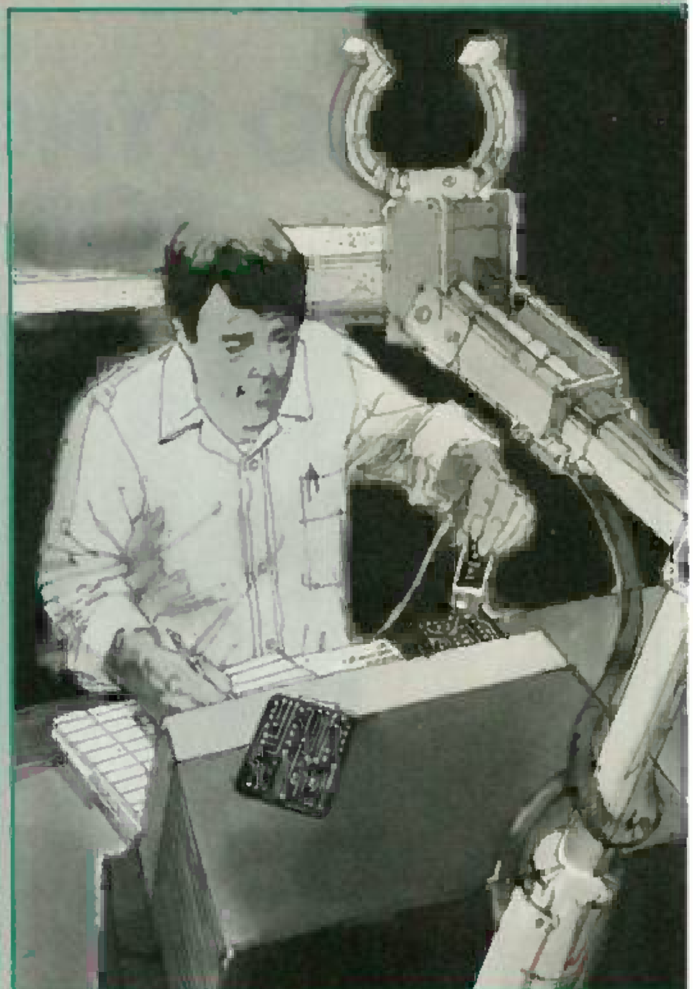
The block diagram of Fig. 1 shows the various sections of the circuit and how they relate to each other. The basic concept of the circuit is to extract the vertical-sync pulse from the video signal and use it to trigger a scope. However, the trigger pulse is not applied directly to the scope. Instead, it is first delayed by a user-adjustable period of time.

Since the scope will not begin its trace until it is triggered at the end of the delay time, and since we have control over the length of the delay after the trigger event (which is a vertical-sync pulse), we can examine any part of the waveform that occurs after that event in great detail.

A useful feature of this upgrade is a clamped video output. The clamp circuit forces the tips of all the sync pulses to line up at the same DC level. So even as the brightness of the scene changes and the average video-voltage level changes, the displayed waveform will remain on exactly the same baseline, making amplitude measurements much easier.

A look at the circuit

The schematic of the sync-separator circuit is shown in Fig. 2. We'll start our description of the circuit at J1, the video



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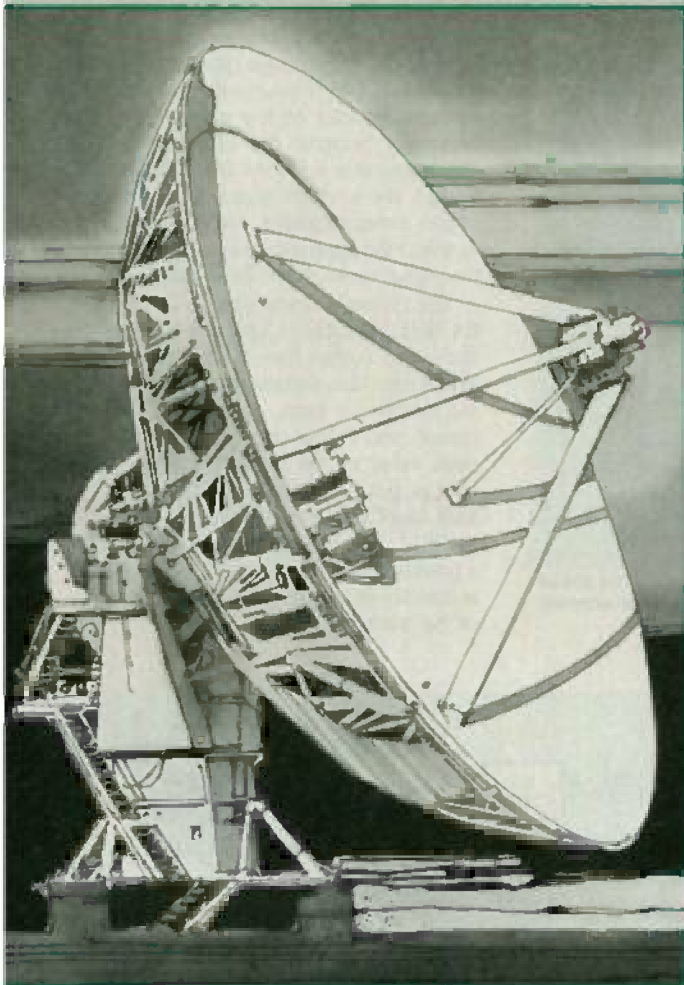

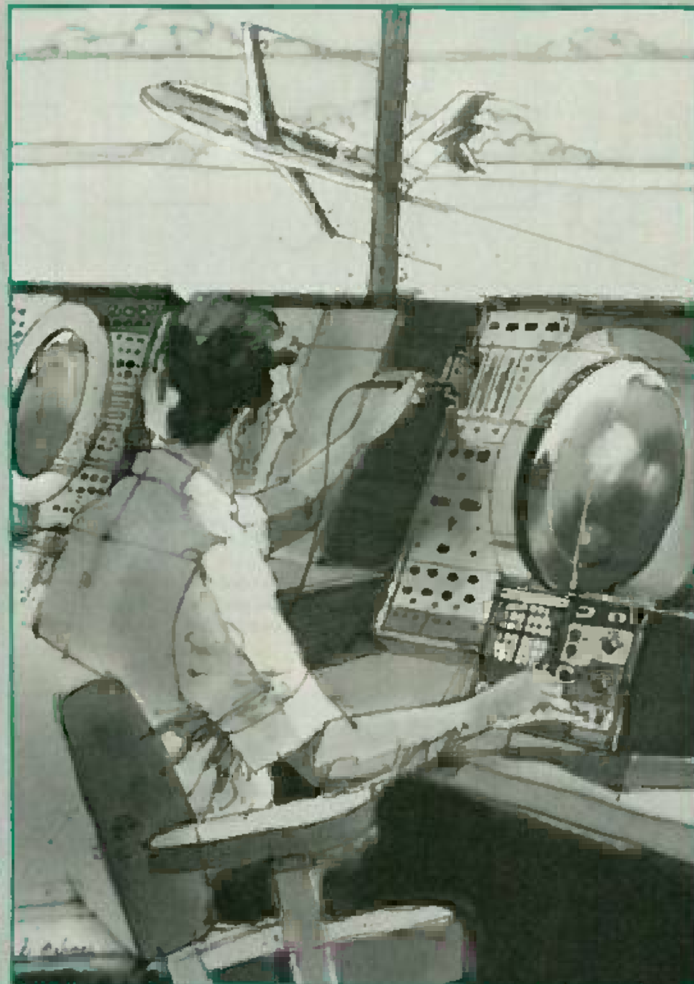

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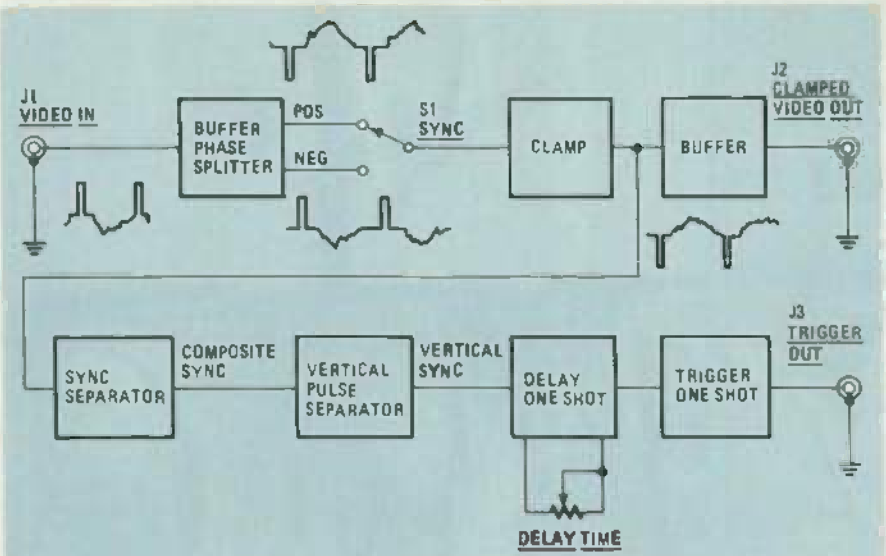

FIG. 1—THIS BLOCK DIAGRAM shows the main sections of the oscilloscope upgrade. The circuit extracts the vertical-sync pulses from a video signal and then delays it's application to the external-trigger input of the scope. Note that a clamped-video output is also available.

input. Diodes D1 and D2 provide over-voltage protection for the gate of Q1, which is a simple phase splitter. The splitter—which can provide either a normal or inverted version of the input signal—is necessary because the video-clamp and sync-separator sections that follow must always see a video signal with its sync pulses going negative. Switch S1 is used to select the appropriate polarity and send the signal on to the video clamp.

The clamp is made up of C2, D3, D4, R4, R11, and R12. Capacitor C2 couples the video signal into the clamp circuit. When the video voltage goes negative during sync-pulse time, diode D3 is forward biased, and C2 quickly charges up to the peak value of the signal. As the signal swings positive, diode D3 is reverse biased and C2 must discharge through R11 and R12. The discharge current produces a positive bias, voltage across R12 which is directly proportional to the peak voltage of the waveform.

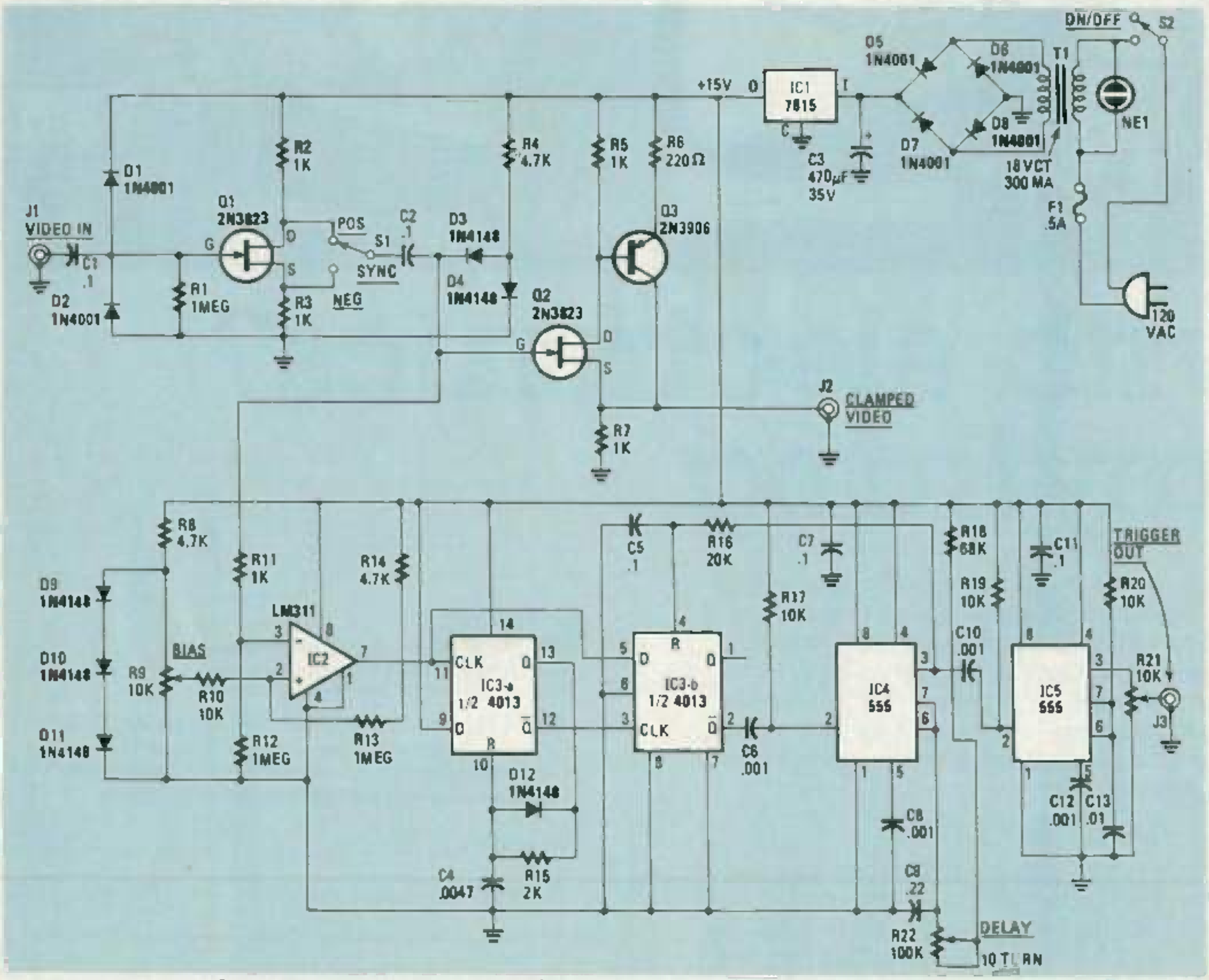

FIG. 2—SCHEMATIC OF THE SYNC SEPARATOR. The "heart" of the circuit is made up of IC2–IC5. The composite-sync output of IC2 is fed to IC3, a dual flip-flop, which outputs vertical-sync pulses. Those pulses are then delayed by IC4 and sent to IC5, which is configured as a one-shot. The output pulse of IC5, which is 100 microseconds, is sent to the scope's trigger circuit.

The C2-R12 time constant is quite long (.1 second) with respect to one horizontal time period. Because of that, the bias voltage remains essentially constant for the full period of the line. The effect of the bias is to force all of the sync pulse-tips to line up at the same level. Resistor R4 and diode D4 provide a +0.6-volt reference level for D3, which prevents the clamped signal from going below ground potential.

Transistor Q2 and Q3 form a wideband high-input-impedance buffer/amplifier that couples the clamped video output to the oscilloscope's vertical-input channel.

As we go through the discussion of the rest of the circuit, you'll find it helpful to study the timing diagrams of Figs. 3 and 4.

IC2 is a straightforward differential comparator that separates the sync pulses from the video information. The bias voltage on pin 2, the non-inverting input of IC2, is set by trimmer potentiometer R9. With the bias voltage properly set, the output (pin 7) will switch or change state only during the sync-pulse time, effectively stripping off the video and leaving only composite-sync signals, as shown in Fig. 3.

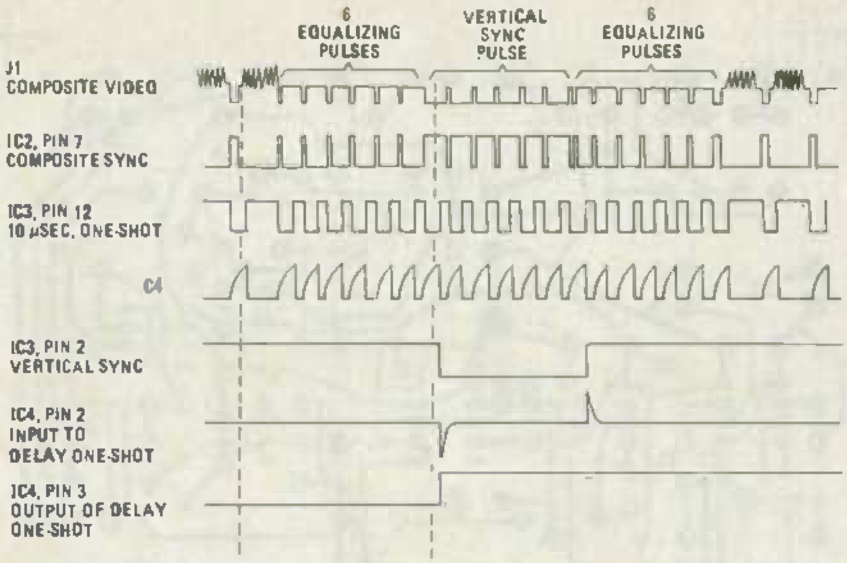

FIG. 3—THIS TIMING DIAGRAM shows how signals at various parts of the circuit are related. It should help you to follow the schematic and understand the operation of the circuit.

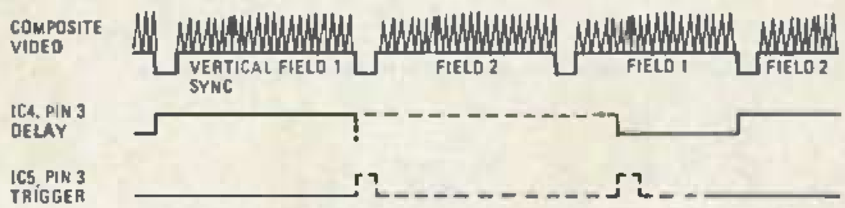

FIG. 4—TIMING DIAGRAM shows the relationship of vertical pulses to the delay and trigger output. The dotted lines indicated the range of delay that is available.

From IC2, the composite sync goes to IC3-a and IC3-b, both halves of a dual D-type CMOS flip-flop. That circuit separates the vertical-sync pulses from the horizontal by detecting the duty cycle change that occurs during the vertical-sync pulse time. Since IC2 is set up as an inverting comparator, the composite-sync pulses at its output are now positive-going. The rising edge of each horizontal-sync pulse clocks the input (pin 11) of IC3-a. Since the D input is tied to a high logic-level, those rising edges clock a high level into the Q output and a low logic-level into the $\bar{Q}$ output. When the Q output goes high, capacitor C4 begins charging up through R15. Diode D12 is reverse biased at this time and has no effect.

After about 10 microseconds, the voltage across C4, and thus the voltage at pin 10 (RESET) will be high enough to reset the flip-flop, forcing the Q output low again. That allows C4 to discharge rapidly through D12, bringing the sequence to an end. The result is that IC3-a is actually a one-shot with a period of approximately 10 microseconds—about twice as long as a standard horizontal-sync pulse.

The $\bar{Q}$ output of IC3-a drives the CLOCK input of IC3-b. That means that the rising edge seen at the CLOCK input corresponds to the end of the 10-microsecond time period. Note that the D input of IC3-b is not tied high. Instead, it is connected to the composite-sync output of IC2. As a result, whenever IC3-a is triggered by the horizontal-sync pulses, the D input of IC3-b will be low when the rising edge occurs at its clock input. Since the D input of IC3-b is low when the clock pulse occurs, no change takes place at the $\bar{Q}$ output.

The duty cycle of a vertical-sync pulse is much wider than that of the horizontal pulses. Therefore, when a vertical-sync pulse triggers IC3-a, the D input of IC3-b will still be high at the end of the 10-microsecond period. Since the D input is at a high logic-level when the clock pulse occurs, $\bar{Q}$ of IC3b will go low. The $\bar{Q}$ output will stay low as long as the duty cycle seen at the D input is longer than that of a horizontal-sync pulse.

So, at the $\bar{Q}$ output of IC3-b we will see a negative-going pulse that corresponds to vertical sync. The falling edge of that pulse is differentiated by C6 and R17 and is used to trigger the delay one-shot, IC4. With the DELAY potentiometer R22 at minimum resistance, IC4 has a time period of 16.5 milliseconds—just about the same length of time as one complete field. With R22 at maximum resistance, the time period is 40 milliseconds, which is equivalent to approximately 2½ fields.

At the end of IC4's time period, wherever it might be set, the output at pin 3 goes low. This edge is differentiated by C10 and R19 and used to trigger the last one-shot; IC5. The period of that monostable is fixed at 100 microseconds. The pulse is routed to J3 and used to trigger the EXTERNAL TRIGGER input of the oscilloscope.

Resistor R16 and capacitor C5 help reduce jitter on long delays. A slightly delayed version of the DELAY one-shot's output is applied to the RESET input (pin 4) of IC3-b. That guarantees that no spurious pulses will appear at its output until well after the delay period.

A minimum time delay of 16.5 milliseconds is used to ensure that the scope is not triggered on consecutive fields. If that were allowed to happen, the display would show the even and odd fields superimposed on one another.

Building the sync separator

The sync separator/trigger delay can be built as a free-standing, self-contained unit. Of course, you also have the option of installing the circuit inside an oscilloscope. The layout of the circuit is not critical, and if you're careful, you can build it on perforated construction board and use point-to-point wiring. Using a printed-circuit board is a better way to go, however. A foil pattern for a single-sided board is shown in Fig. 5. (See the Parts List for information on availability of a pre-etched and drilled board.)

Figure 6 shows a parts-placement diagram, including both on-board and off-board components. Figure 7 shows a photograph of the author's prototype that can be used as a guide. As indicated in the parts-placement diagram, be sure to con-

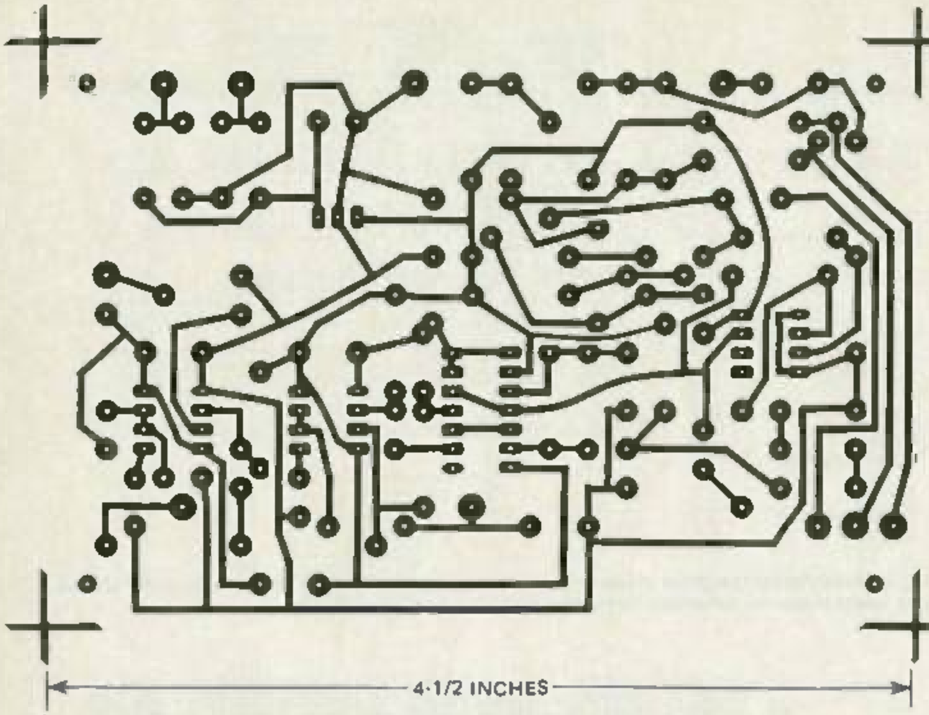

FIG. 5—THE SINGLE-SIDED BOARD is small enough to fit inside many oscilloscopes.

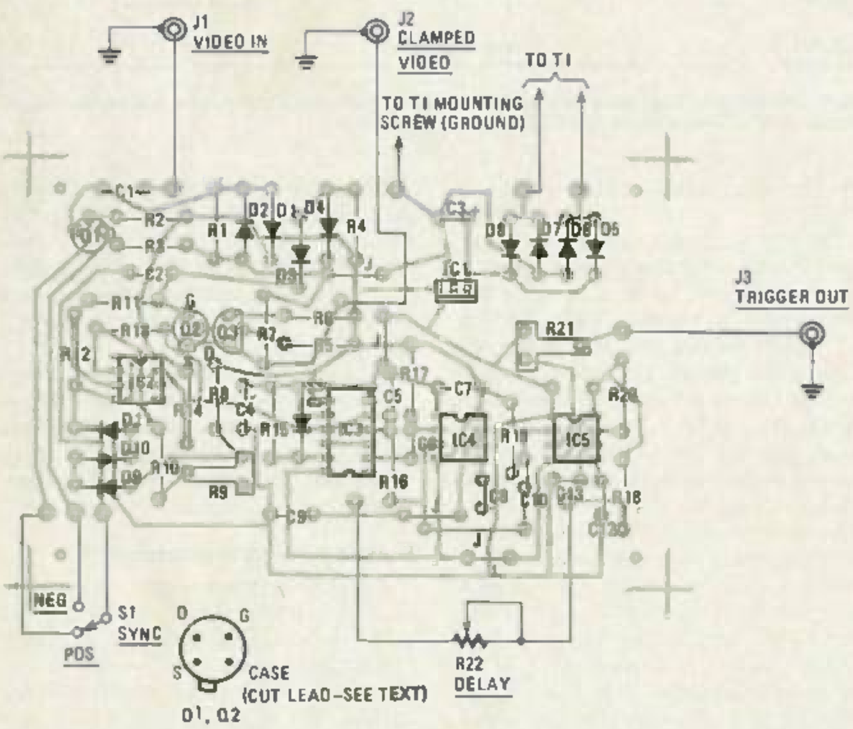

FIG. 6—PARTS PLACEMENT DIAGRAM. Note that before you install Q1 or Q2, you should cut the case lead. Also note that the board's ground should be connected to a transformer mounting screw.

Resistors, ¼-watt, 5% unless otherwise noted
R1, R12, R13—1 megohm
R2, R3, R5, R7, R11—1000 ohms
R4, R8, R14—4700 ohms
R6—220 ohms
R9, R21—10,000 ohms, trimmer potentiometer
R10, R17, R19, R20—10,000 ohms
R15—2000 ohms
R16—20,000 ohms
R22—100,000 ohms, ten-turn potentiometer
Capacitors
C1, C2, C7, C11—0.1 µF, ceramic disc
C3—470 µF, 35 volts, electrolytic
C4—0.0047 µF, 10%, polyester film
C5—0.1 µF, 10%, polyester film
C6, C8, C10, C12—0.001 µF, 10%, polyester film
C9—0.22 µF, 10%, polyester film
C13—0.01 µF, 10%, polyester film
Semiconductors
IC1—7815 15-volt regulator
IC2—LM311 comparator
IC3—4013 dual D-type flip-flop
IC4, IC5—555 timer
Q1, Q2—2N3823
Q3—2N3906
D1, D2, D5–D8—1N4001
D3, D4, D9–D12—1N4148
Other components
F1—fuse, ½ amp
J1–J3—Female BNC jack
NE1—neon lamp, 110 volts
S1—SPDT toggle switch
S2—SPST toggle switch
T1—110:18 volts AC, 300 mA
Miscellaneous: fuse holder, line cord, printed-circuit board, ground lug, case, etc.
The following are available from Elephant Electronics, Box 41770-P, Phoenix, AZ 85080: A complete kit (DT-1) consisting of all items listed above, $49.95. The printed-circuit board is available separately for $12.95. Arizona residents must include 6% sales tax.

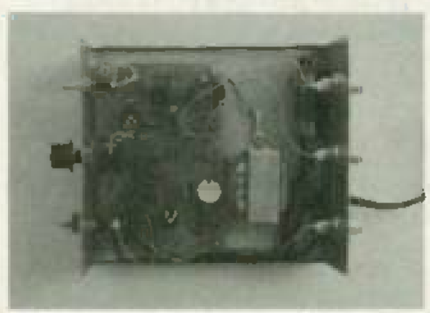

FIG. 7—THE AUTHOR'S PROTOTYPE, shown here with its top removed, was built as a stand-alone unit. If you want to use a smaller box, you might consider using a wall-mount transformer.

nect a wire from the board's ground to one of the transformer's mounting screws. Don't forget to install the 5 jumper wires on the PC board.

