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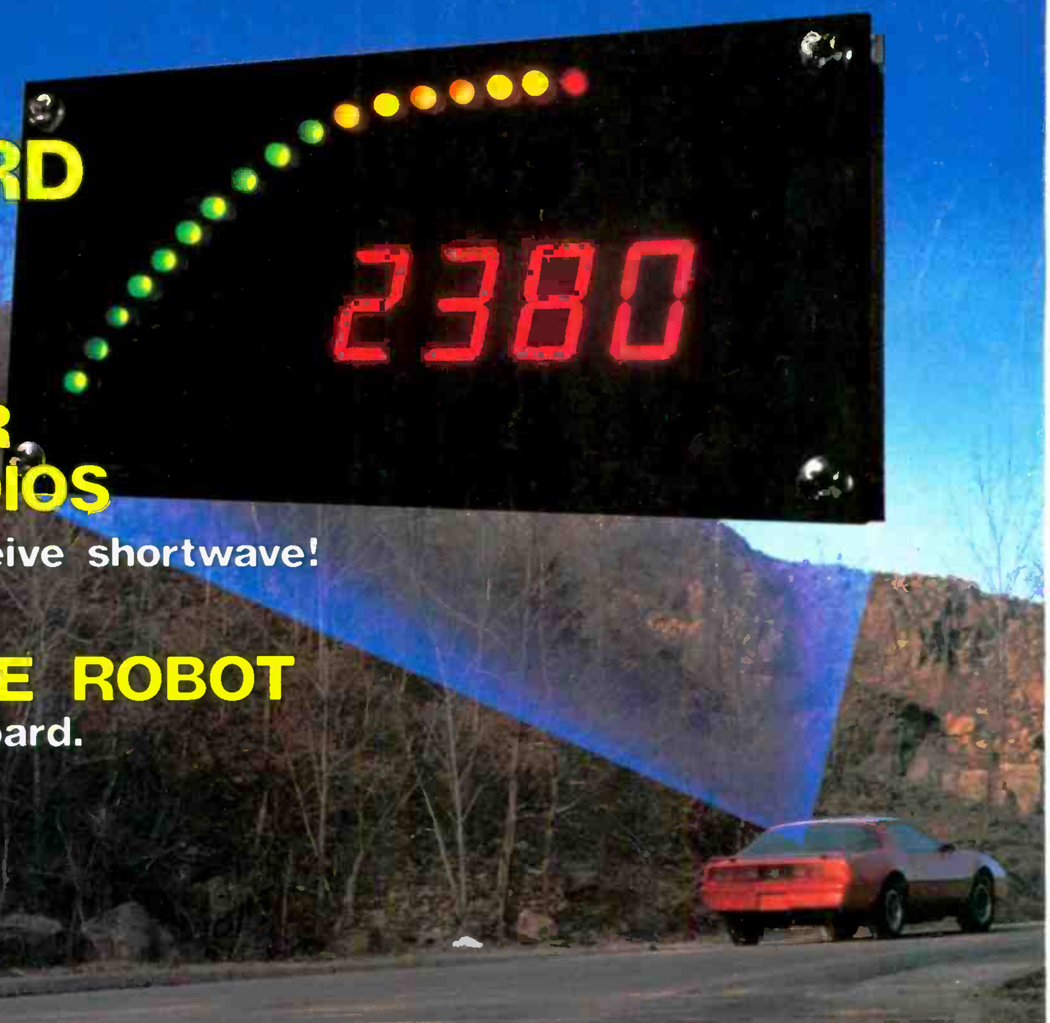

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Time Cursors	Yes	No
Voltmeter	Yes	No
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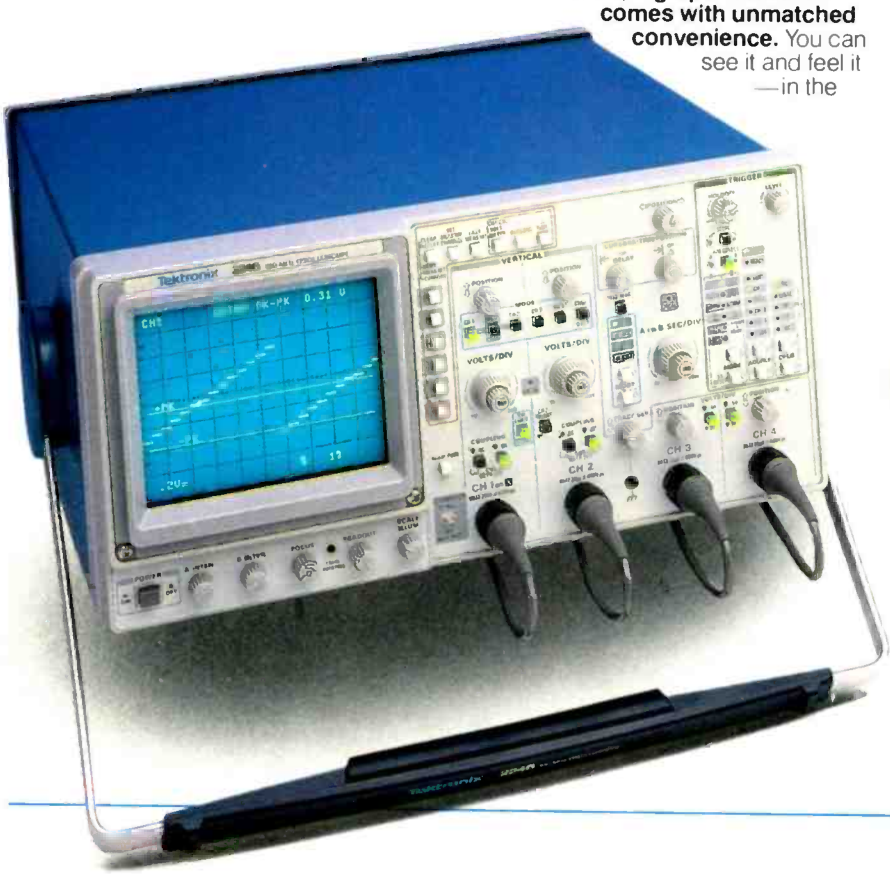
Max. Sweep Speed	2 ns/div	2 ns/div
Vert/Hor Accuracy	2%	2%
Trigger Modes	Auto Level, Auto, Norm, TV Field, TV Line, Single Sweep	
Trigger Level Readout	Yes	No
Weight	6.1 kg	6.1 kg
Warranty	3-year on parts and labor including CRT	
Price	$2400	$1875



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Vol. 58 No. 6

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DEPARTMENTS

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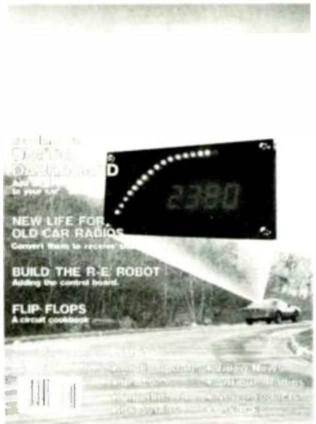

If you like to keep your car up to date no matter how old it is, then our cover project—a digital tachometer—is for you. Although the tach is a digital project and offers a digital display, it also offers an easy-to-read analog