Be careful when installing IC3. It is a CMOS type and is therefore static-sensitive. Note that it's also oriented opposite to that of all the others.

The case lead of transistors Q1 and Q2 should be cut off prior to their installation. The proper lead is pointed out in the parts-placement diagram.

Checkout and setup

After the unit is assembled, apply power and check the power-supply voltage. If that's correct, proceed by connecting a source of video to the input. An ideal source is the video output of a VCR. If you don't have a VCR or other video source available, then the output of your TV's video detector will do nicely. Determine whether the sync pulses are positive- or negative-going and set the SYNC switch accordingly. Connect the CLAMPED VIDEO output of the project to the vertical input of the oscilloscope. You

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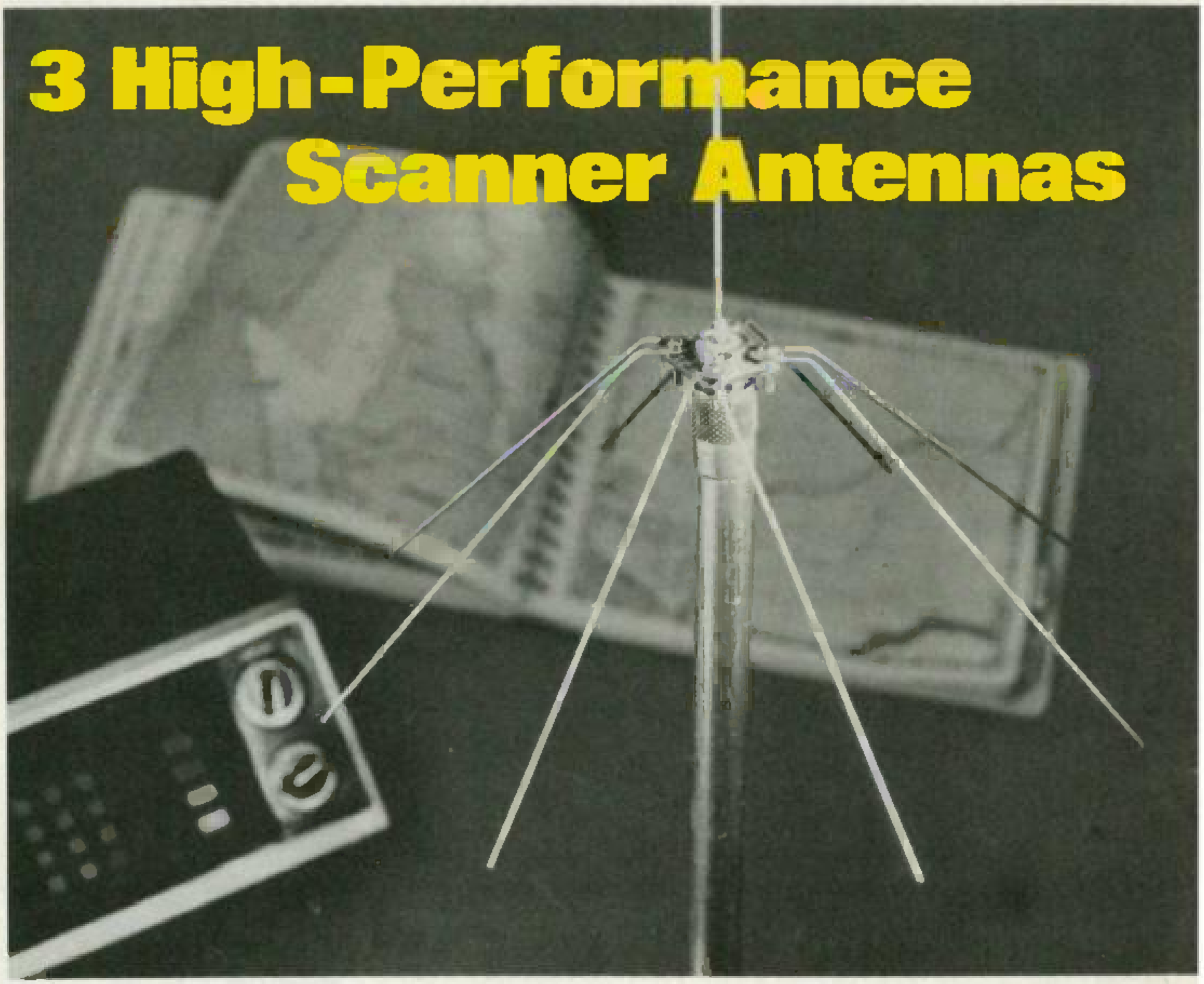


3 High-Performance Scanner Antennas

Are you still using your scanner's built-in antenna? Build one of these custom antennas and pull in those weak signals you've been missing!

LOREN FREBURG

IF YOU'VE RECENTLY BOUGHT A SCANNER/monitor, you've probably become hooked on evesdropping. You have also probably come to the realization that the skimpy little antenna that screws into the top of the unit has serious limitations. Reception from highway-patrol mobile units may come and go. Fire department transmissions from portable units may be inaudible from just a few miles away. And sometimes you may hear *only* the base station side of a conversation in a neighboring town.

If you've had similar experiences, an external antenna may be just what you need. Not the general-purpose (do-everything-half-way) type, but one designed to be optimum for the frequency you are most interested in, and yet provide good reception on the other frequencies!

There are three limitations to the built-in antenna. First, the height is too low. High-frequency radio waves tend to travel in straight lines, so low positioning limits the antenna's performance. Rooftop mounting allows the antenna to "see" farther because the horizon is more distant. The higher you can get your antenna, the better. Second, the length of the filaments are arbitrarily chosen and possibly too short. A correctly designed antenna is of a particular length. If an antenna isn't made to that particular length then, generally speaking, the longer the antenna, the better. Built-in antennas obviously don't meet that criterion. A third problem with built-in antennas is that reflections from nearby objects upset performance. Anything that is electrically conductive can absorb radio-frequency (RF) energy and then re-radiate it, causing interference or signal drop out. Such re-radiators include any thing metallic from house-wiring to pipes, and even metal picture frames.

A well designed outdoor antenna can overcome all those problems. The three antennas that we'll be describe, *ground plane*, *extended double-Zeppelin* and *coaxial collinear*, offer the best performance, and ease of construction at a low cost. They all share two characteristics: they are vertically polarized (mobile units require vertical antennas) and they're omnidirectional.

There are several public service bands that you're probably interested in. Those bands are shown in Table 1. The bands are divided that way because radio frequencies are widely separated between bands. The frequency determines the physical size of a particular type of antenna. Table 2 shows the typical antenna height of each antenna for a given band.

Antenna theory

Electromagnetic radiation travels at a velocity of 186,000 miles per second (C) in free space or a vacuum, and more slowly through other substances—for example, about ⅔ the free-space velocity through solid polyethylene. (The velocity in a particular medium divided by the velocity in free space is termed the *velocity factor*.)

That radiation travels in a wave-like motion; the distance between successive waves is defined as a *wavelength*. (The symbol for wavelength is λ). Frequency is defined as the number of waves passing a given point in one second. So a wavelength (in miles) is equal to 186,000 miles per second divided by the frequency or number of waves per second.

One wavelength, in miles, is expressed as $\lambda = 186{,}300/f$, where λ is the wavelength in miles and f is the frequency in hertz. Likewise, wavelength can be expressed in meters: $\lambda = 3 \times 10^5/f$, where λ is the wavelength in meters and f is the frequency in hertz.

Because we're working with distance measured in feet and frequency in megahertz (MHz), the formula can be rewritten as: $\lambda = 984/f$, where λ is expressed in feet and f in MHz. For example, a frequency of 984 MHz has a wavelength of one foot. (As the frequency increases the wavelength decreases. The opposite is true as frequency decreases.)

Resonance is another point that we should consider. Resonance is defined as a state in which the natural response frequency of a circuit coincides with the frequency of the applied signal. In other words, it's a condition in which a minimum amount of energy is needed to maintain current flow. That condition exists in an antenna when its length is exactly one-half wavelength ($\lambda/2$) long. Only a small amount of additional energy is needed to overcome losses in the conductor.

Let's take the analogy of a playground swing (a rather crude example of resonance, but it will illustrate our point). If a swing is pushed gently once every pass, its motion is sustained indefinitely with little additional energy. But, if the swing is pushed at a rate that doesn't exactly coincide with its movement, the smooth-flowing motion is interrupted. (You might say that it has met some resistance.) Thus, maximum performance is obtained when the antenna is at, or at least near, resonance.

Before we leave our swing, let's consider polarization from the simplest point of view. Although not a strict mathematical explanation, the similarity gives some idea of its importance. A properly timed push, whether from the back or the side, will maintain motion. However, our swing is designed for front-to-back motion (you might say it's polarized). Likewise, an antenna is polarized. Current should flow along a conductor, not across it.

Antenna impedance is a difficult concept to grasp because it doesn't really exist. It is only the mathematical quantity obtained by dividing the instantaneous voltage by the instantaneous current, which varies all along the antenna conductor. In a theoretical antenna in free space, the current at the end is zero and the voltage is at maximum. Thus, the impedance is seen to be infinite.

At a point on the conductor where the voltage is zero and the current at maximum, the impedance is zero. The importance of antenna impedance becomes apparent when we attempt to transfer energy in a antenna to a feedline and then to a receiver or scanner. Maximum energy transfer occurs when the impedances are matched—ideally, a 50-ohm monitor connected via 50-ohm feedline to the point on the antenna where the impedance is also 50 ohms.

That allows all energy picked up by the antenna to be transferred to the scanner, assuming there are no other losses. The same applies for transmitting antennas, except for power differences. A proper transmitting antenna is a proper receiving antenna, and visa versa.

The radiation pattern of a transmitting antenna is a three-dimensional representation of its relative efficiency in radiating power in different directions, as shown in Fig. 1. (Don't be concerned with the terminology, which appears to be describing a transmitting, rather than a receiving, antenna: The functions and terminology are interchangeable.)

An antenna that radiates equally well in all directions can be represented by a sphere, with the antenna being a point at the very center. Such an antenna, which exists only in theory, is called an *isotropic radiator*.

The fundamental resonant antenna (one-half wavelength long) is called a *dipole* when the feedline is connected to its center. Such antennas radiate energy in a figure-8 pattern, with a tiny hole in the center as shown in Fig. 1-*a*. The dipole runs through that hole.

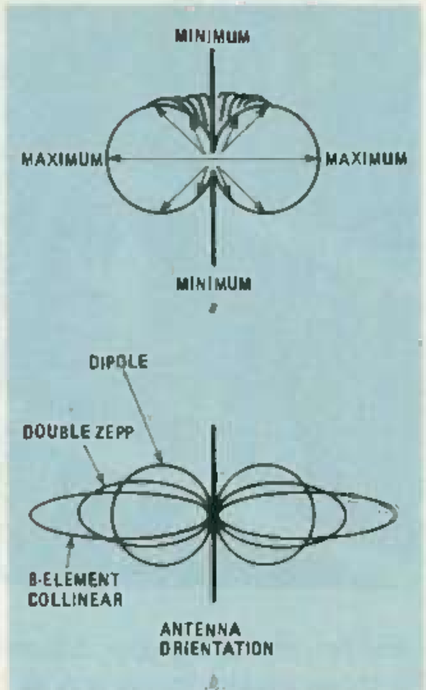


FIG. 1—ANTENNA RADIATION PATTERNS: *a* shows that the radiation pattern of a dipole is most intense at a point perpendicular to its center; *b* compares directional patterns for the three antenna types.

Figure 1-a also shows that maximum radiation (maximum sensitivity in receiving antennas) is in a direction perpendicular to the orientation of the dipole. Moving toward the ends of the dipole, signal pickup is at minimum. The dipole is usually wired at its center because the theoretical impedance is 73.14 ohms, and that is a convenient value to match to a feedline.

The gain of a particular antenna is an expression of the amount of energy radiated (or picked up) in the direction of the highest gain, and compared to a reference antenna. Let's use, for example, the hypo-

TABLE 1
PUBLIC SERVICE BANDS

Band	Frequency Range	Wavelength
VHF-low	30-50 MHz	33 ft - 20 ft.
VHF-high	118-136 MHz	8 ft. - 7 ft.
	148-174 MHz	6.6 ft. - 5.7 ft.
UHF-low	410-470 MHz	2 ft
UHF-high	470-512 MHz	

TABLE 2
TYPICAL ANTENNA LENGTHS

Band	Ground Plane	Extended Double-Zepp	Coaxial-Collinear
VHF-low	6 ft. + radials	32 ft.	80 ft.
VHF-high	1½ ft. + radials	8 ft.	20 ft.
UHF	6 inches + radials	2½ ft	6½ ft.

thetical isotropic antenna (which radiates equally well in all directions) as our reference standard. If both the isotropic antenna and a dipole each radiate all of their energy, the dipole will have some gain because its energy is concentrated in fewer directions. Thus, the gain of an antenna is a function of its radiation pattern.

A high-gain antenna has a radiation pattern that's highly directional. Antenna gain is expressed in decibels (dB): dB = 10 log P_A/P_R, where P_A is the power density or field strength of the antenna being compared and P_R is the field strength of the reference antenna. But how do we get a gain with our antenna if we need reception from all directions? We don't really need reception from all directions, just all compass directions. Signals from above or below us are not needed, and that's the key to unlocking better performance.

If the dipole antenna is positioned vertically as shown in Fig. 1-*a*, its radiation pattern wraps around it (like a coil wrapped around a stick) and there is 2.14 dB gain relative to the theoretical isotropic radiator. To obtain more gain the pattern must be compressed, making it flatter and wider. One way to flatten out the pattern is to stack half-wave dipoles and connect them so that the currents are additive (in phase).

Both the extended double Zeppelin and the coaxial-collinear antennas are variations of the stacked-dipole technique. Their radiation patterns are shown in Fig. 1-*b*, along with that of the dipole type. (Note that the ground plane antenna, which is our third antenna type, is simply a dipole that has been modified).

Antenna design

Until now, we've been talking only theory; but, in the real world, there are additional considerations. The antenna diameter itself must be taken into account at the higher frequencies. That's because a "fat" antenna acts electrically as though it were physically longer. Thus, the antenna must be made shorter than theory indicates. Table 3 shows the correction factor that the calculated wavelength must be multiplied by to obtain more accurate results.

Another factor affecting antenna performance is the presence of the ground beneath an antenna, which acts like an "electrical mirror." The reflected RF reaches the antenna later than the signal strike the antenna directly. Those late-arriving signals are added to the first, and either increase or decrease antenna current, depending upon the length of the delay.

That delay depends on the proximity of the antenna to reflective materials like nearby buildings, metal objects, bodies of water, and ground. All have similar reflective properties, and their effect is a function of their conductivity. Because of the

TABLE 3
CORRECTION FOR DIAMETER OF ROD OR TUBING

Ratio (Wavelength / Antenna Diameter)	Correction Factor
50	0.945
70	0.950
100	0.955
200	0.960
400	0.965
1000	0.970
4000	0.970

complex and often unpredictable nature of reflections, they are best avoided.

One way to minimize ground reflection problems is to make an artificial ground an integral and therefore predictable part of the antenna system. That's an important feature of the *ground plane* antenna.

Design theory must be combined with the available materials to make an antenna. The antennas described here use commonly available materials, and building them requires a minimum amount of tools. The antenna elements themselves are made from brass brazing rods, aluminum tubing, or coaxial cable.

Brazing rods are available from welding supply houses or someone who does brazing (such as auto repair or machine shops). Aluminum tubing can be bought in most hardware stores and home improvement centers. Coaxial cable and connectors can be obtained from electronics supply houses and the miscellaneous materials may be picked up at your local hardware store.

It should be emphasized that when designing an antenna, the dimensions are only a starting point. Use your imagination to combine the measurements with materials that you feel comfortable with or have on hand. Remember, materials can be modified. For instance, two brazing rods are easily soldered together to make longer elements so long as the joint is *first* wrapped with copper wire (see Fig. 2). Likewise, two pieces of tubing may be telescoped if necessary.

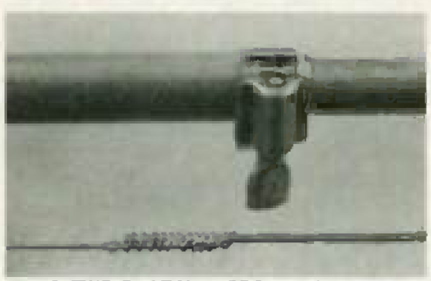


FIG. 2–TWO BRAZING RODS may be soldered together if longer elements are needed.

Ground plane

One of the most common communications antennas is the *ground plane*. (Figure 3 shows how dipole evolves into a ground plane antenna). In Fig. 3-*a*, we have the basic dipole. An artificial ground

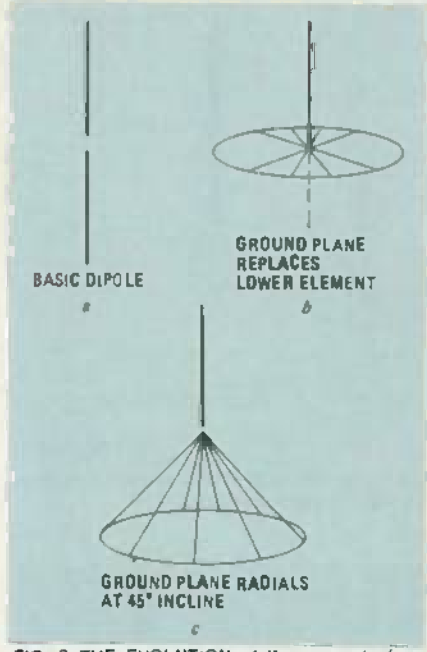


FIG. 3–THE EVOLUTION of the ground plane antenna: *a* shows the basic dipole; in *b*, the lower half of the dipole is replaced by a ground plane, and *c* shows the ground plane bent downward at a 45° angle.

(ground-plane) replaces the lower half of the dipole in Fig. 3-*b* and functions much like a reflector. It has about 1.8 dB less gain than a dipole, but often outperforms a dipole in spite of that. That's because it is less affected by reflections from the ground, which can cancel out antenna current.

The ground plane itself is usually made of wire extending from the base of the vertical element. The ideal antenna would have a continuous ground, perhaps made from a sheet of copper. A series of wires, or radials, approximates that condition. The more radials used, the closer we approach the ideal.

The wires can be self-supporting if made from a stiff rod or tubing. The impedance of a ground plane antenna is about 30 ohms when the plane is flat. By lowering the radials by 45° (as shown in Fig. 3-c) its impedance is made close to 50 ohms, which matches available coaxial cable and typical scanner/monitors. Also, lowering the radials lowers the radiation pattern, which effectively increases its gain.

A ground plane may be made from a coaxial chassis connector and wire. Figure 4 shows how to find the correct length for the radials and antenna element to be mounted on the connector. The antenna element and radials are made from brass brazing rods, which are available in 3-foot lengths and in diameters from 1/16 to 1/4 inch. The rods are fairly rigid, yet may be bent as needed. They're easy to solder, certainly an advantage when elements longer than 3 feet are needed. Use thinner rods for extensions and thicker rods next to the coaxial connector.

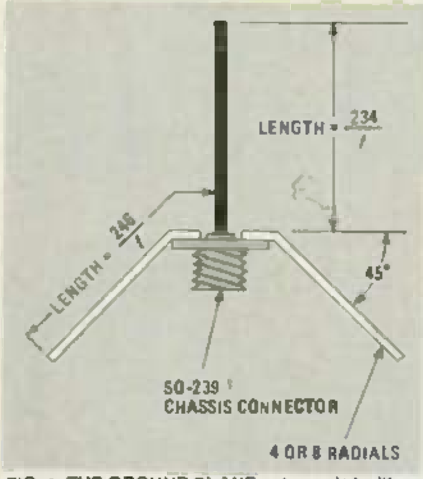


FIG. 4–THE GROUND PLANE antenna is built on a coaxial chassis connector.

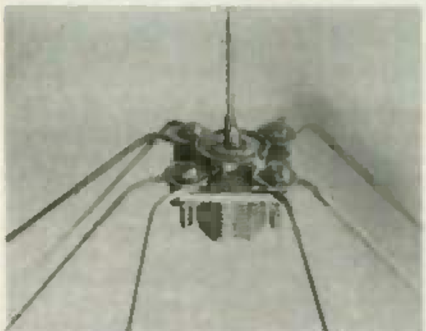


FIG. 5–GROUND PLANE antenna-base: brazing rods form the artificial ground and antenna element.

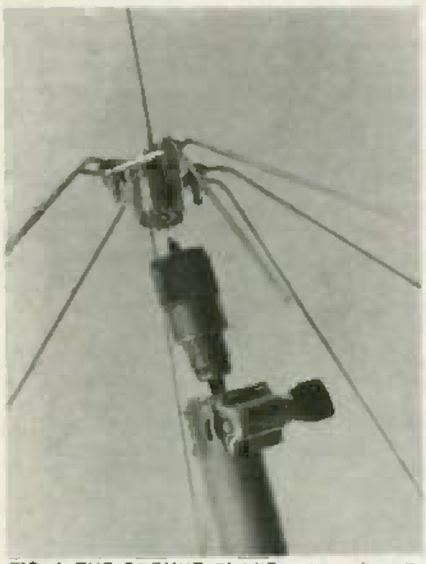


FIG. 6–THE GROUND PLANE antenna's connecting cable is run through the center of the tubing.

The vertical element should be λ/4 long. Cut the rod about ½ inch longer initially, and do the final cut after soldering to the chassis connector. Note that the ground-plane radials are each 5% longer than λ/4. That length includes the distance contributed by the base. Again, the final cutting is done after installation. Don't forget to correct the lengths of the various elements for the diameter of material you're using.

Figure 5 shows how the radials and element are connected. It is best to use eight radials as shown. Four radials will work but not as well. Bend them downward 45° and space evenly around the fitting. Solder the vertical element to the center pin of the fitting.

Now prepare the mast by making four 1½ inch lengthwise cuts in a piece of tubing. The inside diameter of the tubing should be close to the diameter of the plug (about ¾ inch). The plug will be held in the end of the tubing. Connect the plug to the cable and insert the assembly in the slit end of the tubing, as shown in Fig. 6. Then secure the assembly in place with a hose clamp.

The antenna may now be screwed onto the plug and moved to its final location. The ground plane is easily self-supporting when designed for the VHF (high) and UHF bands. However, when the lengths of the elements are 6 feet, as with the VHF low band, a little wind can really whip those rods around.

That problem is easily solved by adding a little bracing. The radials may be supported by 1 × 1 inch piece wood or lightweight tubing. Support is not needed all the way to the ends, about half to a third of the length should do. The vertical element must be braced with non-conductive material like a wooden dowel, 1-inch square piece of wood, plastic PVC tubing or similar material.

Extended double-Zeppelin

The extended double-Zeppelin antenna is a frequently-used modification of the design originally used in World War II Zeppelins, which is where the antenna got its name. The Zeppelin, or Zepp antenna is a resonant, end-fed antenna with a two-wire transmission line. The design presented here has an antenna element connected to each conductor, hence the name double-Zepp.

In the double-Zepp design, three half-wavelength sections are connected end to end, as shown in Fig. 7. The induced currents in the two outside elements flow toward the center conductor. Any induced current in each of the center λ/4 sections (phase-reversing stub) flow in opposite directions relative to each other, so their sum is zero.

That means that resulting current in the center section will be due only to the current induced in the antenna itself. When the antenna elements are close together, as shown in Fig. 7–*a*, those elements interact, reducing the total current flow and the gain of the antenna.

That problem is overcome by wider spacing (see Fig. 7-*b*). Of course, the element is now longer than a half-wavelength. That means that part of the current

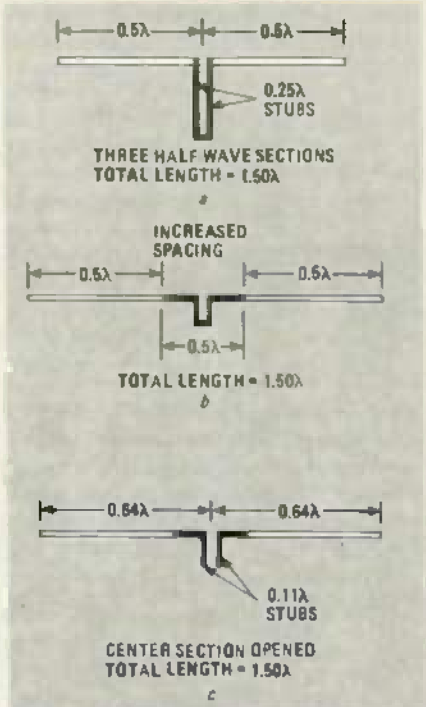


FIG. 7–THE EVOLUTION of the extended double-Zeppelin antenna. In each case, the total length is equal to 1.5 λ.

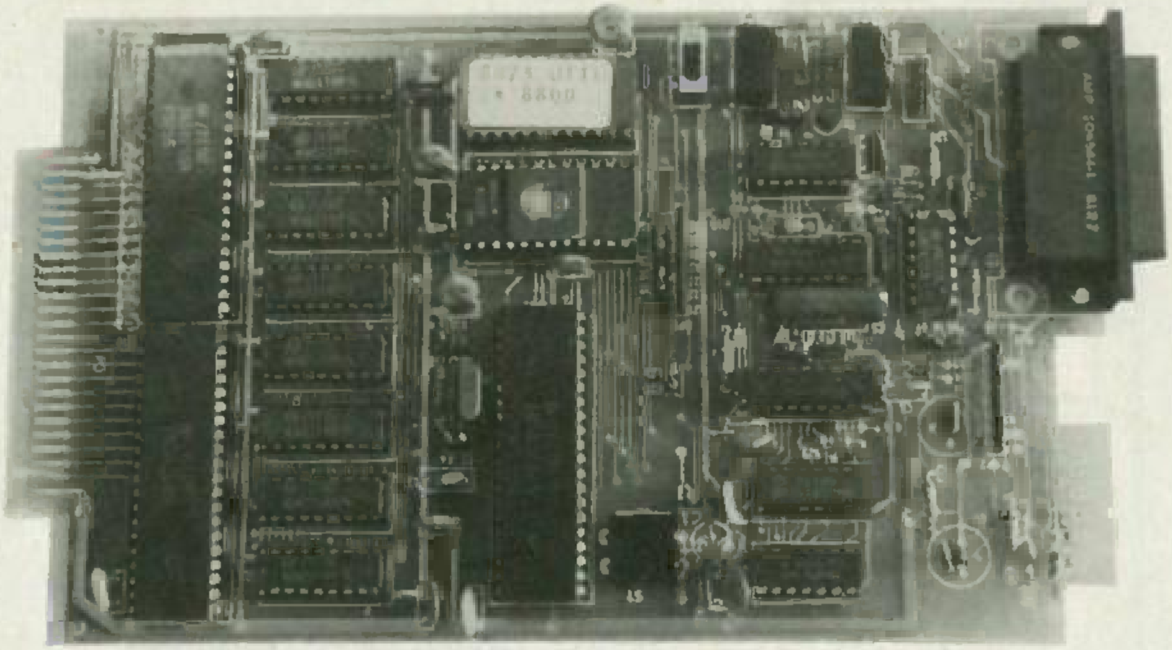
is out of phase, which reduces the total current and gain. When the spacing between the ends of each element is 0.28 of a wavelength, the increased gain, due to wider spacing, more than makes up for the lower gain caused by the short, out-of-phase sections. So the gain of the antenna is at maximum.

Figure 7-*c* shows the extended double-Zepp with an opening in the center conductor, which is the low-impedance point. However, its impedance is still several times greater than the desirable 50 ohms. A closer match may be obtained by using a standard television transformer-balun, the type used to connect 75-ohm coaxial cable to either a 300-ohm antenna or 300-ohm television input.

The vertical, center-fed Zepp is made of tubing, which allows the feedline to be run down its center where it cannot affect antenna performance. The tubing's diameter must be large enough to handle the coaxial cable, and the bolts that will hold it to the mast. A tubing diameter of ¾-inch is fine.

Unfortunately, while there's still much more we want to show you, that is all we have room for this month. When we continue, we will conclude our look at the extended double-Zeppelin by showing you how to calculate the length of the various sections for the frequencies of interest, and how to efficiently build that antenna.

Also, we'll look at what criteria you should consider when selecting which antenna to use, and at some installation notes. **R-E**



How to Design Microprocessor-based Projects

Make your next project "intelligent." Use a single-chip microcomputer to control it.

TOM FOX

ARE YOU FASCINATED BY MICRO-processor-controlled, semi-intelligent gadgets like robots that avoid obstacles, microwave ovens that monitor the food as it cooks, and cars that adjust the engine so that it's working as efficiently as possible? Have you come up with hundreds of control-computer applications that you'd like to try? (But you can't picture tying up your powerful personal computer for control applications?)

There *is* a way to design computer-controlled "smart" devices without tying up your expensive personal computer. It's easy if you use a device called a *microinterpreter*.

In this article, we'll show you how to design almost any computer-controlled device your imagination can dream up—even if you've never worked with microprocessors before! That's because you don't have to learn machine or assembly language and you don't have to invest gobs of money in expensive and complex development systems in order to design a computer-controlled machine. As long as you have some knowledge of electricity and digital logic circuits you should be on your way. But some familiarity with the BASIC programming language, as well as binary and hexadecimal numbers will come in handy too.

To get you on your way toward designing practical, semi-intelligent machines, we will describe, in detail, the design of a such a device: a "burglar outwitter." As its name implies, the purpose of the outwitter is to fool a potential burglar into thinking someone (or something) is home when actually no one is there.

What's a microinterpreter?

If you have ever used today's microcomputers, you probably realize that they're fairly easy to use. However, microprocessors—the brains of the microcomputer—have a notorious confusing nature about them. What is it that turns a complex, often mind boggling, microprocessor into an easy-to-use microcomputer? *Software!* Although it seems at times you can do magic with it, there is nothing magical about software. It's merely a list of detailed instructions that tell the microprocessor exactly what to do.

That's the same thing that makes a microinterpreter easier to use than a microprocessor. A microinterpreter is basically a single IC that contains both a microprocessor and software. The software in microinterpreters is contained in ROM (*R*ead-*O*nly *M*emory).

Before we go any further, we should point out that microprocessors with a built in high-level language are not universally called "microinterpreters." A few semiconductor companies refer to those IC's as single-chip microcomputers. However, that name is not only clumsy, it is unnecessarily vague since many of those same companies call microprocessors that have no built in high-level language "single-chip microcomputers." National Semiconductor refers to their INS8073—the device that we'll examine in detail—as a microinterpreter. This seems to be the best name available, and we will stick to it.

You might be thinking that there must be a catch somewhere. Microinterpreters

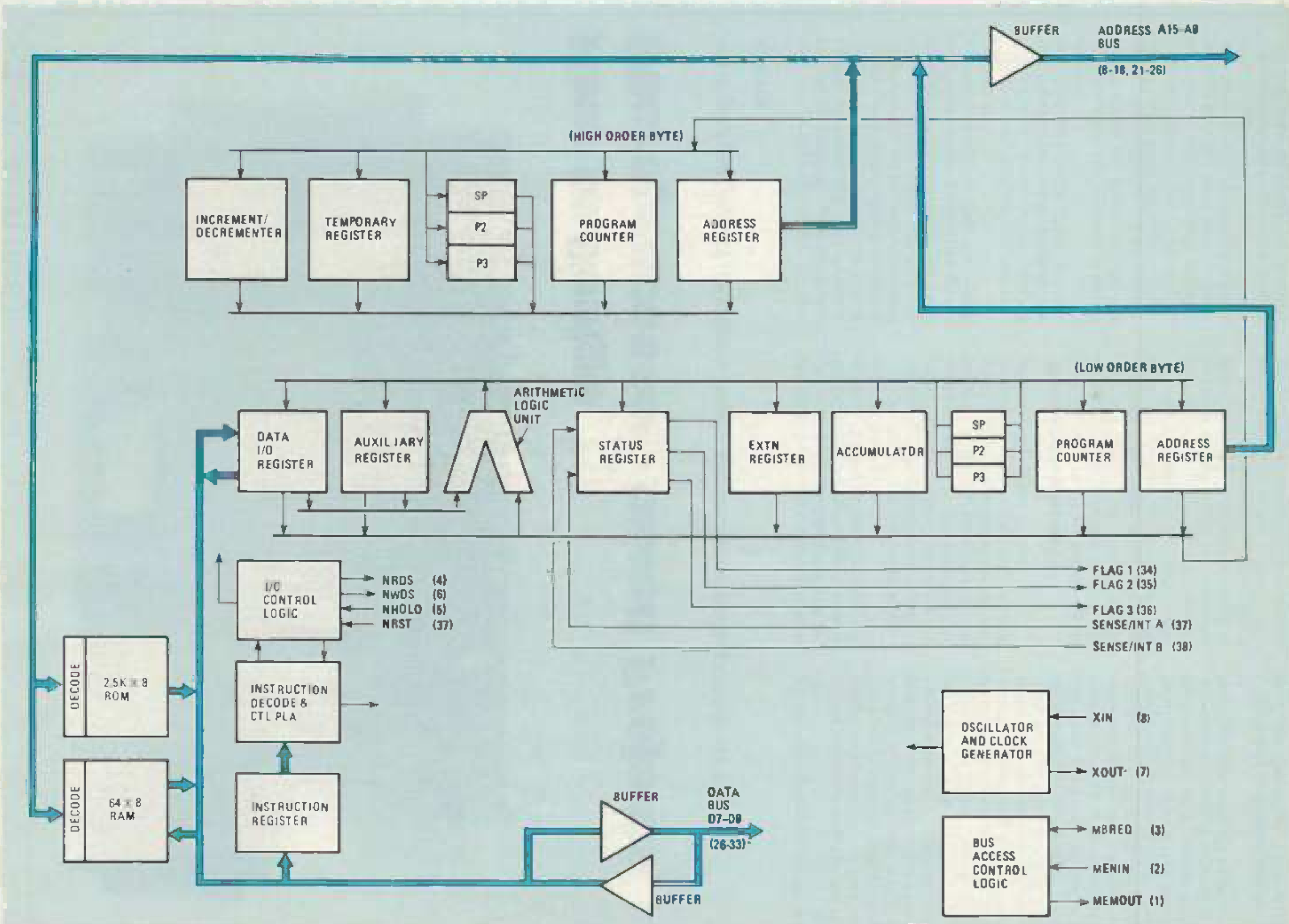


FIG. 1—BLOCK DIAGRAM OF THE INS8073 from National Semiconductor. Note that the microinterpreter contains 2.5K of ROM and 64 bytes of RAM.

seem almost too good; they must have a few bad points. Well in certain applications, they do. For example, if you're planning to design a revolutionary new personal computer that will take the peel right off the Apple, you probably should look past microinterpreters—they are relatively slow. That's because the interpreter (located in ROM) must convert the simple English-like commands into complicated machine language. And it must do that line by line as the program is running. That process takes a bit of time.

The good news is that the microprocessors in microinterpreters are so fast that for most control or monitor applications, they're much faster than the situation requires. But in those applications where a jiffy is several microseconds too long, you can program the time-consuming subroutines in assembly language. But that's enough talking in generalities—let's look at a specific device: the INS8073. It's block diagram is shown in Fig. 1.

The INS8073 microinterpreter

As we mentioned earlier, a microinterpreter is basically a microprocessor that understands a high-level language. Such microinterpreters fall into two general categories: ones that understand Tiny BASIC and ones that understand a form of stripped-down Forth.

Forth was developed in the early 1970's for real-time control of astronomy equipment. Because of that, it is an excellent language for microinterpreters since one of their primary uses is in control applications. Forth's main advantage, compared to Tiny BASIC, is that it is faster. However, unless you have already programmed in Forth, you'll have to spend a considerable amount of time learning the language. While Forth enthusiasts might write some letters to the contrary, most people would agree that Tiny BASIC is easier to learn than Forth.

Even if you have never programmed a computer before, you'll be able to write a program that works using BASIC in less time than with just about any computer language there is. It's true that many BASIC programs might not be very elegant. Nonetheless, if the program does what we want it to, then it's just fine. After all, that's what we're after—to get the job done.

Another advantage of BASIC is that it is the most widely used language among microcomputer users. (*Apple II*, *Timex*, *Sinclair 1000*, *Commodore 64* and many other popular computers all have a form of BASIC built-in.) So there is an excellent chance that you are at least mildly acquainted with BASIC. And if you are, your job in learning how to design smart machines with microinterpreters is nearly half done.

In our quest for simplicity, we will examine only one microinterpreter: the INS8073. However, you will be able to apply much of what we say to other devices. That IC, though relatively simple in architecture, has noteworthy features like 16-bit hardware multiply and divide. However, the best thing about the 8073 is that its language (National Semiconductor's Tiny BASIC) is a true gem. While we will describe that language in more detail later in this article, a few highlights will be given here.

National Semiconductor's Tiny BASIC includes DO-UNTIL commands. That type of loop control was burrowed from PASCAL and is unusual for Tiny BASICS. The ON command simplifies the handling of interrupts, which is important when designing smart machines. Another convenient Instruction is DELAY, which can be used to pause program execution for a user-determined length of time. This BASIC includes a RND function, which we will use extensively when we design our burglar outwitter.

National Semiconductor's Tiny BASIC handles strings and uses the operator (which simplifies transferring data back and forth between the program and memory locations or input/output ports). There are other unusual features of a Tiny BASIC, which we'll discuss in more detail later. Actually, if it were not for its restriction to integer numbers and 26 variable names, National Semiconductor could leave out the adjective "tiny" from the language's name and hear few complaints.

The 8073 has already been chosen by designers for a number of commercial applications. For instance, it is the "brain" of RB Robot Corp's *RB5X* robot and has been used for precision measurement of conditions in oil wells and testing the feasibility of the digital design of FM tuners.

Inside the INS8073

The INS8073 microinterpreter is an INS8072 8-bit microprocessor that contains Tiny BASIC in its 2.5K on-chip ROM. It has a 16-bit address bus and requires a single 5-volt supply voltage. Other features of interest to us include an on-board clock, TTL compatibility and 64 bytes of on-board RAM. (Yes, more RAM would be nice.)

There are some attributes of the 8070 series of microprocessor that affect us only indirectly. Those include 8 *and* 16-bit arithmetic, logic and stack-manipulation instructions, hardware multiply and divide, and single-instruction ASCII-to-decimal conversion. The 8072/8073's multiprocessing feature will not be used.

A feature of the IC that simplifies its use as a stand-alone, real-time controller, is the provision for automatic execution of ROM (or EPROM) at power-up or on reset. The 8073 also contains firmware that allows easy interfacing to a RS-232 terminal.

The INS8073 "understands" ASCII (the *A*merican *S*andard *C*ode for *I*nformation *I*nterchange) so programs can be simply and quickly modified without the need for costly and awkward assemblers, text editors, debuggers and development systems—all you really require is a terminal (or a computer and terminal software) to enter a program into the microinterpreter's RAM.

Figure 1 is a block diagram that shows the architecture of the INS8070. Since this article is primarily concerned with the design of microprocessor-controlled equipment using only Tiny BASIC, we will ignore the fact that the 8073 has a machine level instruction set. However, if we are to design real working circuits, we must examine the IC's pin configuration as well as the function of each pin in some detail.

Pin functions of the 8073

Figure 2 shows the pinout of the INS8073. While we could go through the pins, starting at pin 1 and explaining each pin's function in sequential order, we will start at the easy part first—the power supply connections.

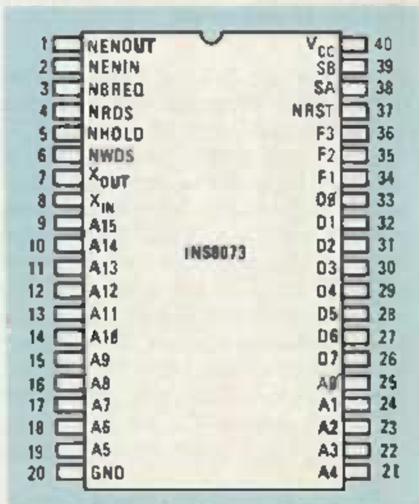


FIG. 2—PIN CONFIGURATION of the INS8073.

Pin 20 is the GROUND pin. It should always be connected to the logic power supply's ground. Pin 40 must be connected to a well-regulated voltage source (+5 volts with respect to pin 20). That voltage shouldn't vary by more than ± 5% (so you have a permissible range from 4.75 to 5.25 volts). The power supply should be able to supply a minimum of 250 ma.

Pins 26–33 are the connections for the bidirectional 8-bit data bus. (The most significant bit, D7, is connected to pin 26.) The data bus is three-state, which in this case means that it is basically disconnected from the circuit except for external write operations. The data bus can drive one standard TTL load or several LS-TTL loads. Pins 9–19 and 21–25 are the address-bus pins. That is also a three-state bus.

In order to use the on-board oscillator, an external crystal must be connected to pins 7 and 8. Figure 3 shows how. If you prefer to drive the IC with an external clock (it must be TTL compatible), connect the signal to pin 8. Pin 7 provides a buffered clock output with either an external or internal clock.

Pin 37 is the RESET pin. It is simple in concept, but extremely important. When it is brought low (below 1 volt) several things happen. Any in-process operations

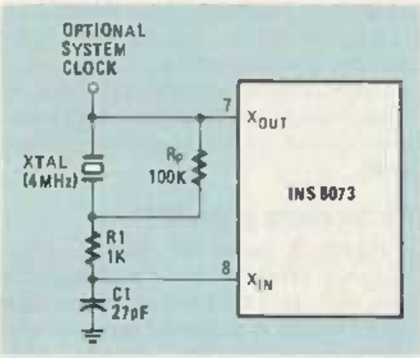


FIG. 3—A INTERNAL OSCILLATOR is contained in the INS8073. Here it is shown configured for a 4-MHz clock rate. A TTL-compatible external clock may be used instead.

are aborted, the data and address bus are disconnected, the program counter, stack pointer, and status register are cleared. As far as we're concerned, however, the most important thing that happens upon the resetting of the microinterpreter is that the program we stored in EPROM will start automatically. (Provided the program in EPROM starts at hex address 8000.) Since that pin is buffered by a TTL compatible Schmitt trigger, we do not have to be overly concerned about rise and fall times. Figure 4 shows one way of connecting this pin so that the device automatically resets when we turn on the power.

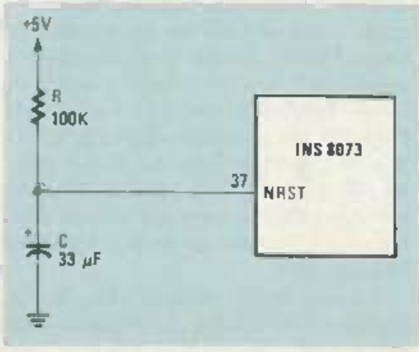


FIG. 4—POWER-ON RESET. If pin 37 of the INS8073 is connected as shown, it will automatically execute a program stored in EPROM (starting at address 8000) at power-up.

Pin 4 is the READ DATA STROBE output. It is a three-state output that goes low when the microinterpreter is reading from external memory.

Other than those times, the output is effectively disconnected from the rest of the circuit. In some circuits, a 10K pull-up resistor should be connected from +5V to pin 4. The READ DATA STROBE output is connected to some address-decoding circuits so that input data is present on the data bus only during an external read operation.

Pin 6, the WRITE DATA STROBE, is similar in function to pin 4. The primary difference is that this pin goes low during external-memory *write* operations. Like pin 4, a 10K pull-up resistor is sometimes connected to this pin. That output is required so that external memory (or output) devices know when the information on the data bus is valid.

Pins 38 and 39 are the INS8070's two interrupt pins. Both act as interrupt-request pins. (The 8073 does not have the equivalent of a non-maskable interrupt.) In order for an interrupt to be serviced, first the input to one of those pins must go from high to low. (It is edge, not level triggered). Also, the least-significant bit in the status register must be 1. (The status register is accessible through the NSC Tiny Basic STAT function.) Pin 38 has priority over pin 39 if both interrupts occur at roughly the same time.

In addition to acting as inputs for interrupts, both pins serve as sense inputs. Here we are mainly concerned with pin 38, which will accept serial ASCII input data. The input data must first be converted to TTL levels.

The remaining pins will be briefly described in sequential order. Don't worry if the description is a bit confusing, the functions these pins provide will not be implemented in our project. Nonetheless, some of these pins must be connected to ground or +5V for proper operation of the microinterpreter. Refer to the notes given in the description of each pin for their proper use in our project.

Pin 1: ENABLE OUTPUT. The 8073 controls that output as follows. 1) If pin 3 (BUS REQUEST) is low, but the 8073 is not holding it low, then pin 1 is brought to the same logic level as pin 2, the ENABLE INPUT. 2) If pin 3 is low because the 8073 is holding it low, pin 1 goes high. 3) Pin 1 is always high if pin 3 is high. Note: Pin 1 can be left unconnected.

Pin 2: ENABLE INPUT. 1) If this pin is high, the 8073 sets pin 1 high and is denied access to the bus. 2) If pin 2 is low and the 8073 is holding pin 3 low, pin 1 goes (or stays) high and the 8073 has access to the bus. 3) If pins 2 and 3 are both low and the 8073 is not holding pin 3 low, pin 1 is set low and the 8073 is denied access to the bus. Note: Pin 2 should be connected to ground.

Pin 3: BUS REQUEST. This is the bidirectional bus request input/output. It already has been referred to. Like pins 1 and 2, pin 3 is used in direct memory access (DMA) and multiprocessing applications. This pin should be connected to a +5V power supply through a 10K pull-up resistor.

Pin 5: HOLD INPUT. The primary application of pin 5 is to allow the use of slow memories and peripherals. It is also used for single memory cycle extension. Setting that pin low causes the 8073 to extend an external read or write cycle. Note: In the burglar outwitter that we'll describe, pin 5 is connected to +5 volts through a 10K pull-up resistor.

Pins 34, 35 and 36: Flags 1, 2, and 3 outputs. These flag outputs can be set by writing into the appropriate flag bits located in the status register. These pins can be left unconnected.

Next month, we'll describe, in some detail, the language of the 8073 microinterpreter—National Semiconductor's Tiny BASIC. We will also take a look at a commercially available demo/development board, which greatly simplifies designing with this exciting microinterpreter. **R-E**

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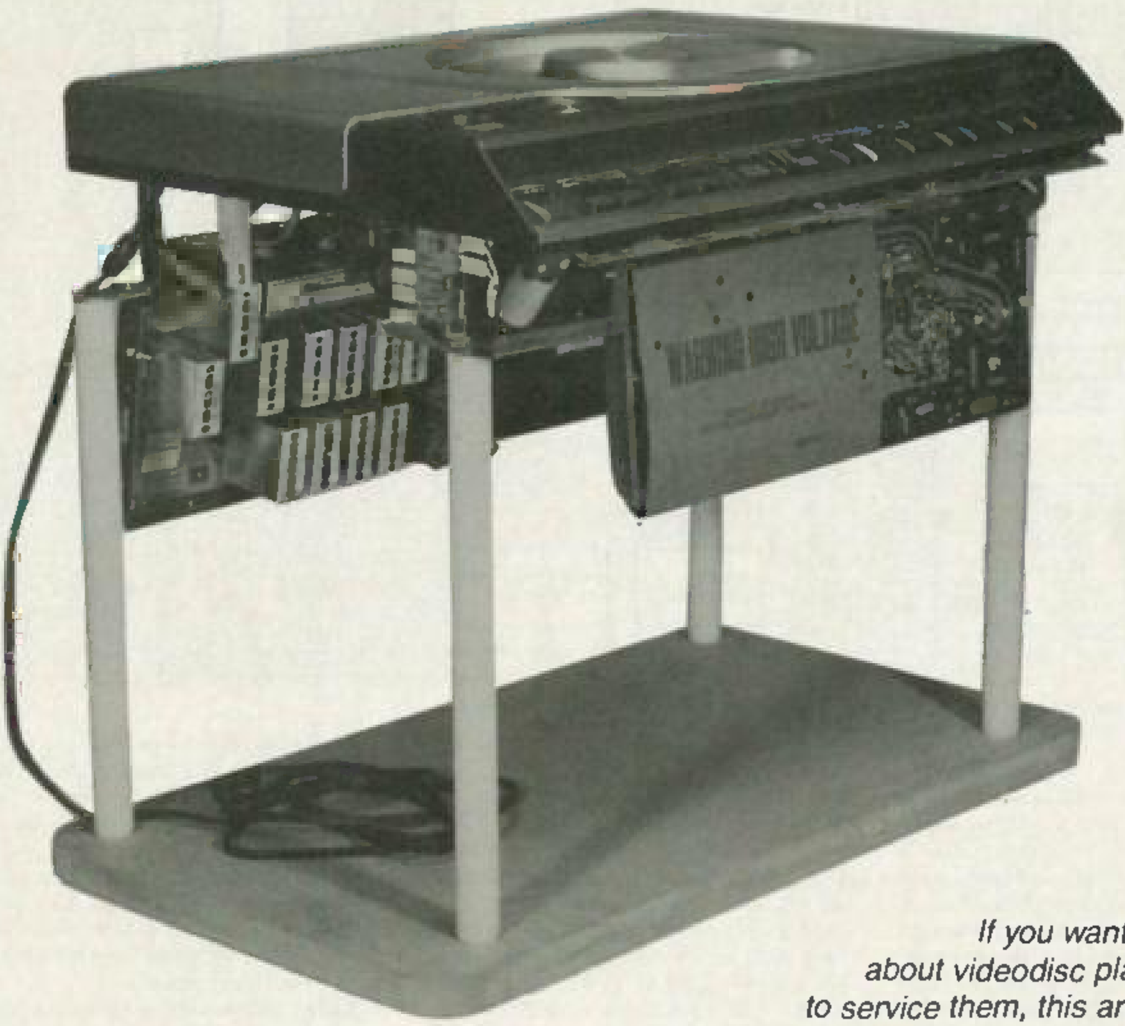
Servicing Videodisc Players



JOHN LENK

If you want to learn more about videodisc players and how to service them, this article is for you. This month we conclude our look at CED players.

Part 4 LET'S CONTINUE OUR look at troubleshooting typical CED player failures. For your convenience, we've reprinted Fig. 14 and Table 2 from February's issue.

Pickup electronics. As shown in Fig. 14, the pickup electronics (resonator, preamp, AFT) are part of the arm assembly. Generally, the preamp and AFT circuits are serviceable, but the resonator is not. The disc signal causes a 915-MHz resonator signal to be amplitude modulated and peak detected to produce the FM video and audio carrier-signals. Those signals are preamplified from about 10 mV to about 300 mV, and applied to the demodulators. An AFT voltage is also returned to the resonator, and keeps the resonator on frequency.

If the player is operating, but you get neither video or audio, look for a 5-MHz FM signal at the input and output of the preamps, and for an AFT voltage at the resonator. If there is no 5-MHz FM at the preamp output, the problem is in the arm. If the preamp output is good, check the wiring between the arm and the demodulators.

If you get both audio and video playback, but there is interference, try applying an external AFT signal and see if that clears the problem. The external AFT should be taken from a variable 0 to 12-volt DC supply. If you get a good signal with an external AFT, the AFT circuits are the likely culprits.

Audio demodulator circuits. As shown in Fig. 14, to recover disc audio-signals, the 716 and/or 905 kHz carrier is

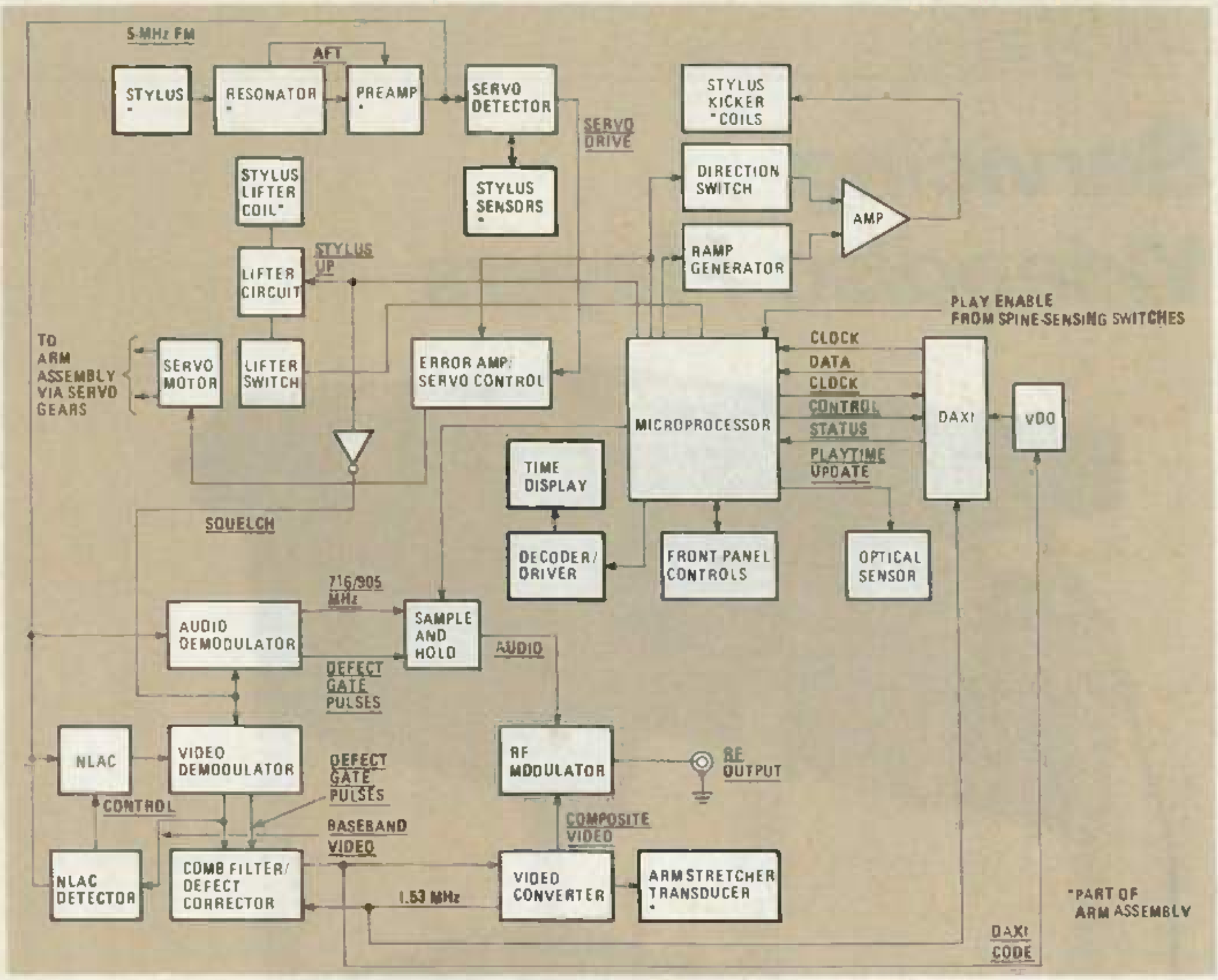


FIG. 14—BLOCK DIAGRAM of the electronic and mechanical systems in a CED videodisc player. The blocks noted with an astrisk are located in the player's arm.

separated from the 5-MHz video carrier and then demodulated by the audio demodulator. The demodulated audio is passed through a sample-and-hold circuit that removes noise spikes when a loss-of-carrier is detected. The audio is then applied to the RF modulator. The audin demodulator includes 716 and/or 905-kHz VCO's that are usually adjustable. In addition to the 5-MHz carrier, the audio demodulator also receives a squelch signal developed by the microprocessor. Generally, that is the same signal used to operate the stylus lifter. Both the audio and video circuits are squelched when the stylus is not in contact with the disc.

If you get good video, but no audio, check for audio at the output of the sample-and-hold circuit. If the audio is good at that point, trace the audio to the RF modulator. If there is no audio to the sample-and-hold, check for audio at the demodulator output (usually about 1.5 volts). Also check that the squelch line is not cutting the demodulator off. Next, check for any adjustments in the audio. As previously mentioned, the 716/905 VCO's are generally adjustable. Likewise, the demodulator output is usually adjustable (through a modulation-level-adjust, or some similar control).

If you get audio, but it is noisy or weak (but with good video), suspect the sample-and-hold circuit, or that you are getting excessive defect-gate-pulses from the demodulator.

NLAC circuits. The arm output (Fig. 14) is applied to the video demodulator through the NLAC circuits which, in turn, are controlled by the NLAC detectnr. Those circuits eliminate the 716/905-kHz audio signals that cause soundbeats (a constant pattern in the picture). If the NLAC circuits are defective, the soundbeats can get through to the video demodulator or, in some cases, the NLAC circuits can be cut off so no video signal is applied.

If the problem is one of soundbeats, try correcting the condition by adjustment. Usually, there is an NLAC-phase-adjustment (to zero out the undesired beat) and a control-voltage level or bias (to set the control voltage amplitude to the NLAC). If that adjustment fails to cure the problem, trace the various NLAC signals. There should be both baseband- and audio-carrier inputs to the detector, and a control-signal output from detector to NLAC. Also look for 5-MHz video from the preamp to the NLAC, and from NLAC to the video demodulator.

Video demndulator-circuits. Video signals are placed on a disc by frequency modulating a 5-MHz carrier with the video signal. The video demodulator contains a 5.25-MHz VCO that combines with the arm output (passed through the NLAC) to produce both video and defect pulses. The video demodulator also receives the squelch signal from the microprocessor, so that there is no video when stylus is lifted from the disc.

If you get good audio, but no video, check for baseband video at the demodulator output. If the video is good at that point, trace the video to the comb-filter/defect-corrector. If there is no video at the demodulator output, but video from the NLAC, check that the squelch line is not cutting the demodulator off. Next, check for any adjustments in video. Generally, the 5.25-MHz VCO is adjustable. Likewise, the demodulator output is usually adjustable (through a video-level-adjust, or some similar control).

If you get video, but it is noisy and weak, with dropouts (but with good audio), check for excessive defect-gate pulses from the video demodulator to the comb filter.

Comb-filter/defect-corrector circuits. Those circuits prevent dropouts in the displayed picture that result from momentary loss of video carrier (caused by contamination or defects in the disc). That is done by recirculating the previous horizontal line of the video signal when a defect occurs. The circuits also separate the 0- to 3-MHz luminance signals from the 1.53-MHz buried-subcarrier chroma signals.

If you get no video or chroma, but audio is good, check for proper inputs. There should be both baseband video and defect-gate-pulses from the video demodulator, and a 1.53-MHz signal from the video converter. If the inputs are present, but there are no chroma and/or luminance outputs (typically about 1 volt) to the video converter, the comb-filter/defect-corrector is probably at fault (although there are buffer circuits between the corrector and converter in some players).

If you are getting both luminance and chroma, but there are excessive dropouts (but with good audio), try adjustment. Generally, there is a delayed-video-adjust or similar control. Note that that adjustment controls the amplitude of the recirculated horizontal line, not the delay time (which is provided by a fixed delay line, typically 63.6 μs or 1H).

Video converter circuits. Once the buried-subcarrier-chroma signals are separated from the luminance signals by the comb filter, the 1.53-MHz chroma signals are up-converted to the standard 3.58-MHz color subcarrier. That is done in the converter by heterodyning the 1.53-MHz chroma signal with a 5.11-MHz VXCO signal. The resultant 3.58-MHz chroma is then added to the combed luminance, producing the composite video (which is applied to the RF modulator through buffers).

The 1.53-MHz signal is also used by the system control and DAXI circuits. So, before you get too far into the converter circuits, check that the 1.53-MHz signal is present, and on-frequency. You will need a 7-digit counter, and should get 1.535625 ± 225 Hz (with the player in PAUSE).

If the 1.53 MHz is absent or abnormal, check for 5.11-MHz and 3.579545-MHz signals at the converter. Adjust those signals if necessary. In some players, the 3.58 MHz is adjustable, but not the 5.11-MHz. If the 1.53 MHz clock is good, but you are having video problems, start tracing circuits as follows.

TABLE 2—CED TROUBLESHOOTING GUIDE

Symptom	Circuits To Check
Player totally inoperative, or turntable on but no picture	Power supply and switch control
Caddy can not be loaded/unloaded	Mechanical adjustments
Player will not turn off	Mechanical adjustments
No playback	Stylus lifter cleaner and pickup electronics
No or noisy audio	Audio demodulator
No or noisy video	Video demodulator and video converter
Picture and or color instability	Time-base corrector
Wrong color, picture not in sync	Comb filter defect corrected
Soundbeats in picture	NLAC circuits
No RF output	RF modulator
Picture and audio repeat, visual search inoperative or incorrect	DAXt signal circuits
Rapid access inoperative or incorrect	DAXt, system control, time display
VISUAL SEARCH or RAPID ACCESS problems	Stylus kicker and servo control

Check for luminance of about 400 mV and chroma of about 200 mV to the converter, and a composite video of about 2.5-volts peak-to-peak to the RF modulator. In most units, the composite video from the converter to the RF modulator can be adjusted by a modulation-depth-adjust or similar control. Likewise, either or both the chroma and luminance from the comb filter to the video converter can be adjusted (on most players).

Time-base corrector circuits. The video-converter circuits also provide time-base correction. During playback, eccentricities and warpage of the disc cause phase and frequency modulation of the recovered video signal. Such modulation can result in tint and color changes in the chroma, and horizontal instability in the luminance signals. The time-base correction circuits modulate the frequency and phase of the 5.11-MHz VXCO, and maintain the disc-to-stylus velocity (by moving the stylus forward or backward along the disc groove). High-frequency and static time-base errors in chroma are corrected by controlling the 5.11-MHz VXCO. Mid-frequency (1 to 300 Hz) correction of both luminance and chroma is done by the armstretcher circuit.

Instability or wiggles in the picture can be caused by incorrect armstretcher gain. So the first step is to try correcting horizontal instability problems by setting the armstretcher gain according to the service literature. If that does not cure the problem, make sure that there is an armstretcher error-signal between the converter and armstretcher transducer on the pickup arm. If not, start at the converter and trace the signal to the transducer (through a series of drivers and amplifiers).

If you are getting an error signal to the transducer, see if the signal varies when the disc speed varies. Monitor the voltage at the transducer (about 2 to 10 volts), and slow the disc down by touching the edge of the disc with your finger. (Touch only the edge and *do not* press hard!) The voltage should change. You can also check the armstretcher-transducer function by confirming that the stylus moves (about 0.01 inch) when you touch the disc.

Before you tear into the time-base circuits, trying to locate a wrong-color, changing-tint, or picture-not-in-sync fault, make sure that the turntable is locked to the line frequency. You can make a quick check of turntable speed by inserting a test disc and operating the player under a fluorescent light. The inner diameter of most CED test discs has black and white wedges on the label. If the turntable is turning at 450 rpm, the strobe effect causes the white wedge to appear at the same point with each flash of the light, producing a stable image. If the white wedges revolve, the turntable is not in sync. The most common causes of that problem are mechanical. With power off, and disc removed, spin the turntable by hand (gently). If you hear grinding or dragging, or if the turntable does not revolve easily, check for dry bearings, or other mechanical binding (such as bent motor-magnet poles).

RF-modulator circuits. The RF-modulator circuits are usually easy to troubleshoot (if you have audio/video inputs, but no RF output, the problem is in the RF modulator). Of course, you must make sure the antenna switch is good, and that the set you are watching is tuned to the correct channel. However, the matter of adjusting the RF-modulator circuits is not that simple. The Channel 3/4 tank-circuits are external from the modulator IC, and must be adjusted separately. The same is true for any sound trap and band-pass filter-circuits. Always use the recommended procedures for those adjustments. For example, you should recheck tank-circuit frequencies after an RF-modulator IC has been replaced, but it is generally not necessary to adjust the trap and filter circuits (unless you have replaced parts in the traps and filters). Keep in mind that those trap and filter circuits prevent undesired player signals from passing to

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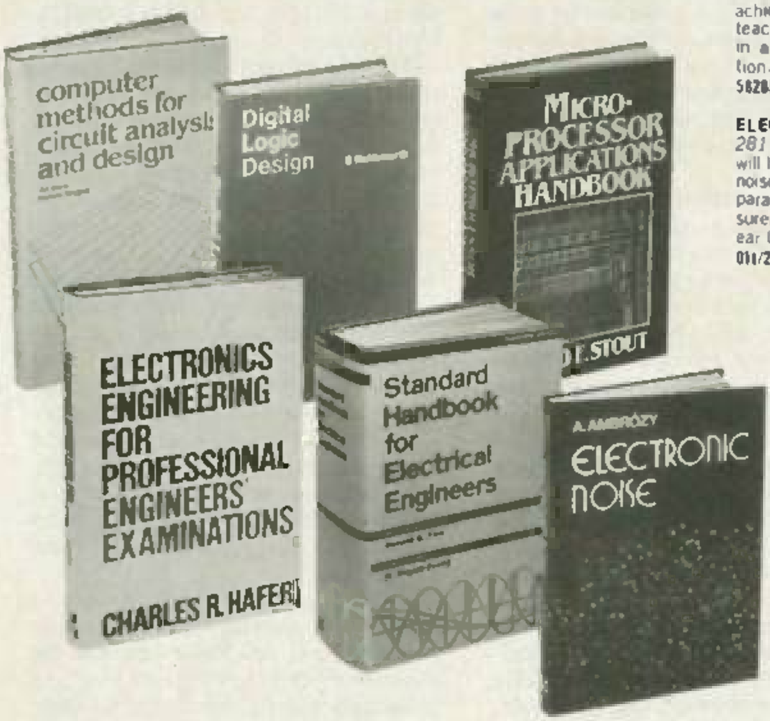

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the TV set (and to the antenna!).

Time-indication circuits. Elapsed program-time, shown on an LED time display, is developed when the microprocessor decodes the DAXI signal, and produces a corresponding binary code. A decoder/driver decodes the binary information and activates the LED's. During RAPID ACCESS (when the stylus is lifted), there is no DAXI. Instead, the microprocessor receives pulses from an optical sensor that produces an output as the arm moves rapidly across the disc.

If there is no (or an incorrect) time display, make sure that you are getting good DAXI signals to the microprocessor. If the time display is incorrect only using RAPID ACCESS, the problem is likely in the optical sensor.

DAXI-signal circuits. Operation of the entire player is controlled by the microprocessor, which decodes the DAXI signal to determine the video field being played and the elapsed time. Locked grooves are also determined by checking the DAXI code for a repeating or decreasing DAXI number (indicating a "skip back"). The microprocessor causes the stylus to exit locked grooves by activating stylus-kicker circuits. So if you are troubleshooting a "locked groove" problem (audio/video repeats) and either RAPID ACCESS or VISUAL SEARCH are inoperative, start by checking for good DAXI signals.

Typically, the control signals from the microprocessor to the DAXI IC are 16ms and about 400µs in width. Wider DAXI control (DCNT) signals (say 800µs), usually indicates DAXI problems (most likely in the DAXI IC or VDO—vertical detail—IC, or possibly in the circuits between the comb-filter/defect-corrector and the DAXI IC). The DAXI-status (DSTAT) signals from the DAXI IC to the microprocessor are also at 16ms, and the width is not critical. Again, the problem can be in the DAXI IC and/or microprocessor.

Stylus-kicker circuits. Those circuits are used to move the stylus two grooves on the disc (either forward or reverse), and occur during a locked groove condition and in VISUAL SEARCH. When the microprocessor senses a locked groove condition (the DAXI numbers keep repeating or decreasing), the microprocessor applies kicker pulses through a ramp generator (Fig. 16) and amplifier circuits to the stylus-kicker coils on the arm to move the stylus forward out of the locked groove. The direction of the pulse (and corresponding stylus movement) is determined by direction-switch-circuits. When the microprocessor receives VISUAL-SEARCH commands from the front panel controls (FORWARD or REVERSE), the microprocessor produces a series of stylus-kick-pulses that are timed to maintain two grooves of movement with each kick.

Failure in the kicker circuits usually shows up as a failure to escape from a locked groove, or no VISUAL SEARCH, or VISUAL SEARCH in one direction only. To make a quick check of both the kicker and VISUAL SEARCH circuits, look for pulses at the kicker coils on the arm while pressing the VISUAL SEARCH buttons. If you get no pulses, make sure that the microprocessor is getting VISUAL-SEARCH commands, and then trace the signals from the microprocessor to the kicker coils.

If you get pulses at the coils, but the pulses have no overshoot, the kicker coils are possibly open. (On most players, you must replace the entire arm if the kicker coils are bad.) If you get no pulses at the coils, trace the circuits between the microprocessor and coils. If the coils are operative, but the arm does not move during VISUAL SEARCH, the problem is probably with the servo control rather than the kicker.

Servo control-circuits. The servo control-system moves the arm (through gears) across the disc (either forward or reverse) in response to signals applied through the error-amplifier/servo-control circuits shown in Fig. 14. In normal PLAY, the servo motor receives drive signals generated by stylus sensors (on the arm) and a servo detector. The servo drive-signal is generated by sensing the position of the stylus relative to the center of the arm assembly. A 260-kHz signal from the detector is applied to two stylus sensors. The signal is inverted by one sensor, generating a 180-degree out-of-phase signal. As the stylus moves closer to one sensor, the stylus picks up the 260-kHz signal from that sensor. The servo signal from the stylus is compared to the original 260-kHz signal to generate an error signal that decreases as the stylus moves closer to the inside sensor, and vice versa. The error signal is amplified to drive the servo and, thus, control arm movement.

During either VISUAL SEARCH or RAPID ACCESS, the error signal is overridden or inhibited by the microprocessor, (which applies continuous drive signals to the servo motor). In VISUAL SEARCH, the microprocessor produces the servo drive-signals to move the arm forward or reverse, and also produces kicker pulses to move the stylus (two grooves per kick) as described. In RAPID ACCESS, the microprocessor produces servo drive-signals that move the arm rapidly, and also removes the stylus-lifter voltage, allowing the lifter spring to raise the stylus. That prevents damage to the stylus and disc during rapid movement. (Also note that the stylus lifts automatically when power is removed, and during load/unload by a switch that is actuated when the spine is not in the normal play position.)

If the arm does not move during PLAY, operate the VISUAL-SEARCH-FORWARD controls and monitor the voltage to the servo motor. Typically, one motor lead will be grounded while the other lead is "hot" (about 20 volts). Then operate the VISUAL-SEARCH-REVERSE control. The previously grounded motor lead should now be at 20 volts, while the previously hot lead should be ground. If the voltages are present, but the motor does not operate, you have found the problem. If the voltages are absent or abnormal, trace the voltage back to the microprocessor (through the error amplifier/servo control-circuits).

If the arm moves during VISUAL SEARCH, but not during PLAY, the problem is likely in the stylus sensors and/or servo detector. First check if there is a 260-kHz (that frequency is approximate; the precise frequency is not too important) signal at the detector and/or sensors. The presence of a 260-kHz signal shows that the detector oscillator is working. Next, monitor the error voltage from the detector to the servo drive while manually rotating the main servo reduction gear (that is usually the largest gear in the servo assembly). The error signal should change (in phase and amplitude). If not, check for bent or damaged servo-sensor leads, and for incorrect servo adjustments. Usually there are at least two servo adjustments (servo position and detector balance). Carefully straightening a bent sensor lead may restore proper operation. If the sensor leads look fine, suspect defective varactor diodes in the sensor. If the diodes are bad, you must replace the entire arm assembly.

If the arm moves during VISUAL SEARCH and normal PLAY, but not in RAPID ACCESS, first make sure that the microprocessor is getting RAPID-ACCESS commands from the front-panel controls. Then trace signals from the microprocessor to the servo motor and stylus lifter. That is essentially the same system that's used during PLAY and VISUAL SEARCH. It is the input to the error-amplifier/servo-control circuits that is different for RAPID ACCESS.

Mechanical problems. As in the case of LV, use the manufacturer's procedures for all mechanical adjustments and disassembly/reassembly. Generally, the service manuals are very good in that respect. Also, unless there has been excessive wear or outright physical damage, CED players are usually more rugged than LV ones, and do not require extensive mechanical adjustment. One exception to that is when you must replace major mechanical components, such as the arm assembly, servo-gear mechanism, or caddy-door load/unload components.

Finally, we have covered only the highlights of videodisc service here. If the procedures described do not cure the fault, you may have other, possibly serious problems and you must consult the manufacturer's literature. **R-E**

DESIGNING WITH DIGITAL IC'S

Here's a look at CMOS, one of the most popular of the logic families, and the special handling that CMOS devices require.

JOSEPH J. CARR

Part 2 LAST TIME WE DISCUSSED several of the popular digital IC logic families. This time, we will continue our discussion of logic families by looking at the complementary metal oxide semiconductor (CMOS) logic family.

Before we get into the details on the internal workings of CMOS devices, we should mention some of the benefits of the CMOS logic family. CMOS circuits are very forgiving with regards to noise, they use extremely small amounts of power when they're in standby, and their power-supply requirements are very uncritical. That makes them very easy to work and experiment with.

MOSFET transistors

The transistors used in CMOS devices are *M*etal *O*xide *S*emiconductor *F*ield *E*ffect *T*ransistors (MOSFET); those are also sometimes called *I*nsulated-*G*ate *F*ield *E*ffect *T*ransistors (IGFET). Those transistors differ markedly from the NPN and PNP bipolar transistors used in other IC digital logic families.

There are two basic types of MOSFET—depletion mode and enhancement mode—each of which are found in two different polarities. N-channel and P-channel. All of those terms are explained below.

Figure 1 shows a cross section of a basic depletion-mode MOSFET. There are three electrodes on that device: drain, source, and gate. The drain and source are ohmic contacts at either end of a "channel" of semiconductor material. In this example, an N-type semiconductor is used, so the device is an N-channel depletion-mode MOSFET. The gate is a metallized contact that is separated from the channel by a thin layer of insulating oxide material (hence we can see where the names "insulated gate" and "metal oxide semiconductor" come from).

A depletion-mode transistor is a normally-on device. That is, when the voltage applied to the gate is zero, current will flow in the channel at a level determined by the drain–source applied voltage and the channel resistance.

Applying a potential to the gate (of correct polarity, depending upon channel material) causes charge carriers to be driven away from the gate region leaving a depletion zone that is essentially free of carriers. Thus, the material in the depletion zone becomes a high resistance insulator. The depletion zone is created by the effect of the electrical field generated by the gate voltage. Changing the size of the depletion zone effectively changes the size (thus the DC resistance) of the charge-carrier channel. We find, therefore, that the resistance between drain and source varies with the voltage applied to the gate.

Figure 2 shows an enhancement-mode MOSFET (N-channel) under two conditions. In Fig. 2-*a* the gate voltage is zero. Since that type of MOSFET is normally off, the enhancement (conductive) zone is minimized, and the drain–source channel resistance is maximum. In Fig. 2-*b*, on the other hand, a voltage is applied to the insulated gate, which creates an electric field within the channel. That voltage draws charge carriers toward the gate, thereby decreasing the drain–source resistance (i.e. the channel is "enhanced").

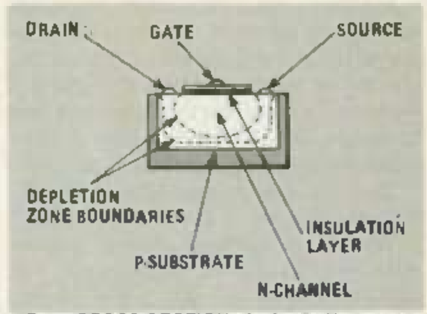


FIG. 1—CROSS SECTION of a basic N-channel. depletion-mode MOSFET transistor. The gate is insulated from the channel by a thin layer of oxide material.

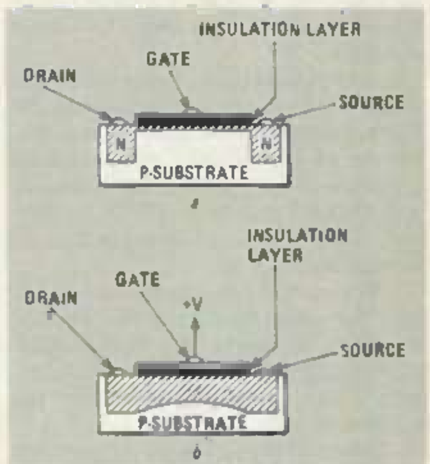


FIG. 2—AN ENHANCEMENT-MODE MOSFET transistor. When the gate voltage is zero, as shown in *a*, the drain-to-source resistance is at a maximum. When a voltage is applied to the gate, as shown in *b*, charge carriers are drawn toward the gate, decreasing the drain-to-source resistance.

In both types of MOSFET's, the channel resistance is varied by the voltage applied to the gate. In an analog circuit, that resistance may vary continuously between limits according to the applied signal voltage. Digital circuits, however, have only two signal levels (high and low), so the MOSFET's used in CMOS devices tend to be all the way on, or all the way off.

The usual schematic symbols for depletion-mode and enhancement-mode transistors are shown in Figs. 3*a* and 3*b*, respectively.

CMOS devices

The term "complementary" in CMOS implies that those digital IC logic devices contain complementary MOSFET transistors (i.e. one or more transistor pairs consisting of an N-channel and a P-channel device). Figure 4 shows a typical CMOS inverter, which consists of one N-channel and one P-channel MOSFET. The drain–source paths (channels) are connected in series, while the gates are in parallel.

In essence, the CMOS inverter consists of a pair of electronic resistors in series across the DC power supply. Those "resistors" are configured such that one is a high resistance when the other is a low resistance: which one is which is controlled by the voltage applied to the gate.

That situation is shown in in Fig. 5. Note that the output signal of the inverter is the voltage between ground and the junction of R1 and R2. In each case, one resistance will be very high (in the megohm range) and one is very low (about 200 ohms). Thus, the output will be essentially +V or −V. Since most CMOS devices use positive logic designations, +V represents a high output condition and −V represents a low output condition.

Let's look a bit more closely at how this circuit works. Since it is an inverter, the output will be high when the input is low. For that to happen, R1 (i.e. the channel resistance of Q1) is very low, while R2 (the channel resistance of Q2) is very high. Thus, +V is connected to the output terminal.

When, on the other hand, the input is high, the output needs to be low. For that to happen, R1 must become the high resistance, while R2 becomes the low resistance. Thus, −V is connected to the output terminal.

The transition point (input voltage) that causes either high-to-low or low-to-high output changes is the mid-point voltage between −V and +V. In many practical situations, we find that the absolute values of −V and +V are equal. There is no reason, however, why we can't use unequal voltages for −V and +V. In fact, in many cases CMOS devices are operated from TTL-style power supplies and thus will use +5 volts DC for +V and 0 volts DC for −V. Some designers set +V to zero and then use a negative voltage for −V. The normal range of ±V is 0 to ±15 volts DC with some operating to ±18 volts DC.

CMOS part numbers

The generic type numbers for CMOS digital logic integrated circuits are in either the 4000 range (i.e. 4049) or 4500 range (i.e. 4528). There are also special devices that carry unique house-type numbers.

There are two general series of CMOS devices, designated "A" and "B." The A series are the original type of CMOS and may or may not carry an "A" suffix to the type numbers. Thus, both 4001 and 4001A can be assumed to be series-A devices. All series-B devices carry a "B" suffix (i.e. 4001B).

The principal difference between A- and B-series devices is that B-series CMOS IC's contain internal zener diodes that shunt high voltage static charges around delicate gate insulators. That reduces (but does not eliminate) the potential for damage from electrostatic discharge (we'll talk more about that problem in a moment).

There are also other differences. The B-series devices generally have higher operating frequencies, faster rise-times, and greater drive capability than A-series devices.

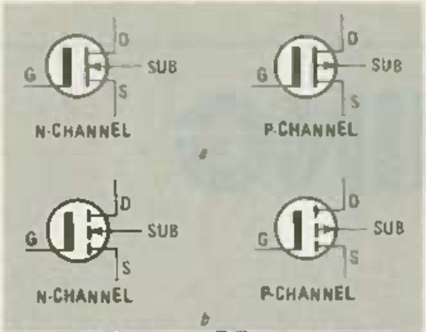


FIG. 3—STANDARD SCHEMATIC SYMBOLS for depletion-mode MOSFET transistors are shown in a, enhancement-mode MOSFET transistors in b.

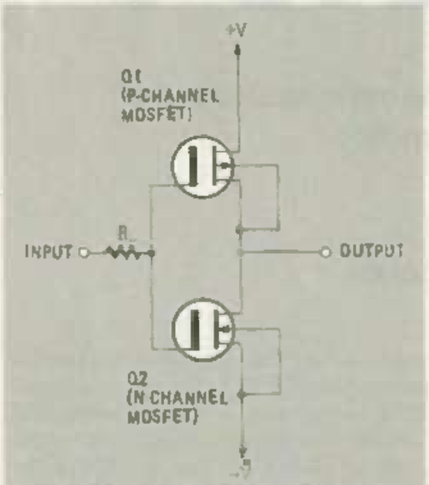


FIG. 4—THIS TYPICAL CMOS INVERTER consists of one N-channel and one P-channel MOSFET transistor.

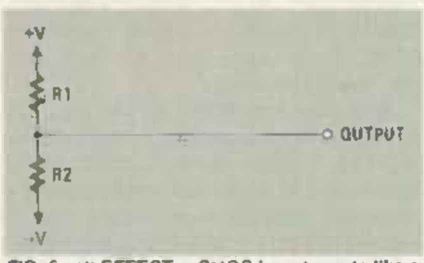


FIG. 5—IN EFFECT, a CMOS inverter acts like a pair of resistors wired across a DC power source. The output is taken from the junction of the transistors. The relative values of the resistors depends on whether the input to the inverter is high or low.

Electrostatic discharge damage

All semiconductor devices potentially can be damaged by high voltage static charges: CMOS devices and other MOSFET semiconductors seem particularly sensitive to electrostatic discharge (ESD) damage.

Static electricity is created by the "triboelectric effect," that is, by creating excess electrons on the surface of an insulating material by mechanical rubbing. Because of that, static electricity can be generated without conscious effort. Table 1 shows typical voltages generated by ordinary activities. With 35 kilovolts generated by walking across a carpet, it's no wonder that you get a shock when you grab the doorknob!

Note that working at the bench on a dry day can generate 6000 volts of static. Let's compare that figure with the typical voltages that will damage electronic devices. Table 2 shows those values. Note that many of these devices can be severely damaged by potentials that are generated even under "muggy" (70% relative humidity) conditions.

Figure 6 shows the anatomy of a CMOS failure. Figure 6-*a* shows an enlarged drawing of a MOSFET-gate region. When a static charge hits, it punches a hole in the insulating oxide (Fig. 6-*b*). Normally, the failure is immediate and catastrophic. Metal from the gate electrode and semiconductor material from the channel fill the void and short the gate to the channel.

At other times, the failure is delayed, often for many months or even years. In those cases, the metallization of the void is not initially sufficient to short out the device. As time goes on, however, metallic ions and semiconductor material will migrate into the void. When that process goes on long enough, a short will develop and the IC or MOSFET will be destroyed. To the user, the result is what appears to be merely a premature failure of the IC: the real culprit, a static discharge, is rarely blamed.

ESD protection

Damage from static electricity can be controlled or even eliminated through the use of proper strategy. The aim of most techniques is to keep all pins of the device at the same potential. If excessive voltages cannot develop between pins of the

TABLE 1		
ACTIVITY	STATIC VOLTAGE GENERATED (V)	
	15% Relative Humidity	70% Relative Humidity
Walking Across Carpet	35,000	1,500
Handling PVC Bag	20,000	1,200
Sitting In Polyurethane Chair	18,000	1,500
Working at Workbench	6,500	150

TABLE 2	
Device	Breakdown Voltage (V)
VMOS IC	30—1500
MOSFET Transistor	100—200
GaAs FET Transistor	100—300
JFET Transistor	140—7000
Bipolar Op-amp	200—2000
CMOS IC	250—3000
Bipolar Transistor	380—7000

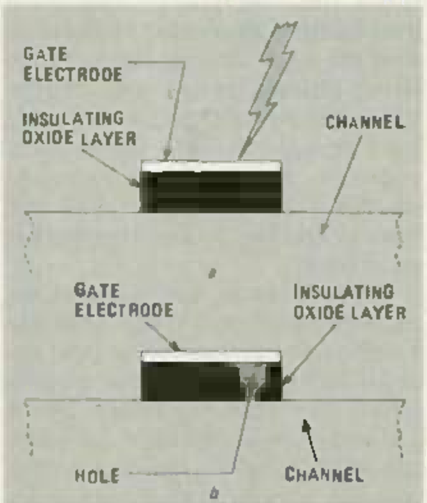


FIG. 6—ANATOMY OF A static-discharge caused CMOS failure. In *a*, we see the discharge striking the CMOS device. In *b*, the hole that results is shown. Either immediately, or after several months or years, metal from the gate and semiconductor material will fill the hole, shorting the gate to the drain.

IC. then damage will not occur. Other methods are just common sense. One basic rule that should be followed is don't handle CMOS or Schottky devices more often than is necessary.

CMOS devices are usually shipped in containers that serve to reduce the chance of static discharge damage. Since the aim is to keep all pins at the same potential, in some cases, especially in the hobbyist market, devices or groups of devices are shipped wrapped in aluminum foil. Most commercial sources, plus those amateur/hobbyist dealers who sell in quantities, will ship CMOS either mounted on black conductive foam, or, inside of sleeves made of anti-static plastic. Blister-pack distributors often use a tiny piece of conductive foam material to hold pins at the same potential. It is prudent to keep the CMOS in the containers (or on the foam) in which they were shipped until it is time to use them.

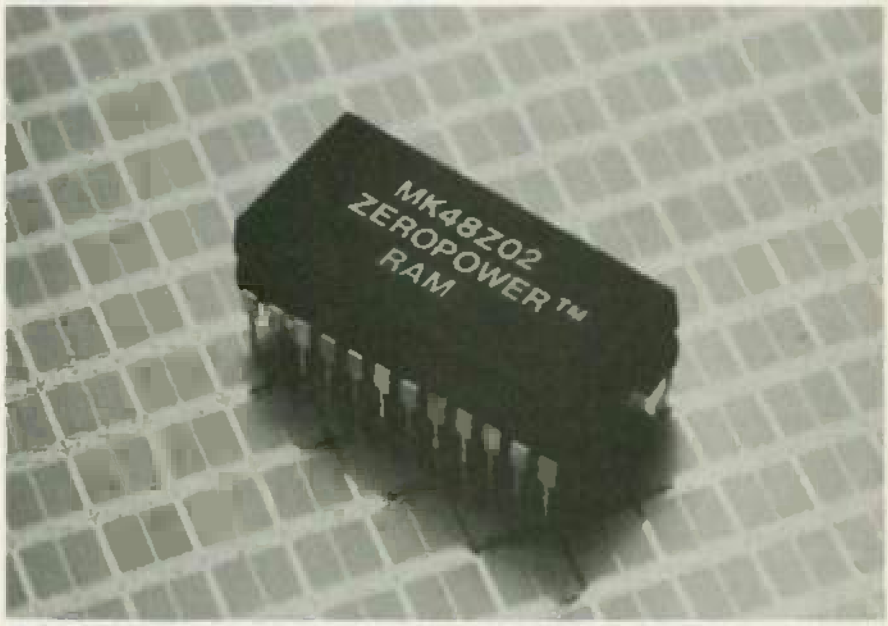
Some texts tell you to ground yourself to prevent static damage. While that strategy might, in fact, prevent static damage to the CMOS devices, it could also kill you! If there is any source of 117 volts AC around the bench, then it may seek ground through your grounded body—turning you into a blown fuse!

One method that works for many hobbyists is to increase the relative humidity. Just step into your bathroom and turn on the shower. When condensation from the steam starts to form on the bathroom mirror, you can begin to install the CMOS devices in their sockets.

A better alternative is to ground yourself, and separately ground your work surface, through a high resistance. A resistance of 2 to 10 megohms will serve to drain off electrostatic charges while also limiting current flow to a relatively safe value in the event of an accidental contact with the AC power. Use a 2-watt (or higher) resistor for that. We are not really worried about the wattage rating in this case, but rather, the voltage rating (yes, that's right, resistors carry a voltage rating). Lower wattage resistors have lower voltage ratings, so may short out and become ineffective—or very dangerous.

For years, hospitals faced a similar problem in operating rooms. Explosive anesthesia agents (ether, cyclopropane, etc.) could be set off by sparks from an electrostatic discharge. To counter that problem, they used conductive, high resistance-to-ground floors; conductive, high resistance shoes or shoe covers, and all cotton garments. That may be extreme for most electronics situations, but may be appropriate in very dry regions if electrostatic discharge seems to be an otherwise unsolvable problem.

Tools such as soldering irons should have a grounded tip in order to prevent electrostatic charge build-up. Also, the finished product (printed wiring boards that contain CMOS devices) should be handled in the same way that you would handle the IC's themselves. Store the PC boards on conductive foam, or in static treated plastic bags. It is a myth that all CMOS devices become safe to handle when "in the circuit;" some do, some don't (it depends on the circuit configuration).



CMOS TECHNOLOGY MAKES POSSIBLE this low-power RAM with internal battery backup.

In conclusion, CMOS digital logic technology competes favorably with TTL. In fact, most large-scale designs contain a mix of CMOS and TTL devices. The technology selected for a design may be a trade-off between speed, power consumption, drive capacity, noise immunity, and other factors. In general, where operating speed is more important, the choice leans toward TTL, but if low power consumption is an important consideration, then CMOS looks more favorable.

Next time, we'll turn our attention to simple gates, the building blocks of digital electronics. **R-E**

HOBBY CORNER

EARL "DOC" SAVAGE, K4SDS,
HOBBY EDITOR

Tuning antennas

UNDER ORDINARY CIRCUMSTANCES most people think only transmitting antennas require tuning. Many believe that any old piece of wire or built-in antenna serves well for receiving. There are, however, times when you'll need to tune a receiving antenna to get the best signal strength (reception) possible.

John Owen (MI) wants to put up an especially effective AM antenna. Well John, you didn't give me enough information to provide a specific answer to your problem, but here are a few principles of antenna design that should help get you headed in the right direction.

First, however, I should point out that the subject of antennas is indeed a complex one. The most complete treatment I know is contained in *The ARRL Antenna Book* published by The American Radio Relay League (Newington, CT 06111). Perhaps you can find that publication at your local library. The examples given therein are for amateur (ham) frequencies but the theory, explanations, and formulas apply to any frequency, including AM.

To make a long story short (oversimplified), an effective antenna should be: Mounted high above ground and as clear of surrounding objects as practical; its electrical configuration correct for the frequency at which it's to be used, and finally, its impedance should match that of the receiver or transmitter to which it is connected.

Getting a wire high and clear is simply a matter of putting it up as best you can. Sometimes, the highest and clearest you can get is in the attic or under the eaves of your house—if that's the best you can do, use it. Other than special cases, making an antenna both resonant and impedance-matched is usually accomplished with an "antenna tuner." There are many designs for tuners.

Figure 1 shows an antenna tuner that's variable over a wide range. The coil, L1, is wound on a cardboard or plastic form about three inches in diameter. There should be 40 turns of wire, evenly spaced over a span of five inches. Use a switch with at least 12 positions and connect it as shown in Fig. 1-*a*.

If you cannot find a switch with that many contacts, you can use two (or more) switches connected as shown in Fig. 1-*b*. Actually, you can get even better results by having a lever run across the top of the coil, thereby, providing a "tap" on every turn of the coil.

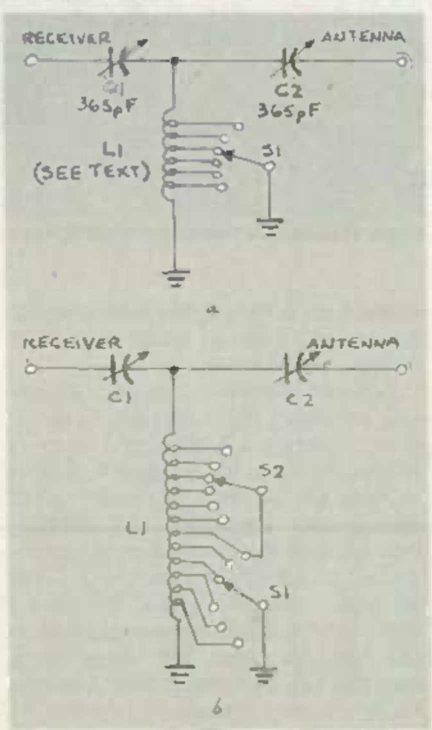


FIG. 1

To use the tuner, place it between the receiver and the antenna as shown. Then find a weak station and manipulate the controls for greatest signal strength (volume). You may have to repeat the procedure with weaker stations to find the best setting. The settings won't change unless you change the antenna, although you may have to vary them a bit in rain, snow, or ice conditions. If you are using a multi-band radio, you will have to find the proper settings for each band.

Oh yes, let us not overlook an essential part of a good antenna system—the ground. The best reception (or transmission) occurs when the antenna has a good ground. Where possible, an earth ground (a long rod driven into the ground) is best. If that's not practical, connect the ground wire to a water pipe (be sure it is metallic all the way to the earth).

Good luck, John. I hope you can now receive many DX (distant) stations.

Stacked antennas

Jad Sherbo (MD) has asked about connecting two or more TV antennas to pick up some of the more distant stations. Indeed, antennas can be "stacked," as it is called, to increase their effectiveness. Yagi antennas, for example, (the type usually used for TV reception) can be mounted one above the other and connected to a common coax or twin-lead feed line. Wiring harnesses are available for some commercial TV antennas.

There are too many variables in determining optimum separation of the antennas and the proper

matching of their feed points for me to tell you exactly how to use those you may have on hand. Your best bet is to get a commercial harness to suit your antennas or to study *The ARRL Antenna Book* mentioned above. I hope you too can pull in many DX stations, lad.

12-to-6 volt converter

There are many devices that we would like to operate from a car's 12-volt electrical system. Some require 12 volts; they are no problem. Others require some lesser voltage, so we must drop the auto's supply voltage to a level that's usable by the device.

David Housel (NJ) wants to run a tape recorder that requires 6 volts DC from his auto's 12-volt system. There are several ways to approach that problem. However, you should select one that overcomes two difficulties: First, an automobile battery's output can vary from 12 to 13.8 volts under normal circumstances. Second, the load requirements of the device can vary, for example, when the recorder motor is turned on and off.

The circuit should maintain a constant voltage regardless of how those factors change. In cases such as yours, I use a simple circuit based on a 7805 voltage regulator. In addition to a constant output, that IC provides overload and short-circuit protection. Of course that unit is a 5-volt, 1-amp regulator, but when placed in a circuit like that in shown in Fig. 2-*a*, it can be tricked into providing other voltages as well.

In that circuit, as the arm of potentiometer R1 is moved from the upper end toward ground, the output varies from 5 to about 10 volts. All you have to do, David, is to set the wiper of R2 for 6 volts and connect your cassette machine. If your recorder draws 0.5 amp or more, be sure to mount the 7805 on a heat sink.

While you are making that little circuit, though, why not add a few more components and make it more versatile? By adding a switch and two more resistors, you can have a choice of three commonly used voltages: 6, 7.5, and 9 volts as shown in Fig. 2-*b*. The values of the two additional resistors are determined in the same way as the first.

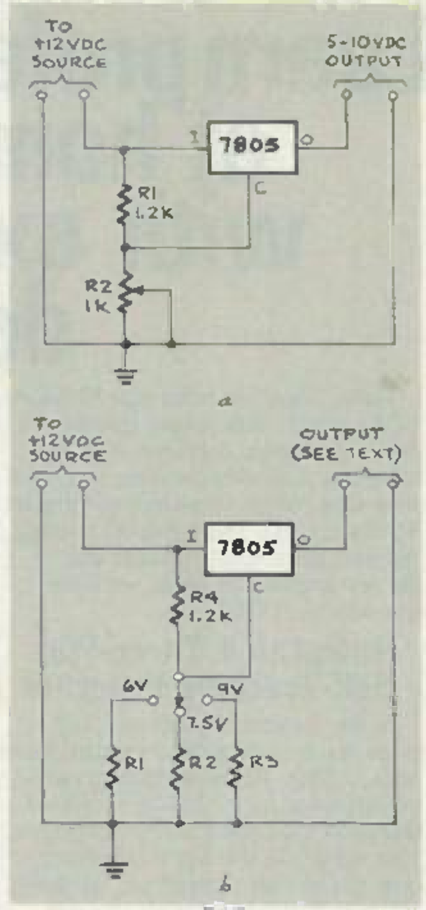


FIG. 2

Also, slightly modifying that arrangement, you can string the resistors in series and tap off the needed voltages at different points along the divider. In that way, R1 sets the voltage level to 6, the sum of R1 and R2 determines the next, and all three take care of the finally tap. Just be sure to check the output voltages before closing the unit and using it. R-E

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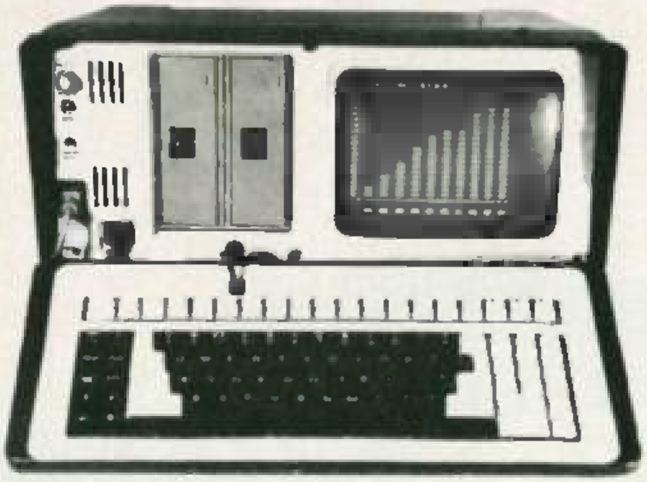

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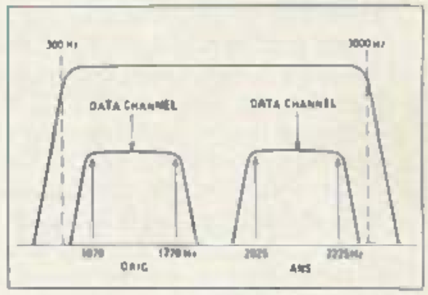

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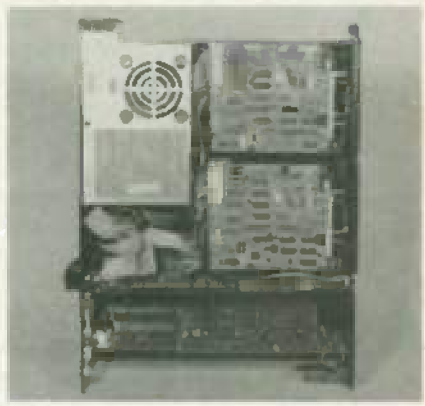

See page 13.

ON THE COVER

The 2400 BPS Smartmodem transfers data across regular telephone lines and offers a link between mainframe and personal computers. The unit has expanded capabilities to monitor the progress of a call, distinguishing between a busy signal, no dial tone or no answer. For additional information on modems, see page 7.

EDITORIAL

Computers and the CB Syndrome.

Let's face it—Electronics swings in wide patterns of interest that flare up almost spontaneously, set the world afire, and then ignominiously die out. The business got a swift boot out of high fidelity when that first burst on the scene, and this was taken up, in turn, by stereo. Audio-type magazines flourished to cater to the interests of those who followed these trends. Then there was a stabilization, and a wide-spread moderating.

Just about that time, reverberation came into being, and the artificial echo chamber was added to audio systems. Audio came back to life.

Things lay quiet for some time. Oh, the die-hards and purists continued to pursue their hobby, but it wasn't quite like the "good old days." Then Citizens Band Radio came along, and it was bigger than audio ever was. Everybody got involved. Every car had a CB rig. Housewives were forming networks to gossip over the air. Teenagers were making dates over the CB. And CB, once the realm of truckers alone, was now everybody's property. You could hear the bands bristling with phony southern accents as the kids tried to emulate the truckers. The language the CB'ers developed was as unique as some of their "handles." And of course, magazines catering to the new interest flourished as well.

Then, as suddenly as it appeared, the interest in CB died off. People who once craved an occasional "Good buddy, how's it look over your shoulder," as they drove down the road, were just as happy listening to the BC radio. Now when you see a car ahead of you on the road, you begin by asking "Hey good buddy, got your ears up?"

Now it's computers, and again, everybody from school kids that have just learned how to read, on through graduate engineers, are taking up the computer cudgle. Magazines have sprung up and died out. Is the computer to face a like fate as all its forebears?

No. The computer, thanks to its innate value, will never exhaust the interest that holds its practicioners spellbound. Because of its extreme versatility, the computer is going to be with us for many, many years to come, and we at **ComputerDigest** hope to continue to bring you the latest news and developments in this astounding field.

Byron G. Wels

Byron G. Wels
Editor

COMPUTER DIGEST

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LETTERS

LIKES "PRINTER PROBLEMS"

I found the "Printer Problems" articles in **ComputerDigest** to be very useful. How about more hardware and interconnect related articles?—Warren W. Munro, Aiea, HI.

Right, Warren. We've got lots of those in the works right now. Keep watching for them; they'll be appearing regularly.

A ROBOT NAMED "BYRON?"

I named my robot Byron immediately after soldering in the last connection and powering him up. This in recognition of a kindred spirit. Hope you don't mind. Byron isn't finished yet as he has a total lack of mobility. At least he knows who his maker is! WORKING!!!—T. E. Deagle, Boydton, VA

We all had a good laugh here in the office over that one, T. E. The general impression is that you did well. I don't have too much in the way of mobility either, but at least your Byron works!

BUILD YOUR OWN COMPUTER?

I have good skills, have been an electronics hobbyist all my life, and was wondering about the idea of building my own computer from scratch. Would I save money on this? How would I best go about it? By the way, I don't want to build from a kit, either.—J. Mahoney, Sioux Falls, S.D.

We can't really recommend this course of action. While it could be done, it would not be economically feasible, compared with buying a used or refurbished unit. Do let us know what you decide, and share what you learn with our readers. We'll all be very interested!

UNUSUAL REQUEST!

I know a lot of people have been buying **Radio-Electronics** and ripping out and throwing away **ComputerDigest**. You may not believe this, but I buy the magazine, rip out **Computer-Digest** and throw **Radio-Electronics** away! I hate to see it go to waste each month, and was wondering if one of your non-readers might like to split the cost with me for a subscription?—S. Brandt, Caspar, WY

Any takers?

PROTECTING INVENTIONS

I've invented a computer-oriented device I'd like to protect, but can't afford a patent. Any suggestions?—Sam Dixon, San Francisco, CA

There are several "ideas." If it's sufficiently interesting, get it published in a magazine like **ComputerDigest**. *The magazine and its contents are copyrighted, and it gives you proof of prior published art. Another old saw is to write up a description and mail it to yourself in a sealed, registered letter to later be able to prove earlier discovery. The smart money suggests investing in a good patent attorney and playing it really safe!*

COMPUTER PRODUCTS

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

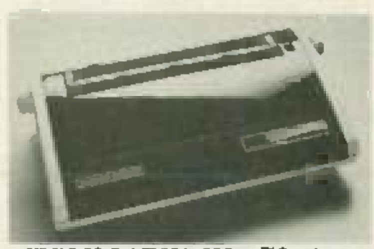
SURGE/SPIKE SUPPRESSOR, model *061*, is designed to protect computers, microprocessor-based instruments, sensitive electronic and audio equipment, and scientific instrumentation from high-voltage transients and surges by instantaneously sensing and suppressing them.

CIRCLE 21 ON FREE INFORMATION CARD

The model *061* features suppression capabilities of 6,000 amperes maximum surge current, with an energy absorption of 70 joules. It is designed for use on any standard 120-volt AC line, and responds to common and differential mode transients and surges at once. There are 4 three-wire grounded outlets and a main ON/OFF lighted rocker; the unit plugs directly into any 3-prong grounded outlet to provide maximum convenience. It is priced at $59.95.—**PMC Industries, Inc.,** 9353 Activity Road, San Diego, CA 92126.

DAISY-WHEEL PRINTER,

The *Alphapro 101*, is a 20 character-per-second printer that uses standard Diablo and Qume-compatible print wheels and ribbon cartridges. It uses an intelligent printer cartridge to adapt



CIRCLE 22 ON FREE INFORMATION CARD

it to all popular personal computers, including those with Centronics ports—such as the *IBM, PC, PCjr,* and compatibles; those with RS232 ports, such as the *Apple IIe* and the *IIc*, and others, such as Apple's *Macintosh*.

The *Alphapro 101* features path-seeking logic to maximize printing speed and a 93-byte memory buffer (4000 bytes optional). True proportional spacing, boldface, double strike, strikeout, phantom face, superscripts and subscripts, and reverse line feeds are also supported. It is priced at $399.95.—**Alphacom, Inc.,** 2323 Bascom Ave., Campbell, CA 95008.

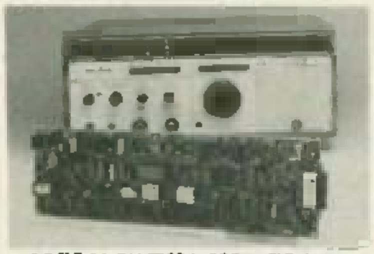
EDUCATIONAL PROGRAM, *Bumblebee*, is designed to introduce children age 6 and up to the disciplines of computer programming in a game-like format.

CIRCLE 23 ON FREE INFORMATION CARD

The player controls Bartholomew ("Bart") the bee by giving him instructions that enable him to move from flower-to-flower and pick up "pollen points." The bee's flight must be carefully designed, or he will bump into walls or be caught by "Olga," the evil garden spider. If Bart returns safely to the beehive, the screen lights up in a colorful graphic display.

Bumblebee features increasing levels of difficulty, some of them requiring the construction of more complicated flight patterns. The disk-based program is priced at $29.95.—**Creative Software,** 230 East Caribbean Drive, Sunnyvale, CA 94089.

RADIO INTERFACE CARD, model *PCI-2000*, is a plug-in card for the IBM-PC, which interfaces the computer to a shortwave radio for copying radio-teleprinter and Morse-code signals. Examples of signals that could be copied include weather information, news services, and amateur radio communications. The model *PCI-2000* can also transmit Morse and teleprinter



CIRCLE 24 ON FREE INFORMATION CARD

signals in applications where two-way radio communications are required. It is priced at $595.00, including software.—**HAL Communications Corp.,** Box 365, Urbana, IL 61801.

CO-PROCESSOR BOARD, for the IBM PC and XT, the *Trackstar*, supports Apple DOS 3.3, Pro-DOS, Apple Pascal and Apple CP/M 2.2. With the addition of the *Trackstar*, the IBM user can access the vast library of Apple games, educational and business programs, and the extensive library of CP/M business software.

CIRCLE 25 ON FREE INFORMATION CARD

Additional features include a full 80-column mode, connector for an Apple-compatible disk drive to overcome copy-protection problems, both RGB and composite output and support of the language card features. *Trackstar* is priced at $695.00.—**Diamond Computer Systems, Inc.,** 3380 Montgomery Drive, Santa Clara, CA 95054.

TRAINING PROGRAM, *The Desk Organizer*, is for use with the IBM PC, and designed for training secretaries. *The Desk Organizer files* anything the user needs to remember, for instant recall at any time; *dials* phone calls, retrieves phone numbers, inserts access codes; *writes* and prints memos, letters, reports; *calculates* with a visual

CIRCLE 26 ON FREE INFORMATION CARD

calculator and an electronic tape, stores and runs equations and formulas; *transfers data* automatically from mode to mode; *organizes*, alphabetizes, indexes, cross-references, and *manages time* with chimes to remind the user of commitments.

The Desk Organizer is priced at $195.00.—**Warner Software,** 666 Fifth Avenue, New York, NY 10103.

DATA COMMUNICATIONS BOARD, the model *WD4025*, features the universal CCITT X.25 LAPB protocol, and is designed to be compatible with the IBM PC, XT, AT, and compatibles. It will link computers at the same site, or scattered across the country via dial-up, or leased lines through a packet

CIRCLE 27 ON FREE INFORMATION CARD

switching network. It will also provide a gateway connection for the Local Area Networks (LAN).

Pricing for the model *WD4025* without software in OEM quantity is $385.00; pricing with software is $695.00.—**Western Digital Corporation,** 2445 McCabe Way, Irvine, CA 92714.

TAX SOFTWARE, the *Personal Planner*, can calculate tax liabilities for 1984 through 1987. It organizes all relevant tax information, keeping everything available for instant evaluation. It can be used for such tasks as retirement planning, investing, IRA contributions, home buying, two-income planning, and even checking a federal tax return.

CIRCLE 28 ON FREE INFORMATION CARD

The *Personal Planner* carries a suggested retail price of $49, and is tax-deductible.—**CPAids,** 1061 Fraternity Circle, Kent, OH 44240.

MODEMS

All about the newest high-speed modems; where they are and how they work.

MARC STERN

■For those who maintain that the higher the baud (communications) rate the more bandwidth is needed, 9600-baud communications may seem like an impossibility over the standard phone system, which is limited to 3 KHz of bandwidth, or the range of average voice conversation. After all, 9600-baud is a 3200 percent increase over 300-baud. But, modem manufacturers have done it.

Frequency Shift Keying

As recently as three years ago, the state of the art in digital communications was 300-baud. The typical 300-baud 103A modem of 1981 used two pairs of arbitrary frequencies for send and receive (originate and answer), 1070 to 1270 Hz for originate and 2025 to 2225 Hz for answer. (See Fig. 1) These are the tones emitted by both modems during a call. You can hear them if you listen closely during dial-up. The 300-baud modem also used Frequency Shift Keying (FSK) to represent the digital data being transmitted. (The 103A standard defined the originate-answer tones needed for data transmission, as well as the parameters needed for communication. All modems which adhered to this standard could communicate, one in the originate mode and the other in the answer mode.)

Fig. 2 shows a graphic representation of FSK. In this type of data transmission, the modem's circuitry modulates the carrier frequency to one level to represent a digital 0 and to another to represent a digital 1. You can actually hear the data stream of 1s and 0s if you listen to the phone line during a low-speed (300-baud) transmission. This type of transmission relies on a UART (Universal Asynchronous Receiver/Transmitter) as well as the circuitry which takes the digital signals from the UART and transforms them into audio signals which are compatible with the phone system.

The reason digital data must be turned into audio is that the phone system is geared toward voice audio with its bandwidth of 3 KHz. Since it is, data must be turned into its audio analogs and FSK is used to produce those analogs.

Let's see what happens when you begin digital communications at 300-baud (300-bits-per-second). First, your computer establishes a connection with the remote computer system or terminal with which you want to communicate. With today's intelligent modems, you just call up a program in your computer and command it to dial the remote system. After the dialing and the call are completed, you will hear a tone emanate from your modem. It is the originate carrier and is transmitted for a length of time as your modem patiently waits for the answer tone. When it hears the answer tone, the modem latches onto it and your system is connected to the remote system. These tones are generated by the modulator section of the modem.

Now the communications program in your computer waits for your action. If you are the originator of the call, the chances are good you will either be uploading or downloading information. Let's say you are sending—UPloading— a file to the remote system. If you are, you will be asked for the filename which you select. You then hit the appropriate keys on the keyboard and the transmission begins. While you were choosing the file, unknown to you, the program was putting the modem's UART into a *ready* state.

(A computer works in a parallel mode within the confines of its box with all data moving along in 8-bit chunks, unless you have a 16-bit computer and then it moves along in 16-bit or 24-bit chunks.)

With the UART ready, the file transfer session begins. The UART takes the parallel data and turns it into serial data, holding each piece of data in place until it is ready to be sent by the transmitter section of the modem. The UART has the necessary storage registers to do this.

At this point, the UART begins releasing the data to the transmitter section, where the data are changed from their digital forms into their audio analogs and it is then frequency modulated through the phone system.

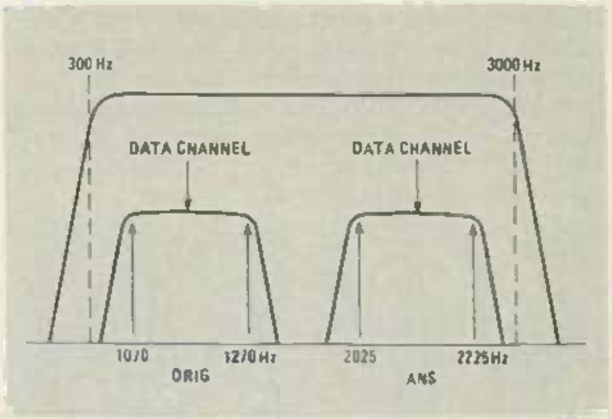


FIG.1—THE 300-BAUD ORIGINATE/ANSWER modem uses two sets of discrete frequencies to establish communications. When the modem originates a call, the tone is between 1070 and 1270 KHz. The answering modem emits a tone in the 2025 to 2225 KHz range. The top and bottom frequencies correspond to mark and space, two timing parameters used in asynchronous communication.

Receiving

Let's see what happens when audio information is received.

On the receiving side, the modem takes the audio information it is receiving and turns it back into digital form. The receiving circuitry sends this information to its own UART, where each bit of information is held in storage until the particular digital word is formed. When that 8-bit word is formed, it is sent to the computer's information bus and on into digital storage. The action of the UART and its associated circuitry is so fast that you think everything is happening instantly, but it isn't. If you could slow this circuitry's time reference enough you would see that each digital event is distinct in itself. However, the speed with which each event occurs is so high —microseconds—that it appears instantaneous.

In the 1981-1982 period, data transmission was limited to the 300-baud rate because the circuitry for higher-speed transmission still hadn't migrated to the average microcomputer user. It was beginning to make its appearance, but was still too expensive for the average computerist. It took developments in large-scale integration (LSI) to make this possible. These developments included UARTs which could handle data at 1200-baud asynchronously, as well as microcircuitry which could create the proper modulation needed so the modem would recognize high-speed transmission.

Asynchronous transmission

Asynchronous simply means data transmission without tight timing Constraints and it is important to note it here. At this time, the highest speed thought possible for asynchronous communication was 300-baud (300 bits per second). At higher speeds, it was thought that tight timing requirements were needed so both the transmitting and receiving modems could operate reliably. It was also believed that you needed a specially dedicated, conditioned—clean—phone line so that data transmission would be error-free. It was assumed the phone system was too noisy for reliable high-speed data transmission. Therefore those high-speed links which existed—there were 1200-baud and higher systems—were synchronous and used dedicated lines. Synchronous systems required special timing codes to be inserted as "header" information for each packet of data that was sent. The timing requirements were quite strict.

Phase Shift keying

Phase Shift Keying (PSK) takes advantage of the natural period of an audio frequency wave and, rather than using a set of discrete frequencies to define digital 1s and 0s, PSK represents data bits by using the changing phase of the signal and superimposing two or more data bits for each cycle.

Visualize a sine wave

The best way to envision this is to think of a sine wave, showing the entire period of an audio signal. Now, put a dot at the 0 point and another at the 180-degree point. These two points represent the digital 1 and 0, or the binary system used in data communications. This system iscalled Coherent Phase Shift Keying and relies on defined reference points to represent data. It differs from FSK in that FSK relies on using the carrier frequency to represent one digital bit of information—0, for instance—and a higher frequency to which it shifts to represent the other—1, for example.

To explain this more fully, let's say you are using traditional FSK to transmit data. Since you are using an audio-frequency range, you are also creating sidebands, or the sum and difference of the carrier and the modulation rate. For example, let's say the modem uses an 1800 Hz carrier and you are sending data at 1200-baud. Because the modem is using this set of parameters, you will find sidebands at 3000 Hz—1200 + 800—and 600 Hz—1800-1200—and therefore higher-speed transmission can fit within the constraints imposed by the phone system.

With low-speed (300-baud) and FSK, you are simply using one-half the cycle to define the data you are transmitting. This is the key difference between modes. FSK uses the 1800 Hz point, for example, to define 0 and the 2100 Hz point or upper sideband (1800 + 300) to define 1. The lower sideband or 1500 Hz point is unused. Further, this type of modulation does not take full advantage of the 3000 Hz bandwidth of the phone system, while higher speed and PSK do. Low speed and FSK only uses about 600 Hz of bandwidth—2100-1500 Hz—leaving 2400 Hz unused.

Another way to go

Coherent Phase Shift Keying isn't the only way of handling high-speed data communications. There are two others which are equally as valid and interesting, Amplitude Modulation (AM) and Differentially Coherent

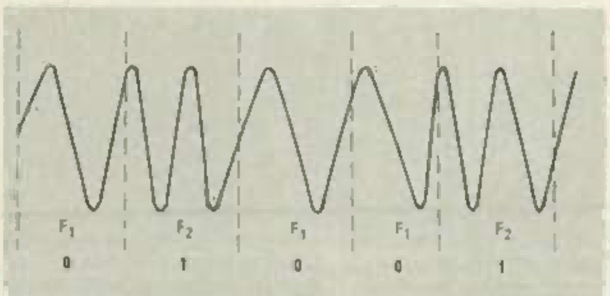


FIG.2—FREQUENCY-SHIFT KEYING uses shifts in frequency to denote digital information. One frequency level denotes digital 0 and the second denotes digital 1.

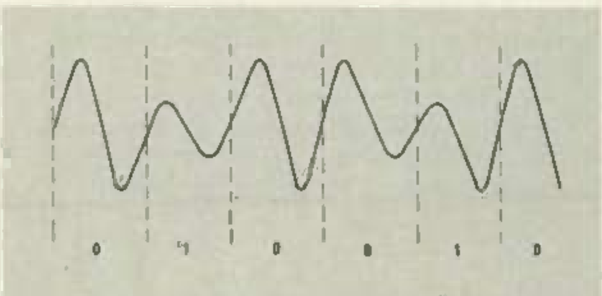


FIG.3—WITH AMPLITUDE MODULATION, the difference in amplitude of the modulating signal determines the digital information flow.

Phase Shift Keying (DCPSK).

With Amplitude Modulation, the amplitude of the carrier is the determining factor. By varying the amplitude of the carrier, with one level representing a digital 1 and another representing a 0, you can have effective data communication.

To represent this, think of the traditional AM sine wave and then superimpose a modulating signal upon it. The difference in amplitude of the modulating signal determines the 1 and 0. (See Fig. 3).

Another form of Amplitude Modulation, is simple on-off keying where the digital 1 or 0 is determined simply by switching the carrier on and off. While we call this Amplitude Modulation, it's really Interrupted Continuous Wave (ICW).

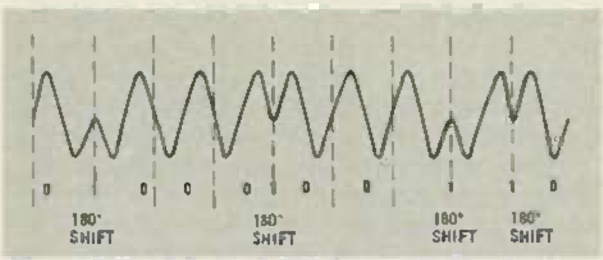


FIG.4—HIGH-SPEED MODEMS, which use phase-shift keying, use changing phase relationships to attain their speed while remaining within the constraints of the phone system. Figure 4 demonstrates this using a 180-degree phase shift.

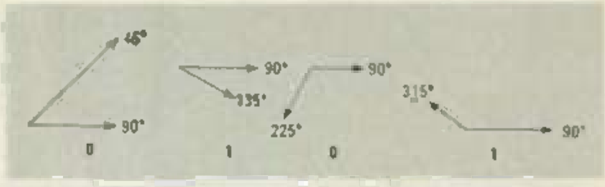


FIG.5—DEMONSTRATING THAT ENCODED BITS OF DATA—two bits—using a phase shift relationship of 45 degrees is one of many possibilities. Here data are encoded at 45, 135, 225, and 315 degrees on the signal cycle. Each is still separated by 90 degrees.

DCPSK

With this said, let's move on to Differentially Coherent Phase Shift Keying (DCPSK). It is unlike Coherent Phase Shift Keying in that the necessity of identifying specific locations on the sine wave is discarded in favor of encoding data using the phase change between two signal elements.

And because there's an almost unlimited potential for encoding data during phase changes (See Fig. 4), you can see it would be possible to increase data transmission speed without increasing bandwidth. Large-scale integrated circuitry handles the necessary detection and decoding of data.

How DCPSK works

Let's take a closer look at DCPSK for a better understanding of this concept by first comparing it to coherent PSK. As we have noted, coherent PSK relies on establishing reference points on the sine wave's cycle. For instance, this type of modulation technique may use the 0 and 180 degree points, with a 0 degree phase shift representing the digital 0 and a 180 degree shift representing the 1. The circuitry in the receiver requires phase coherence capability so it can demodulate the signal. DCPSK, on the other hand, does away with the necessity of absolutely identifying the reference points in the shift of an audio wave cycle. Instead, data are encoded in terms of the phase change between successive parts of the audio wave.

To see this more clearly, envision the coherent PSK waveform with data points at 0 and 180, or the type of waveform you might see if you scoped a 1200-baud modem. Change the waveform slightly to encode data at different spots on the wave. The difference in phase between these insertion points is what defines the digital 1s and 0s needed for data communication. For instance, with DCPSK, you may have data inserted at 0 degrees, 90 degrees, 180 degrees and 270 degrees, or a two-fold increase in communication speed since two full digital bits are represented on the wave. This is called a dibit, with 0 and 180 representing one set of 1s and 0s and 90 and 270 representing the second set. We only used these points for easy reference because there is no hard and fast rule defining where the information is to be inserted. It can be anywhere on the waveform. (See Fig. 5)

On the receiving side, the DCPSK discards the necessity for fixed reference points, relying, instead, on the relationship between the changing phase between the signal elements.

By now you should be able to see the possibilities inherent with DCPSK. By using the change in phase, you can take advantage of as many as four, eight or 16 phases on the signal and this, in turn, allows you to group two, three and four bit groups of data. It gives you a fourfold increase in the amount of data transmitted within the constraints imposed by the phone system. You are taking full advantage of the bandwidth available and all the while the phone system still thinks you are using a 1200-baud modem because you are still relying on the same bandwidth we noted in our earlier example (600 and 3000 Hz or the sum and difference of the 1800 carrier and 1200 Hz modulating signal.)

Since this type of communication relies on timing shifts, it requires synchronous operation. It is also uses multilevel data coding in the modem. Research has found a relationship between the amount of data you send per signaling period, also called the bandwidth compression ratio. It is log 2 M, where M is the number of levels (signal elements per cycle). This type of coding can be applied to any form of modulation.

The one drawback with DCPSK is that as you increase the amount of digital data within a waveform, you need a higher signal-to-noise ratio in the receiver. This is usually handled by either increasing the power of the transmitter or lowering noise levels.

Introducing Quadrature AM

It is possible to combine Amplitude Modulation with DCPSK. Also known as Quadrature Amplitude

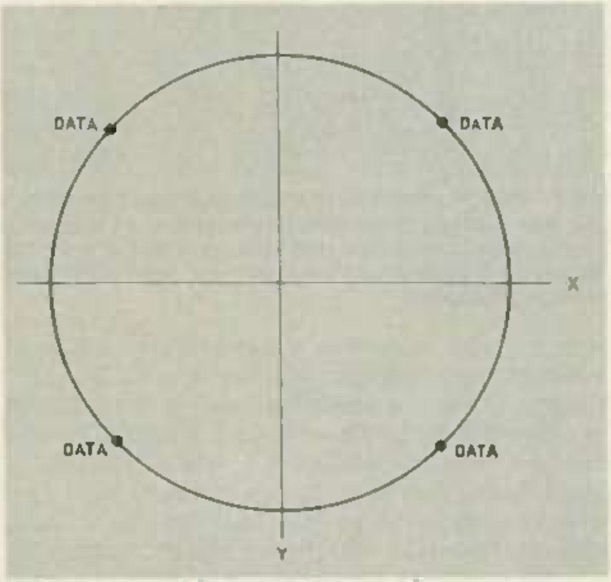


FIG.6—TO SIMPLIFY MATTERS, the relationship of data in a 2400-bit modem is shown as it would appear on an oscilloscope. Note the relationship of the four insertions of data.

Modulation, it can use a two-level AM, four-phase scheme to encode three data bits and achieve high-speed communications. It is also possible to use a two-level AM, eight-phase scheme to encode four bits of data per cycle. You can see where the name quadrature came from since it relies on the four-phase relationship.

At 1200-baud, the standard 212A modem takes advantage of coherent PSK for its high-speed, 1200-baud mode and uses FSK for 300-baud. (Bell standard 212A, which defines the characteristics for 1200-baud asynchronous communication. All 212A modems share the same standards so they can talk with one another. This standard supercedes the older Bell 202 standard.)

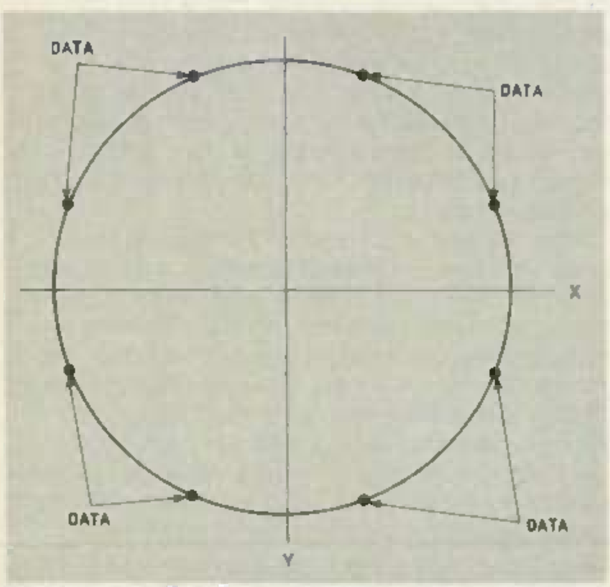


FIG.7—BY COMPRESSING THE DATA, another bit can be inserted, effectively doubling the modem's speed to 4800-baud. By compressing the data, another bit can be inserted, effectively doubling the modem's speed to 4800-baud. The relationship, as it would appear on an oscilloscope, is shown above.

This type of modem is capable of recognizing both FSK and PSK.

Dibits and Tribits

The jump from 1200 to 2400 is achieved by using a dibit—two bits of data. The dibit—00, 01, 11, 10, for instance—is used to encode one of four specific phase shifts. For instance, a 2400-baud modem will function using four-level DCPSK modulation with a phase change of 45 degrees between bits. Pictorially, it can be seen in Fig. 6. Since there are now four bits of information, rather than two, the amount of information is effectively doubled, though the phone system thinks the modem is communicating at 1200-baud.

Inserting another data bit and increasing the number to three—a tribit—means you can effectively double the speed of the communications once again. This makes it 4800-baud. This type of modem relies on eight-level or diagonal DCPSK and requires three bits of information to define the eight specific phase shifts. The tribit pattern can be seen in Fig. 7. Again, you are adding one extra piece of information at each phase shift point—compressing data—allows a manifold increase in speed. This type of scheme operates using eight data patterns which look much like triangles when superimposed on one another. Although it would seem

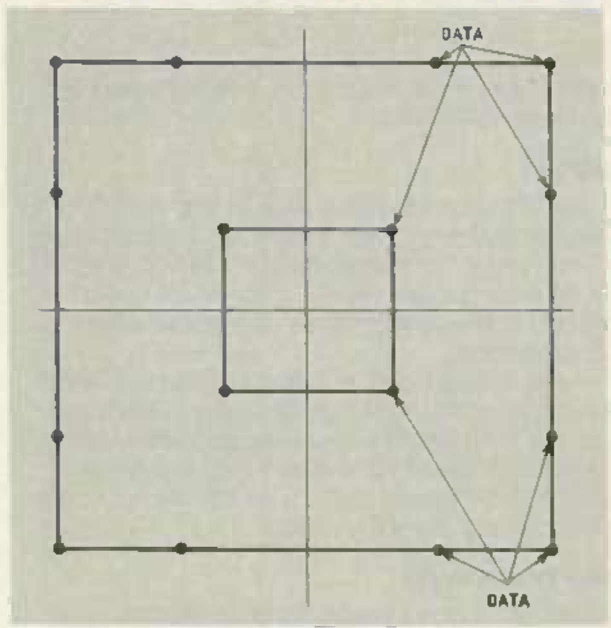


FIG.8—THE RELATIONSHIP OF THE FOUR bits of data inserted at various points on a signal cycle in a 9600-baud modem is shown. These points not only determine the phase relationship, but also the relative amplitude of the signal.

that you would only be increasing speed to 3600 baud, you now have eight levels of data and six bits of information per cycle, $8 \times 6 = 48$.

Moving from this point, speed again doubles to 9600-baud. This type of modem uses Quadrature Amplitude Modulation and uses four consecutive data bits to define both the amplitude of the signal and phase changes. It also determines the absolute phase of the signal element. You can see the relationship of all the elements in this realm in Fig. 8.

RESONANT CIRCUIT DESIGN

If you're designing resonant circuits, try putting your computer to work!

LAWRENCE G. FRIEDMAN

■ "Resonant Circuit Design" is a generic BASIC program specifically intended for technicians and experimenters who work with RF circuits or RF filters. "Resonant Circuit Design" will calculate the F, C and L (Frequency, Capacitance, and Inductance) values for a resonant circuit and then go on to calculate the design of an air-wound coil using the calculated or a preselected inductance value.

The program automatically recycles: If the calculated inductor and capacitor values aren't to your liking, you can substitute different known values over and over until you get practical answers.

Finally, you select the coil's dimensions and the program will calculate the required number of turns and the maximum size solid enamel-insulated wire that can be used to wind the coil. This part of the program also recycles, so if you don't like the answer(s) you can specify other dimensions and the computer will automatically recalculate the number of turns and the maximum size wire.

If you want to use a specific size wire you can recycle the parameter section and vary the dimensions of the coil until the desired wire size is indicated.

The program listing is for clarity and universality rather than memory conservation or "pretty printing." In some instances I have taken the "long way 'round" to insure the program will run on most, if not all, modern personal computers—including the pocket-sized portable models.

Possible "translation" problems are indicated in lines 10 and 20. If your computer uses different commands or symbols for CLEAR SCREEN and exponentiation, make the required changes to the program.

To keep the program reasonably short error-trapping is used only for line 110 where there is the possibility of an incorrect keyboard entry. Other than the keyboard entries ahead of line 140, if you deliberately try to trick the computer with false entries or data the computer will respond with a false answer. But give the program the data it asks for and it will crank out correct values as fast as you can handle them.

PROGRAM

```
10 REM. CLS = "CLEAR SCREEN"
20 REM. SOME COMPUTERS USE [ INSTEAD OF
    ∧ FOR EXPONENTIATION
30 CLS
40 PRINT "RESONANT CIRCUIT DESIGN"
50 PRINT "By Lawrence G. Friedman"
60 FOR X=1 TO 500:NEXT X
70 CLS
80 PRINT TAB(10) "MENU":PRINT
90 PRINT "TO DETERMINE L, C, OR F ENTER 1"
100 PRINT "TO CALCULATE COIL PARAMETERS
    ENTER 2
110 INPUT A
120 IF A=1 GOTO 160
130 IF A=2 GOTO 320
140 CLS;PRINT "RE-ENTER":PRINT:GOTO90
150 IF A=2 GOTO 320
160 CLS:CLEAR
170 INPUT "ALSO CALCULATE COIL PARAMETERS
    (Y/N?)";A$
180 CLS
190 PRINT "ENTER A'0' FOR UNKNOWN VALUE"
200 PRINT
210 INPUT "ENTER F IN MHZ>";F
220 INPUT "ENTER L IN UH> ";L
230 INPUT "ENTER C IN PF>";C
240 IF F=0 THEN PRINT 1000/(6.238 *
    SQR(L*C));"MHZ"
250 IF L=0 THEN Z=25330/((F∧2)*C)
260 IF L<>0 THEN Z=L
270 IF L=0 THEN PRINT 25330/((F∧2)*C);"UH"
280 IF C=0 THEN PRINT 25330/((F∧2)*L);"PF"
290 IF A$="N" THEN 200
300 IF A$="n" GOTO 200
310 GOTO 390
320 CLS:CLEAR
330 PRINT "COIL PARAMETERS"
340 FOR X=1 TO 1000:NEXT X
350 PRINT:PRINT
360 IF Z<>0 GOTO 390
370 INPUT "ENTER L IN UH> ";L
380 LET Z=L
390 INPUT "ENTER COIL DIAM. IN INCHES";D
400 LET D=D/2
410 INPUT "ENTER COIL LENGTH IN INCHES> ";G
420 T=SQR((Z*((9*D)+(10*G)))/D)
430 PRINT T;"TURNS"
440 W=T/G
450 C$="IS THE LARGEST WIRE SIZE."
460 IF W< 18.9 THEN PRINT "#16";C$:GOTO 540
470 IF W< 23.6 THEN PRINT "#18";C$:GOTO 540
480 IF W< 29.4 THEN PRINT "#20";C$:GOTO 540
490 IF W< 37 THEN PRINT "#22";C$:GOTO540
500 IF W< 46.3 THEN PRINT "#24";C$:GOTO 540
510 IF W< 50 THEN PRINT "#26";C$:GOTO 540
520 IF W< 72.7 THEN PRINT "#28";C$:GOTO 570
530 IF W< 80.5 THEN PRINT "#30";C$: GOTO 540
540 PRINT:INPUT "REPEAT PARAMETER DESIGN
    (Y/N?)";R$
550 IF R$="Y" GOTO 390
560 IF R$="y" GOTO 390
570 INPUT "REPEAT L,C,F CALCULATION
    (Y/N?)";P$
580 IF P$="Y" GOTO 160
590 IF P$="y" GOTO 160
600 END
```

INEXPENSIVE IBM'S

Third-party hardware can mean big savings and added performance for your IBM PC.

HERB FRIEDMAN

■While calling the IBM PC a home-and-family computer stretches the limits of the imagination (because of its price, for one thing), it is true that for business use—even for a kitchen-table operation—the IBM PC is the way to go. Why? Because most high-performance software is written first for the IBM PC. This makes the PC a very attractive machine in the eyes of many. And if you require some highly-specialized software, chances are that you'll find it ready and waiting if you have a PC to run it.

Unfortunately, an IBM PC is expensive, and gets more so as you add accessories. In fact, you cannot even use an IBM PC until you have spent several hundred, or even a thousand dollars for peripherals and accessories. Essentially, the PC works on the same principle as the Barbie Doll: the basic doll is relatively inexpensive or affordable; it's Barbie's clothes and accessories, not to forget the boyfriend Ken doll and his accessories, that eat up the budget. (Barbie and Ken dress better than I do!)

But there are ways you can save anywhere from $300 to over $1000:

- Plan carefully so you don't duplicate features.
- Be patient and shop around.
- Have a moderate (at least!) understanding of what you need and what you can substitute for.
- Assemble your own IBM PC system, substituting third-party components—hardware not manufactured by IBM—wherever it won't affect, or will actually improve overall performance.

Besides saving money, you'll end up with a PC having many more features than IBM offers and a model that's customized for your particular needs. The minimum IBM PC configuration that can be purchased (at the time this article was prepared) has 64K RAM and one double-sided disk drive. It retails for $1815. But for real computing power you'll need a second disk drive ($425, IBM's price). And if you intend to run a printer you'll need at least one printer adapter, which costs $75 (parallel) or $100 (serial). Something missing? Right! There's no video output or monitor. An IBM color/graphics adapter, which has a composite output suitable for color or monochrome, will cost $245, and the least expensive "recommended for IBM" monochrome monitor will cost about $150. So for a computer with two drives, a video monitor and a printer output you would have spent at least $2710, only to discover that few programs run in 64K RAM: you'll often need at least 128K, preferably 256K. IBM charges $100 for each 64K of RAM, so your total bill will be $3010, and you won't even have a serial output for a modem, or a printer. Now if you have read the advertisements in the big city newspapers and the mail order catalogs, you have probably discovered you can purchase a "standard" PC system for well under IBM's price, often saving in the area of $300 to $700 depending on the specific hardware you select—or what the dealer insists you *must* purchase.

Is this a discount on the IBM computer? Usually not. In many instances the dealer is using an IBM "bare system," which comes with only 64K of RAM, a keyboard and nothing else. He fleshes the system out using third-party hardware and peripherals. Third-party hardware is the stuff that isn't sold by IBM. For example, IBM charges $425 for a single disk drive with the IBM logo etched on the front panel. You can purchase a Tandon 100-2 or CDC-9409 disk drive without the IBM logo for about $200, a savings of approximately $225 per drive. Let's look at another example. IBM gets $100 per 64K RAM. The Great Salt Lake Computer Company (1780 West 2300 South, Salt Lake City, UT 84119) sells the 64K kits for about $50, or $150 for three kits, a savings of $150 when expandng the system from 64K to 256K. As you can see, this isn't one of those articles on how to save pennies: we're talking about a lot of money, often the difference between whether you, your business, or your school can afford an IBM PC; and we haven't even started discussing extra features yet.

The basics

First things first, you must get a bare system, officially called "System Unit 64K," whose part number 5150104 is often shortened to simply "...104." This isn't the easiest of things to locate. At the time this article was prepared it was no longer on the price list of some IBM product centers, and neither the local Computerland nor Sears Business Systems would sell one to an individual. (They don't want to sell you one because they don't want you building up a complete computer system for less money than they will charge you.) However, business is business, and advertisements offering a "bare PC"are appearing with increasing frequency.) Even some IBM product centers suggest they will be selling them in early 1985 when the anticipated demand for the IBM PC slackens.

If you are offered a bare PC at any price—list or discounted—take extreme care to be certain you are getting a PC2—the latest version—which is socketed for 256K RAM in 64K modules, each module consisting of nine (yes, 9) ICs (only 64K is provided in the bare unit). The earlier PC, often called the PC1, was socketed for only 64K RAM in 16K modules. Do not accept a PC1. You want a PC2.

Okay, you now have a computer, but there's no display. First thing you'll need is a monochrome monitor. Amber screens are all the rage, but many users find them difficult to use hour after hour. We suggest the monochrome green-screen Zenith ZVM-121, which sells in the discount price range of $90-$115. It has excellent bandwidth, delivers sharp characters from corner to corner, and is the monitor we use when photographing real-time computer video displays. It is in no way the equal of the IBM monochrome display, but it doesn't sell for the IBM's price of $620 (the cost of the IBM monitor plus the required monochrome adapter).

You'll need something that generates an output from the computer for the video display. For that we suggest the $245 IBM Color/Graphics Monitor adaptor, which provides either a 40 or 80 character "composite" (color output also suitable for monochrome), and an RGB color output. Just connect your monochrome monitor to the composite output's phono-type jack. While there are third-party color/graphic monitor boards, they aren't all that much better and they cost about the same as the IBM. And why not go with IBM when the price is about the same? There are other boards that deliver a better graphic display, but they are much more expensive and justified only if you have a need for graphics.

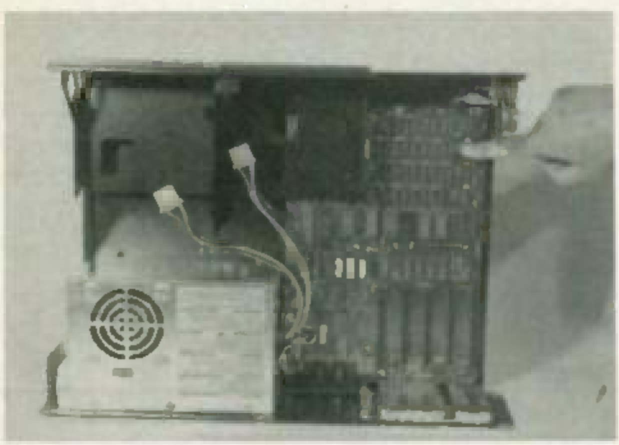


FIG.1—THIS IS THE MINIMUM *PC* system you can get. The finger points to the three rows of empty sockets that the user can populate with low-cost IC's to upgrade the supplied 64K of RAM to 256K.

Disk drives

Next, you'll need disk drives and a disk controller. Many sources sell the Tandon 100-2 and/or CDC-9409 drives for about $200. Find the least expensive source, but if possible—even if it costs a few dollars more—buy them from an outfit that provides installation instructions on how to set the drives' internal jumpers, and which terminating resistor block to remove. If you try to go-it-alone you can spend weeks trying to determine what's wrong, and the IBM service center isn't going to help you with third-party hardware. For this article we obtained the drives from Conroy-Lapoint (12060 Garden Place, Portland, OR 97223), who provides notably good instructions for their disk drives and user-intalled RAM upgrades.

The disk controller

Disk drives need a disk controller to tell them what to do. IBM's own disk controller (called a "disk adapter") now costs only $100—a fantastic value. However, the disk controller takes up one of the five available slots, while the color/graphics monitor adapter takes up another slot: leaving three slots for everything else. If you add a printer and a serial output adapter there's just one slot left for future expansion inside the main cabinet. But the disk controller is a plug-in board, and like other plug-ins such as the parallel and serial adapters, calendar/clocks, and RAM upgrades, they are available from third-party sources.

In fact, greater computer flexibility is attained—though it costs a few dollars more—by using multi-function boards (adapters) from third-party sources. For example, a Maynard disk controller, which can be purchased for as little as $169, is also available with a serial or a parallel printer adapter. Or—and this is preferable—you can use Maynard's *Sandstar* disk interface (approximately $200), which can accept any combination of up to three additional modules: serial or parallel interfaces, a battery-powered clock/ calendar, or a game port. The Sandstar interface equipped with a serial and parallel interface is the one we used and recommend. At the minimum, it saves at

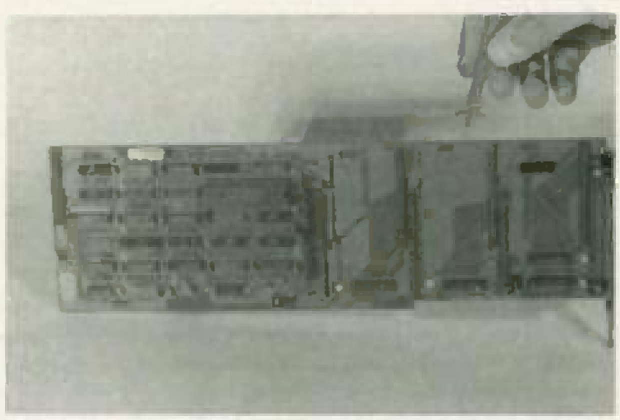


FIG.2—THE PENCIL POINTS to one of three empty module locations on a Sandstar disk controller board. Any of the available modules will fit any location.

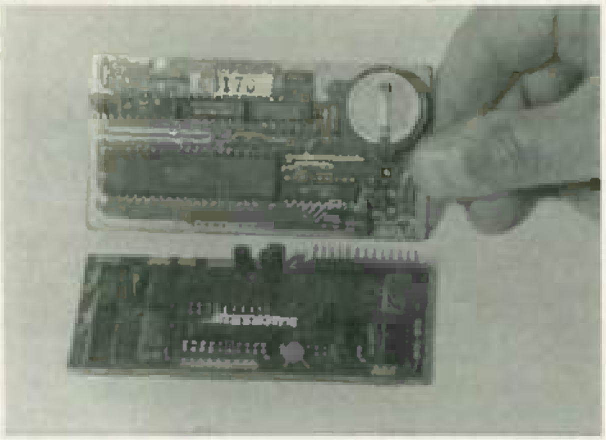


FIG.3—THE CLOCK/CALENDAR MODULE (top) is non-volatile because it is powered by its own on-board rechargeable battery. Like the parallel printer module (bottom), it plugs directly into the disk controller board.

least two, possibly three slots. The extra position on our Sandstar controller was used for a battery-powered clock/calendar. We actually had four functions in a single slot. (Because of recent IBM price cuts for their disk controller, we anticipate third-party controllers will be discounted for additional savings.)

Still more computer power

Before you run out to purchase your hardware, stop and reflect on what kind of system you'll want to end up with. Will you want a RAMdisk—memory that can function as a disk drive? For that you'll need extra memory and the software. If all you need is extra RAM you can get just a memory expansion adapter from IBM, assuming you have an available slot.

On the other hand, a board called the *Captain*, from Tecmar, Inc. (6225 Cochran Rd., Cleveland, OH 44139) provides the extra memory as well as serial and parallel ports, and a battery clock/calendar. But be careful not to duplicate existing functions. If you started out with a Sandstar disk controller you might already have the needed ports: You might only need extra memory, which is available as a separate memory-only board. To avoid the extra costs of duplicate functions, determine the kind of computer system you hope to end up with before you make any purchases. If you think you'll want or need the extra memory, use the Tecmar board with its serial and parallel ports, and the basic (no ports) Maynard disk controller, or the IBM controller—which is a best buy at $100. There are several other sources for memory/port/calendar boards, among them Quadram and AST. More or less, they offer the same features: extra memory, serial and parallel ports, a game (paddle) port, and a battery-powered clock/calendar. An extra "plus" for the non-IBM multi-function boards is that they are usually supplied with a "free" software package that often includes high performance utilities. But there is software, and then there is *good* software.

For example, some of the "free" software which partitions part of RAM into a disk emulator (RAMdisk) simply assigns a drive letter to the partitioned memory. On the other hand, The Tecmar software lets the user substitute the RAMdisk for an existing drive, and then automatically moves the assignment of the existing drives up one notch: if the user assigns the RAMdisk as the B: drive, the software automatically makes the original B: drive into drive C:.

This doesn't sound like much, but if your software is always looking for a data file on drive B: it will default correctly if you copy the necessary files from what is now drive C: to RAMdisk B:. If the RAMdisk is any old assignment, software that defaults to B: will never work correctly out of the RAMdisk. (You can pull off the same trick using PC DOS 2.0 and 2.1, but it's easier if done automatically by the RAMdisk software.)

Software for multi-function memory boards also often permits the RAM to serve as a printer spooler. Again, there is software, and then there is *good* software. Some spooler software doesn't permit disk access for the foreground program while the spooler is in the background. Other software programs the extra RAM on the multi-function card to function as an independent spooler, allowing disk access by the foreground program. Make certain you understand exactly what you are getting in the way of spooler software. As a general rule of thumb, the multi-function boards are primarily super-high resolution graphics adapters, or memory boards with I/O ports, calendars and game ports. If you don't anticipate needing more than the basic 256KB of RAM it's questionable whether a multi-function board will be worth the money. You might be better off with a multi-I/O board—an adapter with any combination of up to four serial or parallel ports. Just eliminating the memory capacity (empty sockets) from a multi-function board can save $50 or more.

Putting it all together

We have wandered around a little to give you an idea of the kinds of savings to be made, and the various kinds of hardware available from third-party sources. It's now time to assemble our PC.

First things first. Take the cover off the bare PC by removing the six screws on the rear apron and sliding the cover forward. Then remove the covers for the disk drive compartments: simply pop the two speed nuts off the plastic posts on the rear of the covers. The RAM and other ICs used on the plug-in boards are extremely

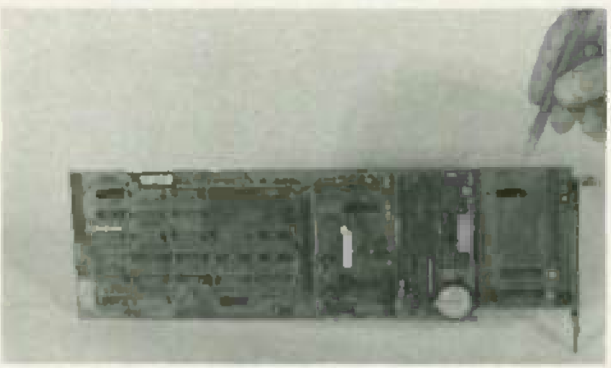


FIG.4—THIS IS HOW the disk controller board looks with the calendar/clock and parallel printer adapter installed. The pencil points to the remaining module location, which can be used for a serial I/O, another parallel port, or a game port.

sensitive to static voltage surges; any static elctricity in your body must be discharged to ground before you handle any components. Before you do anything else make certain you have a grounding bracelet connected from your wrist to a true electrical ground. If you don't have a grounding bracelet, make one by splicing a 1-megohm resistor in series with a length of wire, solder a small clip to one end of the wire and and connect the opposite end to the electrical ground. Attach the clip to your metal watchband, or the metal buckle if your watch has a leather or plastic band. If you don't wear a watch, make some provision to ground yourself because the RAM and the accessory boards usually lose their warranty if they are "blown" by static electricity. Handle nothing if you aren't grounded.

The next step in assembling your "cheaper and better" PC is to install the extra RAM into the empty sockets, making certain the notch on the end of the IC faces the rear of the chassis. Once again, we suggest you make 256KB of RAM the minimum configuration, so fill the three rows of empty sockets.

Next, install the graphics/monitor adapter in any slot except the one closest to the power supply and check out the computer before you install any other boards or accessories. (At each step of the way you must be certain the computer works before you go on to the next step). The monitor adapter installs the same as all the other boards: Select a slot, install the small plastic guide that's supplied with the adapter by simply pressing it into the matching holes on the front of the chassis, and seat the board in its slot. (Note, you must remove the matching slot cover on the rear apron before you seat the adapter in its socket.)

There are two internal DIP switches that must be set to correspond to the amount of memory and the number of disk drives. Remember, at this stage you have no drives. The instructions supplied with IBM's color/monitor board show how to set the switches.

Plug in the monitor and fire up the computer. If it works, install the disk drives and their controller board. The disk controller board must be installed in the slot nearest the power supply.

The standard controllers are supplied with the necessary connecting cables and notably excellent installation instructions, so there's no necessity to go into details here. Take note, however, that the cable is twisted at one of the two drive connectors: this is normal. It accommodates a clever system IBM used to avoid errors when programming each drive's disk selection jumpers.

Unike the programming of the drive-select jumpers for other computers, IBM programs both drives exactly the same with a "shorting bar" across drive select #2. Do not use any other shorting bars on the drive-select socket. Only drive A: uses a terminating "resistor block" that resembles an IC. Pull the block from the B: drive. Some disk suppliers such as CONROY-LAPOINT provide complete instructions on how to set up the drives.

Install the drives in their compartments. Secure any modules you plan to use with the controller on the disk adapter board along with all connecting cables, then install the controller in the last slot, the one immediately adjacent to the power supply. Connect the power plugs (part of the bare PC) to the drives, and then the ribbon cable from the controller. The cable goes to drive B: first; the end of the cable goes to drive A:. It might appear reversed but that's the way to do it.

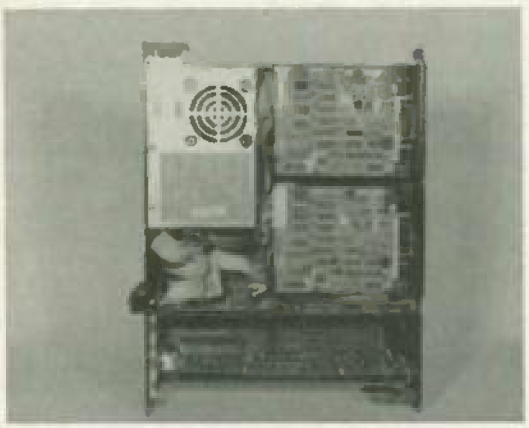


FIG.5—OUR MINIMAL DO-IT-OURSELVES configuration before further upgrading. The disk drives have been installed, along with the disk controller and graphics monitor adapter boards. Both parallel and serial modules are installed on the disk controller card, which now provides four functions in a single slot. What appears to be a *rat's nest* of ribbon wire from the parallel and serial modules is just fine; don't try for neatness—Just position the wire wherever it will fit.

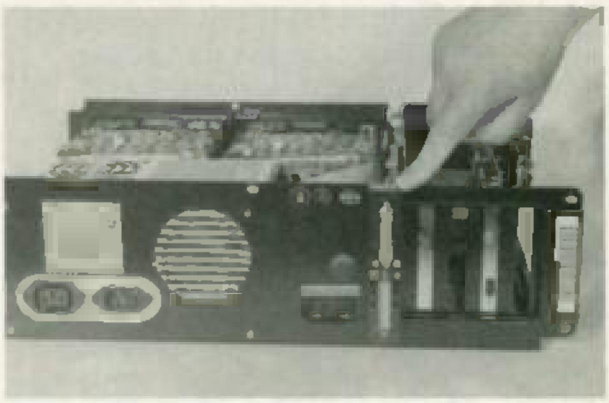


FIG.6—MORE SLOT CONSERVATION. The parallel and serial connectors are installed on a single mounting adapter to avoid "killing" a slot position just for a connector.

Set the DIP switches on the motherboard for two disk drives. Next, using IBM's DOS 2.0 or 2.1 (which you must purchase), check that everything works correctly. There will be a long delay after you turn the power switch *on* as the computer checks it's RAM. After what seems like an eternity (actually a few seconds), disk drive A: will start and load the DOS (*Disk Operating System*).

If everything checks out, install your multi-function boards one at a time, testing every function before installing the next board. If you have done your planning carefully you will probably have every feature you want or need and still have at least one slot open for future expansion.

COMMUNICATIONS CORNER

Communication odds-n-ends

HERB FRIEDMAN,
COMMUNICATIONS EDITOR

THE MAILBAG USUALLY BRINGS A steady stream of information, devices, and procedures that by themselves would not justify a full column, or even half a column for that matter. But because they are often things that may be useful to communications technicians, every once in a while we put them all together even if they're unrelated. This time we'll start out with a look at portable telephones.

A few years ago telephone manufacturers were almost climbing the walls because there were only four authorized channels for mobile telecommunication services. The way they told it, the switched telephone system—the thing I usually call the dial-up system—would eventually sound like the Tower of Babel as neighbors accessed each other's phone.

From the rock-bound coast of Maine to the sunny shores of California, newspapers have entertained us with articles telling of people cruising through neighborhoods trying to determine whose portable telephone they could access to make free long-distance calls.

I've tried to track down that illusive service thief, but each report that I've followed turned out to be ninth hand. And as you might expect, I've never located anyone whose phone was actually accessed by the "phantom of the portable telephone." (No doubt, tomorrow's mailbag will bring in a stack of mail from people whose best friends have illegally accessed their portable telephones.) In addition, there is another problem: People are constantly being harassed by the interminable clicking caused by some one else's portable telephone or other device in the same building.

Well, as the FCC said when petitioned for more channels: "Technology will take care of the problem." And that's just what happened. The most modern portable telephones use digital encoding—a digital burst transmitted when any key on the unit is pressed. The base unit (which contains the dialer) doesn't respond until it senses the correct code. Therefore, no one can creep through the neighborhood looking for free access to long-distance service, and the folks watching "Dallas" on the TV won't be disturbed by dial-clicking (from the telephone relays) or calls intended for their neighbors.

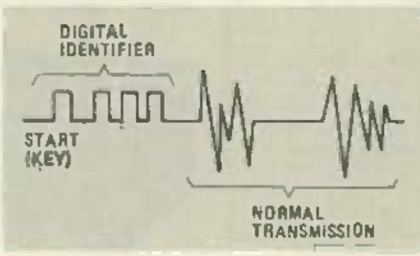


FIG. 1

Figure 1 is a representation of the waveforms you might expect to see for one encoding system used in portable telephones. Whether it's the base unit transmitting to the portable handset or vice-versa, a digital identifier is automatically transmitted when the device is first keyed, which activates the receivers in both the headset and base.

The receiver responds only after the correct code is sensed, and only then is the system ready to handle the normal telephone chitchat. At the end of the call, hanging up the phone causes the decoder to automatically reset the system. If either the base or remote unit does not receive the correct code it remains in the standby or muted condition.

While I haven't seen tone-encoded versions of portable telephones, some readers have inquired about them, so I expect they do exist. They would work the same as the tone-encoded walkie-talkies, using either a continuous subaudible tone, or DTMF (Touch-Tones). Speaking personally, digital is probably cheaper, and certainly the wave of the future.

New modem uses old idea

Every once in a while I get letters suggesting that I leave the stone age. And a recent column on new uses for carrier-current transmissions—signals broadcast through electric power-lines—was no exception! That discussion brought with it the usual assortment of letters taking me to task for trying to resurrect ideas from the 1930's. Well, this time we're resurrecting old ideas to enhance modern communications systems.

The latest modem for computers is the *Line Carrier Modem* (LCM), which uses the powerline to carry the computer signals. The LCM contains a miniature transmitter and receiver whose I/O connects to the powerline through the same linecord that powers the modem; the computer connects to the LCM through the standard RS-232 connector. It works the same way as the conventional computer and modem setup used with the dial-up telephone system.

The primary functional difference between standard arrangements and the LCM system is that the signals in an LCM system travel from computer to computer through the powerline rather than telephone wires. That means that for communications between computers, you don't have to make a telephone call, and neither do you have to stretch direct wires between two computers. Instead, you simply plug the LCM into the nearest convenience outlet.

For more information on the powerline modems, write to Global Computer Supplies, 9138 Hemlock Drive, Hempstead, NY 11550. (They also have a nifty fiber-optic modem. How's that for the other extreme?)

Telephone repair

Since the government's smashing victory over AT&T—giving them exactly what they wanted in the first place—the consumer is left with a telephone system that provides poorer service, charges higher rates and, more important, is difficult to obtain repairs from.

In a brilliant move, AT&T split its telephone hardware between two separate companies. That means if a customer—like some sweet little old lady with no knowledge of telephone electronics—calls the wrong people, she not only doesn't get her telephone repaired, but also gets smacked with a bill for $40 or $50 because she called the wrong people!

In short, AT&T managed to unload all responsibility for their products by making repair a gamble; guess wrong and it will costs you a good part of your weekly salary or monthly pension. The elderly or infirm, the poor, and anyone just getting by on a small fixed income are going to need help from someone when their telephones won't work.

Given a vacuum, someone must fill it and it is conceivable that they'll turn to the people who keep their TV's running. It's very likely that the TV serviceman will eventually double as a telephone repairman because his is the only service people can rely on.

Think it's farfetched? Then take a look at the latest advertisements for B&K test instruments. Their model *1042* telephone line analyzer ($19.95) will test the incoming line for proper voltages and ring signals, as well as the loop. Carry one of those in your tool box along with a "real telephone" (a Bell Systems model *500* or equivalent) and you can help any customer get a service call straightened out while AT&T and the local operating company play their little game.

Since it's likely that everyone will eventually purchase telephone equipment from third-party sources (what AT&T was after from the beginning), B&K's *1042* can put you in a position to handle your own household telephone service.

Undoubtedly I'll be receiving mail from B&K in the next few days with information on their model *1045* tester, which tests just about everything having to do with wired and wireless phones. Because of its nearly $400 price tag, I feel that it deserves a little more space. So, we'll save it for another time. R-E

DRAWING BOARD

ROBERT GROSSBLATT

Automatic data sequencing

IN OUR LAST DISCUSSION OF MEMORIES, we mapped out the design criteria for our demonstration circuit. We've taken care of keyboard data entry with the binary keyboard encoder that we've already built. This time, we'll see what must be added to that circuit to make it do something useful. After all, what good is the encoder without having some way of storing and/or manipulating its output data.

Since one of the design criteria is automatic sequencing of the address and data, we'll need something in the circuit that automatically does one thing after another. The problem of data sequencing was addressed when we built the binary keyboard encoder, which was designed to continuously scan a series of switches in search of a depressed key.

Automatic sequencing scheme

Since we'll be sequencing both address and data, we also need some way to let the circuit know which is which. The easiest way to keep track of what's stored where is to store the low and high order halves of the address, plus the data separately. Given all that, let's take a look at Fig. 1, a tentative solution to the problem.

The data coming out of last month's keyboard are fed to a series of latches, each of which is four bits wide. Since the 5101 (the

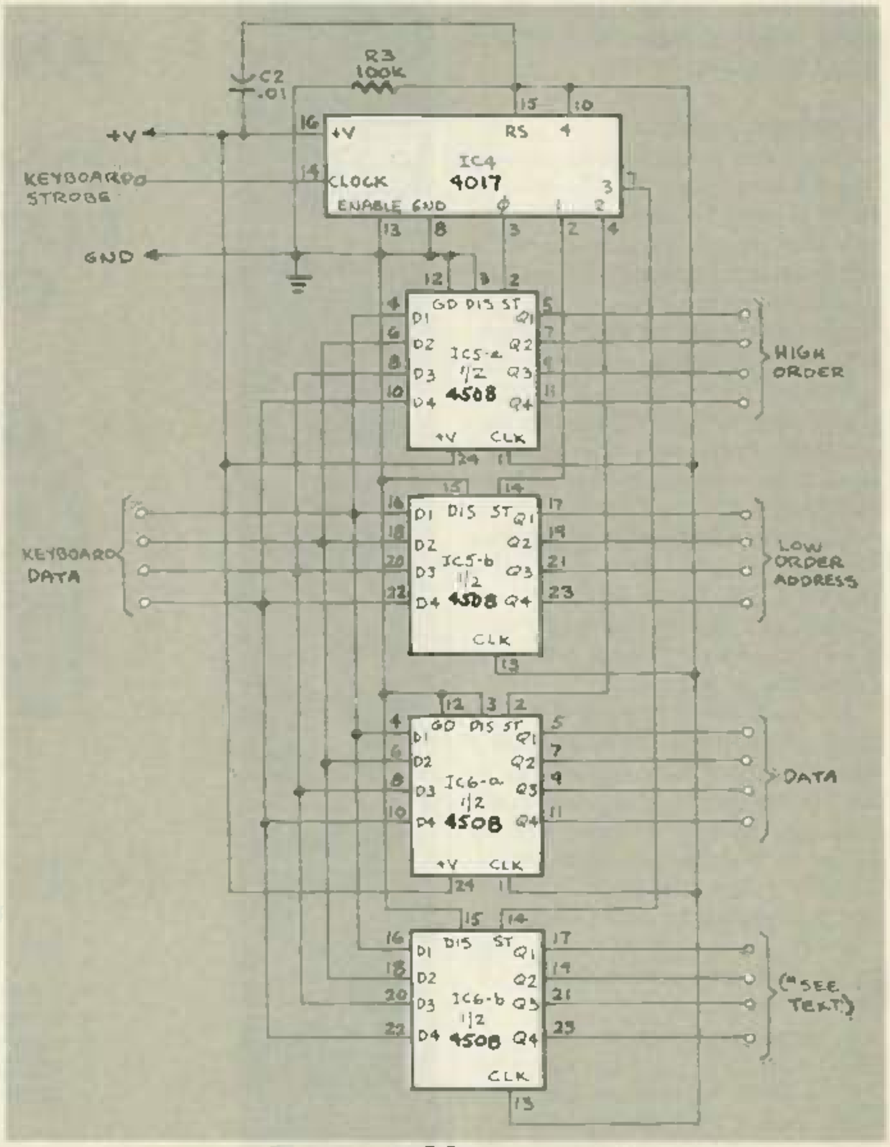


FIG. 2

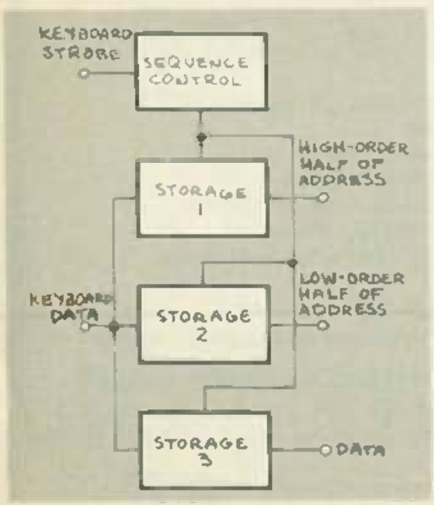


FIG. 1

static RAM that we'll be using for storage) has eight address pins and four data inputs, we'll need three latches to handle the job. You can get IC's that are 4-bit latches, but a "neater" way is to use a 4508. It's a 24-pin IC that is really two 4-bit hold-and-follow latches in one package. By using that IC, we'll only need two 4508's and have one latch left over for any brainstorms we might come up with in the future.

The easiest way to sequence things is to use a 4017 binary counter, an IC you should be really familiar with by now. We spent some time discussing that IC in November and December, 1983. Now that we have the cast of characters for this portion of the circuit, let's put them together and see how they fit into our design.

How it works

Figure 2 is a schematic of the circuit we'll use to sequence the binary in information from the keyboard encoder that we built last month. It consists of a 4017 counter/driver and two 4508 dual 4-bit latches. (If you're wondering about the parts numbering, I'm keeping things in line with last month's circuit to avoid confusion.)

The action of the 4017 is (or should be) self explanatory. One thing that does deserve a bit of attention, however, is the way the clocking is being done. The 4017 sequences on the positive going (ground to +V) half of the incoming clock pulse.

Note that the four data lines (0–3) of the 4017 are connected to the STROBE inputs of the latches. That is done to sequentially enable each latch. Also notice that the DISABLE pins of each latch is tied to ground: That means that the outputs of the 4508's are permanently enabled. However, there is no data output unless the strobe input is high.

The 4508 can provide a three-state output, but there is no need for it because there's no common output-bus. Each latch will be used to control different parts of the memory and will, therefore, be connected to different pins. (But keep the three-state option in mind because many applications require that feature, which is not found on all latches.)

When power is turned on, all four latches are cleared by the R-C pulse generated by R3 and C2. Also at turn-on, pin 3 (output "0") of the 4017 goes high and enables the inputs of the first latch. The circuit then sits there and waits patiently for you to press a key on the keyboard. In other words, any data presented to the input of IC5-a will now be transferred to its output.

When a key is pressed, encoded data enters IC5-a and is passed on to its outputs (which is connected to 4 address inputs on the 5101 CMOS static RAM). At the same time, the strobe line goes from high to low and remains in that state so long as the switch is held down.

After the key is released, the strobe line returns to the high state and the 4017 advances by one count. That disables the first latch (IC5-a) and enables IC5-b, the next latch in the chain. The same action is repeated for each successive latch.

When putting the circuit together (and you should), note that the 4017 counts on the release of the switch rather than on the pressing of the switch. You could make things happen when the key is first pressed if you want, but it would take a bit more hardware and, quite honestly, I can't think of one reason for doing things that way.

When data comes off the keyboard, they are sequentially stored in each latch automatically. Now, automation is a wonderful thing, but there are times when you want a little more control. In our case, automation means that there's no way to go back. Put another way, if you hit the wrong key, there's no way to correct it. That's the penalty you pay for not designing things to work with an "enter" key.

If you feel that you'd like to be able to go back, or you want to actually strobe the data into the latch separately, all you have to do is put a clear switch into the circuit, or clock the 4017 with a separate switch. How to go about doing such things is a good exercise to see if you really have a clear understanding of all the things we've done so far. Design it yourself and try it out. As for me, I'm all in favor of automation.

When you add extra features to the circuit, keep in mind all the design rules we've discussed. Write everything down, from the criteria to the actual hardware you're putting in the circuit. As I said before, bad habits are hard to break, and any circuits designed with bad habits have a way of going up in smoke!

You'll notice that we have an extra latch left over. Since all we're handling is four data-bits and eight address-bits, the last latch seems to be an unavoidable waste of hardware. Why not put in some brain burning time until next time; see if you can think of some use for it? I've already got something slick in mind—how about you?

Feedback

Before we end this month's discussion, there's a piece of important business that requires immediate attention. I thought that I'd taken care of it some time ago, but it seems that it needs a little bit of clearing up and now's as good a time as any.

I've received several letters lately that contain more or less the same comment. Several of you have said, "I like what you're doing but" (followed by): "I know a way to do it better;" "I know a way to do it easier;" "I can do it with fewer parts;" "My way uses a lot less power," and other such statements.

I guess there's some confusion about what you're supposed to get from this column. There are many schematics of workable circuits drawn and explained here, but the point of them *isn't* to compile a list of construction projects or, for that matter, anything like the sort of thing you'd see in the many books dealing with the 555 timer.

If you look over some of our past discussions, like the ones on the 4018, which began in January, 1984, you'll realize there's much more to it than just figuring out how to generate sinewaves. After all, our final circuit only had a handful of parts and was far short of what is needed for any really serious audio measurements. Not only that, but we spent three months or so putting it together!

Once and for all, let me state what I thought was obvious: The point of these discussions *is not* to show you how to build anything in particular, but merely to show you how to build anything in general. More often than not, the reason what works out well on paper falls apart in practice is because the approach to the project is wrong!

Getting something from *brainstorm* to *breadboard* must be done in a rigorous, systematic way, or the chances of success are just about non-existent. Listing design criteria and flowcharting the initial idea are as important to the final design as deciding how long the power cord should be. Without a scientific, well documented approach to the problem, you might as well forget the whole thing and take up stamp collecting.

Besides emphasizing the method of design, I've tried to pick areas that interest me and, I hope, you as well. Using neglected IC's and coming up with the "bare bones" of useful circuits is only a side benefit. The main benefit is to show how any design problem is handled......in a very structured, step-by-step way.

Bad habits will do you in every time. Not keeping notes and a listings of what you started out to do, are doing, and expect to wind up with is a guaranteed way to screw yourself up. Breadboards have a really nasty habit of turning into a "rat's nest" of wires with parts placed on the board as you think about adding them.

Imagine getting a working, breadboarded version of some circuit and then being forced to leave it alone for a couple of weeks. When you finally get back to it, figuring out which wires go where, and why certain parts were used, is just about impossible unless you have taken good notes.

I'm sure that many of you out there can figure out better, simpler, or less power-hungry circuits than the ones finally developed here. In fact, I'd be surprised if you couldn't, and somewhat disappointed if you didn't. Remember Grossblatt's Fifth Law: There's always a better way! R-E

ANTIQUE RADIOS

Restoring antique radios

RICHARD D. FITCH

PREVIOUSLY, WE STEPPED BACKWARD IN time a half century or so, and saw that what was then new technology has today become an intriguing hobby. It's perhaps a new adventure for the modern computer genius, but it's a return of old memories for the more mature radio and TV servicemen, or hobbyist. No matter what category you fall into, the objective remains the same—to make that old radio look and work like new.

Once you've discovered that old treasure and taken it home, you'll want to set it up in the living room for all to see. That's when the temptation to plug it in and see if it works sets in. But there are a few things that should be taken care of first!

Preparation for restoration

The first you should do is set the unit outside your house or shop, so that it can be cleaned and fumigated—yes, fumigated. Any item that has been just lying around dormant—who knows where—for over 30 years should be cleaned before being brought into your home or shop.

During that preliminary cleaning, take care not to destroy any valuable information. Things like tube diagrams, schematics, and model numbers can be lost forever because of carelessness. Its a good idea to cover anything that you may want to keep.

The unit should be treated with insecticide inside and under the cabinet, but try not to spray the speaker cone. After that, it should be covered for a few days to protect it from the weather and left outside to ventilate. (Have you ever smelled one of those old units after it has been sitting in a damp basement for a while?) Once done, you can brush out the loose dirt and "anything else" you might find. Your radio should now be presentable enough to go into the house.

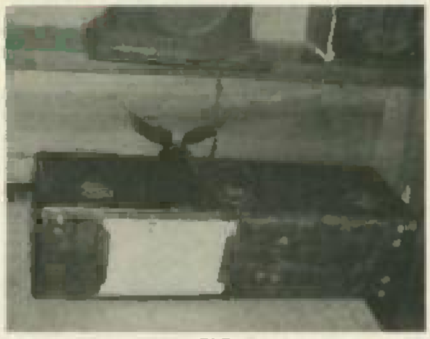


FIG. 1

FIG. 2

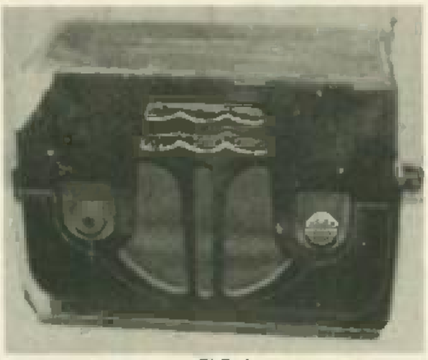


FIG. 3

Once the set is reasonably clean, you should be able to see any obvious defects; for instance, there may be cracks or scratches in the wood. Also, make sure that there aren't any tube sockets without tubes or tubes in the wrong sockets.

Any wires sticking out of a hole in the chassis should be suspect to you. Also make sure that the big dynamic speaker is in place, though that's something that should have checked out before buying the set.

As when working with any other electrical or electronic device, your own safety should be of primary concern. Many 40 to 50 year-old radios may not have their original circuitry. Modifications in the set can be extremely hazardous, as can missing knobs, or frayed wires.

If the set is missing a knob and you don't have a spare, at least wrap some tape around the shaft before plugging the set in. Frayed power cords are also potentially dangerous.

Until a few simple tests are made, it's best not to touch any conductive part of the unit once it's plugged in. That includes chassis bolts (see Fig. 1), which will probably be sticking out from the bottom of the cabinet.

Besides the shock hazards, the early radio serviceman often suffered painful burns from hot (temperaturewise) components. Many old radios had large wire-wound tapped resistors sticking straight up on the chassis, as shown in Fig. 2, which were so placed to dissipate heat through the back of the cabinet.

Those resistors were about as in-the-way as they could be, and there was no way to stick your hand into the cabinet without being burned. The old rectifier tubes were also favorite "get-burned-on" components. Most other components in radios, including the power transformer, shouldn't get hot enough to cause injury. If they are excessively hot, the parts are either shorted or in a faulty circuit.

Turning it on

Before plugging in a strange old radio, it's usually best to turn the power switch on. Then you can plug the line cord into a receptacle momentarily and not have to physically touch the set. If the panel light comes on when the set is plugged in, approach it cautiously, making sure the set is positioned so that you can look into the back of the cabinet to see the chassis.

If there is any smoke or a strange smell coming from the unit, unplug it immediately. All those who are experienced in electronics are familiar with the different odors emitted by various smoldering components. Find out where the smoke or smell is coming from and don't plug the radio back in before you've corrected the problem. If you do, you may burn up a component that's difficult to replace.

Further, if when the set is turned on you get no audio, there should at least be a slight audible hum coming from the speaker. If the hum is objectionable (excessively loud) or non existent, you have a problem. (The individual problems will be discussed in a future article.) No hum at all may not be as serious as an objectionable hum.

If the power supply seems to be working and there is no hum, check the speaker wires. Also check to make sure that the speaker is not unplugged. Even a damaged speaker with a torn cone and an off-center voice coil should emit some kind of sound. Check all wires going to the speaker array. That could be anywhere from two wires on up, depending on how many other components are mounted to or near the speaker.

With all the tubes and panel lamps lighted, you should—provided there is also a slight hum—hear some music (or *something*) through that old electro-dynamic loudspeaker. If not, try feeding a quick signal to the unit through a grid capacitor or the antenna terminal. For the best signals, check that the band switch isn't tuned to one of the shortwave frequencies.

Also, some old radios have separate volume controls and power switches. Make sure power is turned on and the volume control is turned all the way up. Despite the massive size and tube complement, many radios won't play without an external antenna (one that's outside the set, not necessarily outside the house). Any short piece of wire, makes a fine temporary antenna. You don't have to be authentic and go out the window and across the roof (as was necessary in times past).

In the 1930's, some manufacturers went all out to include special features in their radios. Multi-bands, treble and bass controls, and tuning eyes can be found on many old radios. Any of those controls can contribute to a no-signal condition or excessive hum. Some of the smaller "budget-priced" sets produced during that era may not include extra features.

Those budget sets, like the one shown in Fig. 3, were designed to make it possible for almost everyone to own a radio during the depression era (1930's). While the chassis in those sets were adequate, the cabinets that the units were housed in didn't seem to hold up as well as their console counterparts. That might be the reason why old console-model radios seem easier to come by today than the smaller types. If you do find one of the smaller units, you'll need to have a little more patience when restoring the cabinet.

Before closing, we have an announcement to make. If you have old radio parts and/or information that you'd like to share, or perhaps are in need of the same, write to this column and let us know. We'll do our best to match up those that need with those that have something to share. **R-E**

SERVICE CLINIC

JACK DARR

Some "new" developments

LOOK AT ONE OF THE NEWER SETS ON the market and you'll find lots of new circuits and devices, but you'll also find "new" circuits and devices that are merely redesigned old ones. One such device is an optocoupler. The first ones were pretty bulky; they used a pilot lamp and a selenium photoelectric cell located at opposite ends of a tube about 3 inches long and half an inch in diameter. When the pilot lamp was on, it generated a signal in the selenium cell.

The early optocouplers were fairly bulky, and were not too good when it came to frequency response. Those devices have been refined and miniaturized now. The newer ones are made in an IC package and use a LED as the light source and a phototransistor as the photoelectric cell. They are also more useful at higher frequencies.

With those devices, the isolation between input and output is extremely good. So, they are used in several new sets to couple the horizontal drive signal to the output stage. They are also used to isolate the two grounds—the AC ground of the line-connected DC power supply, and the signal ground of the rest of the circuitry.

Figure 1 shows the optocoupler used in a Sylvannia chassis. In that circuit you can see the two grounds. The emitter of the driver transistor is the power-supply ground. The other ground in the circuit is the signal ground and is isolated from the other ground in the circuit.

Testing an optocoupler for proper operation is simple. Just use a scope to look at the input and output signals. If they are the same, everything is fine.

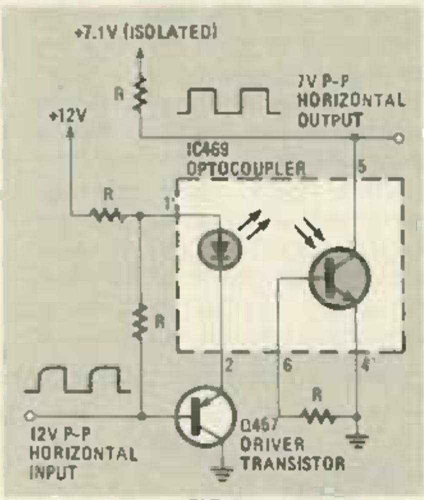


FIG. 1

Stereo TV

Now let's get to something that really seems to be new. That is stereo TV sound. But stereo sound is not really new, and stereo TV sound is basically just the same as the stereo FM we have been working on for a long time. The sound carrier, at 4.5 Mhz, carries the L+R signal, as well as the pilot carrier for use in demodulation. It just that we are not used to seeing the circuitry in a TV chassis.

One new wrinkle that has been added is SAP, or Separate Audio Program. That can be used to provide a channel of "alternate" audio programming. It can be used to provide a second language sound track for a program, or for audio programming that has nothing at all to do with the video programming.

As to the stereo decoding process, the TV sound carrier is picked off at the video detector, as usual. The 4.5 MHz carrier is then fed to a buffer stage to build it up a little, then on to the FM detector, and, finally, to the stereo decoder module. The process of detection seems to be identical to that used in FM stereo, with a pilot carrier to help in the separation.

There doesn't seem to be anything new or radical in the decoder, and the servicing of which should be just as easy as any FM stereo system. That is, check for the presence of the pilot signal, and the two (L and R) outputs. Most of the circuitry is contained within IC's, so troubleshooting will mainly consist of seeing that the inputs and the outputs to all of the IC's is correct.

Be that as it may, it looks as if TV stereo sound has finally arrived, after years of complaining about the quality of TV sound. The new audio circuits should not be difficult to service, once you get used to the slightly different frequencies used. And, thank goodness, no new equipment will be needed for troubleshooting and servicing stereo TV's. R-E

SERVICE QUESTIONS

ROLLING, UNDERSIZED PICTURE

On a GE 19YA I replaced the horizontal output transistor and the flyback. When I finally got a picture, it was undersized and rolled intermittently. The voltage coming out of

the power supply is low. How can I isolate problems in the scan supply? What can I look for?—D.D., Huntington, WV

Your trouble is not in the scan supply, but in the low-voltage supply. You are getting 95 volts where you should be getting 140 volts. I have a strong feeling that C904A, the input filter, is open.

SNOWY PICTURE

An RCA CTC-43A that I'm working on has snow in the picture. The RF-AGC control has some effect, but not much. I checked all resistors in the RF Amp. and AGC circuits to no avail.—R.C., La Crosse, WI

Of course, you realize that a weak RF amp, 2054, would give you snow, and of course, because it's an expensive little bugger, you don't want to go out and buy one just on a hunch. Hook an external DC supply to the AGC post on the tuner. Sweep up and down the operational voltage by a volt or two. If you cannot get rid of the snow, you have tuner trouble. If you do get rid of it, then go back to the AGC circuit to find out why it is not doing automatically what you can do manually.

BLOWING FUSE

On a Samsung TV, I replaced the open .8 amp fuse which blew again a week later. All components in the power supply checked good. Do you think something might be breaking down under load?—G.S., Philadelphia, PA

Sure, but it's not an easy thing to find until it breaks down for keeps. On the other hand, you might have one of those borderline cases in which the fuse is simply underrated. I am strictly opposed to playing around with circuit designs, but raising the fuse value by 0.2 amp to a 1 amp will give you that extra edge without compromising safety. If the new fuse blows again, then all doubt about breakdown will be removed. R-E

HOT FLYBACK

The 6JE6 current in this set is normal at 210 millamps. I have a good picture with good brightness and no picture shrinking. Yet, the flyback transformer runs hot to touch after 30 minutes of operation. What could cause this?—V.G.T., Phillippines

In every instance that I can remember, a hot flyback meant a defective flyback, and that usually also meant shrinking picture, focus problems, and low high-voltage. Heat can be a relative thing. What you feel is "hot to touch" may be normal heat build-up after 30 minutes of play. My advice to you is to do nothing for now. Just observe. If the flyback is indeed on the way out, you'll know it soon enough. However, if nothing further happens, you are mis-diagnosing.

REPAIRING VCR's

With the proliferation of VCR's in the home, there seems to be a real opportunity growing. In your opinion, what equipment is basic in VCR servicing?—J.J., Haddon Heights, NJ

The basic equipment is what every TV repair shop should already have. A good meter is, of course, essential, as is a wide-band scope and color generator. Then there is a matter of quality: An NTSC color generator is more useful than a keyed-rainbow generator and a triggered scope more useful than a conventional one. For high-output and high-grade VCR servicing, one would need to go into a frequency counter and sweep/marker generator for alignment purposes. An analyst, or signal-injector, would make the high-tech workbench complete.

SLOW GUNS

We are having a problem with an old Fleetwood color set that is defying logic. The symptom is all green on the left edge of the raster, caused by a slow coming on of the red and blue guns. Picture and color are otherwise perfect. We've checked every part in the RGB circuit, demodulator and video output.—P.D., Waterloo, Ont.

Anything that might be wrong in the signal circuits would be evident over the entire screen, not just one side. Your statement about the slow emission of the red and blue makes me think of a poor kine. Why not run a purity check to see if you can clean up the raster? Another thought: You might have defective blanking or filtering, showing up as green simply because that is the strongest component. R-E

SPECTRUM ANALYZER

continued from page 47

FIG. 7—THE COMPLETED ANALYZER, mounted in a 19-inch rack cabinet. Since most of the components are mounted on the circuit board, there is a lot of room inside the cabinet.

board mounted, the depth of the switch and potentiometer will determine the length of the standoffs you'll require. If you use very low-profile parts for that section, you'll be able to bolt the circuit board very close to the faceplate. That will give excellent visibility to the LED's. A red plastic filter may be glued on the back of the window for a professionally finished display.

FIG. 8—THE REAL-TIME AUDIO ANALYZER as seen from the front. It is very clean in appearance and will look right at home with your stereo system.

Calibrating the analyzer

The following resistors should be placed in position but not soldered: R91, R93, R95, R97, R99, R101, R103, R105 and R109. To calibrate the analyzer:

- The unit should be powered up with the selector switch in the oscillator-output position (AUX). That will display the oscillator output.
- The LEVEL potentiometer, R113, should be adjusted until the LED's make the straightest possible horizontal line with one LED lit per octave. The level should be played up and down until the straightest line is achieved.
- It is normal for some of the LED's to be higher or lower than what is desired.
- Table 1 lists the resistors for each respective octave. Using the chart, replace the resistor for the lowest octave that has a LED too low with a 430K calibrating resistor. Be sure to remove power from the unit anyting you replace resistors!
- Readjust the level control for the straightest possible line. Since all of these parts are interactive, each change may alter the line. Repeat the process for all of the LED's that are too low, lowest octaves first, until all that is remaining is a straight line and LED's that are too high.
- The procedure is again repeated for the high LED's, beginning with the lower octaves. The resistors removed for the high LED's are to be replaced with 520K calibrating resistors.

To re-iterate, the steps are to: a) Find the lowest octave that has a LED too low. b) Find the resistor number for that octave. c) Replace that resistor with a 430K calibrating resistor. d) Readjust level control for straightest line. e) Repeat until only straightest line with LED's too high remain. f) Find the lowest octave that has a LED too high. g) Replace that resistor with a 520K ohm calibrating resistor. h) Readjust level control for straightest line. i) Repeat until only a horizontal straight line of LED's is visible.

The audio analyzer is now calibrated. The calibration resistors can now be soldered in place and the leads clipped to proper length.

The addition of the real-time analyzer to a stereo system, PA, or recording console allows you to see what you're hearing (or what you're not hearing). It can be used as a tool when taping (to match tapes with the original source, or to discover the playback characteristics of a tape machine). As it reveals the spectral content of the music played it can be enjoyed as an educational, entertaining, and colorful display. R-E

TABLE 1

Octave	Resistor
31.5	R99
62	R97
125	R95
250	R93
500	R91
1K	R101
2K	R103
4K	R105
8K	R109

SYNC SEPARATOR

continued from page 58

should see a DC level of about 2.5 volts with all of the sync-pulse tips lining up at that level.

Set the DELAY control and BIAS trimmer potentiometer R9 fully counterclockwise. Remove the clamped video from the input to the scope and observe the signal at pin 2 of IC3. Slowly adjust R9 until you see a clean, negative-going pulse approximately 200 microseconds wide.

Next set R21 fully clockwise and observe the trigger output. Here you should see a positive-going pulse 100 microseconds wide. Adjust the amplitude of that pulse with R21 to a level compatible with the external-trigger input of your scope. (That's usually about 5 volts peak.)

Applications

To use the unit, apply a video signal to the input. Connect the CLAMPED VIDEO output to the vertical input of the oscilloscope, set the SYNC switch to the appropriate polarity, and connect the TRIGGER OUTPUT to the external-trigger input of your oscilloscope. Adjust the scope's trigger level control for reliable triggering.

You should now see a clamped video waveform on the screen. By adjusting the delay control, you should be able to move the display to any part of the waveform you desire. The display can be expanded as much as you like by simply increasing the sweep rate of the timebase.

When powered up, the circuit will lock on to one or the other of the two fields in a random manner. In order to observe the other field simply flip the SYNC switch to the opposite position and back again. Do that until the desired field is locked in. (Flipping the switch disrupts the operation of the sync separator, allowing the circuit again to randomly select a field to lock onto.)

If your oscilloscope is a dual-trace model with an "alternate" mode, you can display both the odd and even fields at the same time. Replace R18 with a 220-ohm resistor to reduce IC4's minimum delay time to zero. That will allow the vertical pulse of each consecutive field to trigger the scope instead of every other field. If, for example, the vertical pulse of field 1 triggers channel 1 of the scope, it will be displayed on channel 1. The next trigger pulse will trigger the alternate scope channel (2) and field 2 will be displayed on channel 2.

A display of that type allows you to see the half-line offset between the two fields. It also allows you to compare the VITS waveforms that normally ride on lines 17 and 18 of both fields. (VITS stands for *V*ertical *I*nterval *T*est *S*ignal.) See if you can find VITS's on a local TV signal. R-E

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FREE Survival Catalog—50+ survival publications—electronics, computers, energy, weapons, medical, financial!!! **CONSUMERTRONICS,** 2011-RE Crescent, Alamogordo, NM 88310.

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SATELLITE TV systems. Best prices. Catalog $1.00. **STARLINK, INC.**, 1122 Park Plaza, Suite 41, Huntsville, AL 35801.

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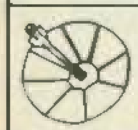

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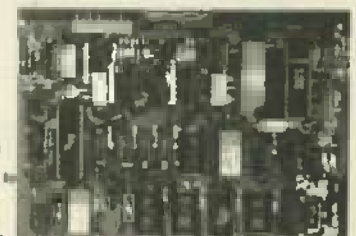

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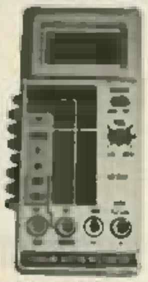

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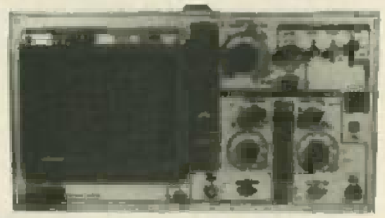

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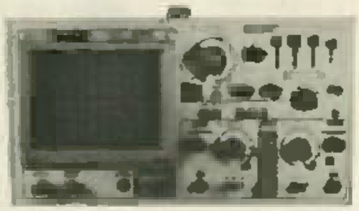

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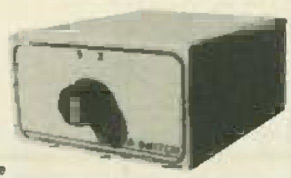

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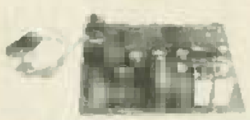

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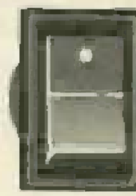

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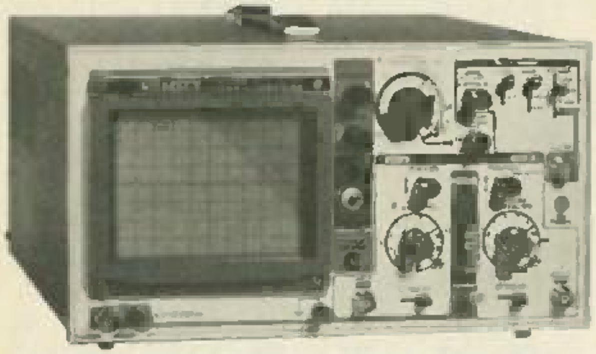

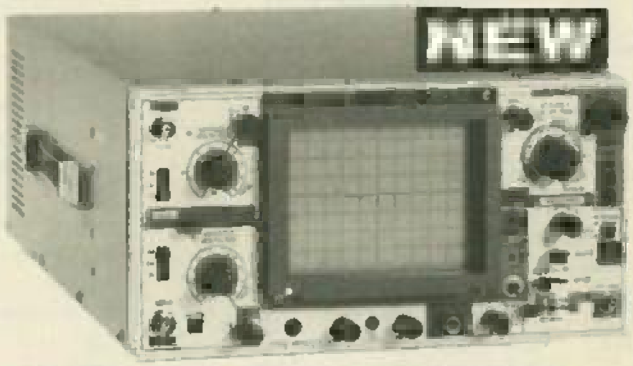

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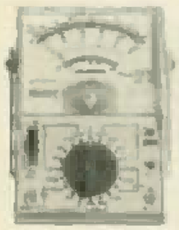

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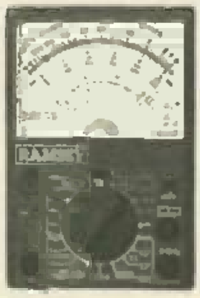

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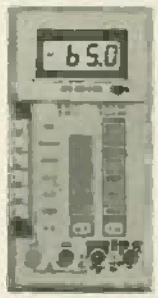

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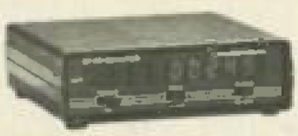

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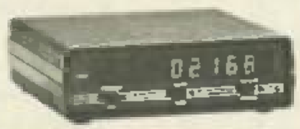

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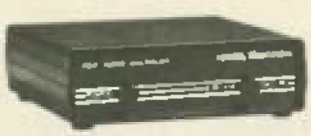

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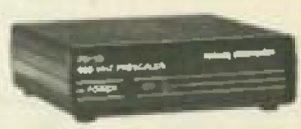

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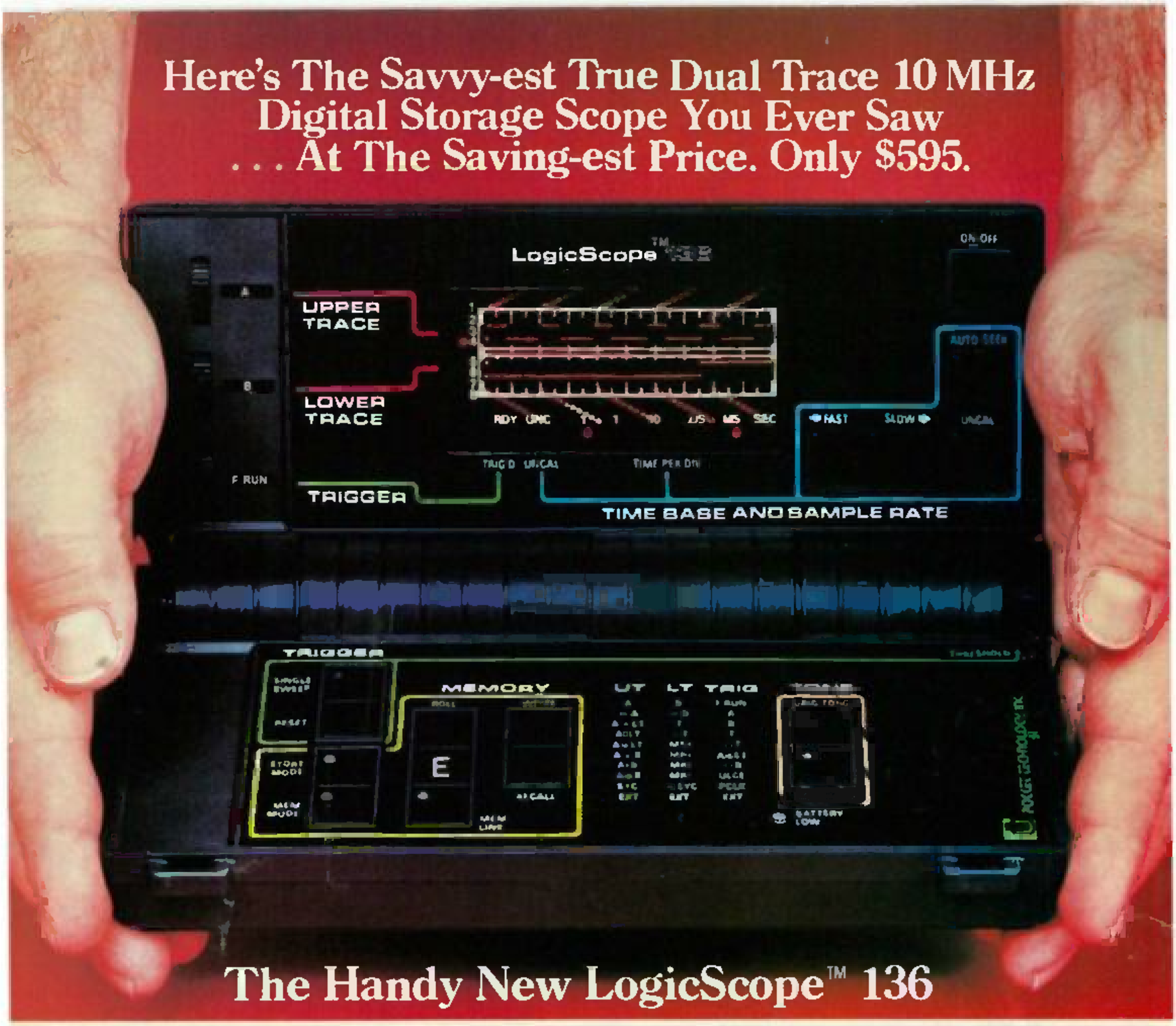

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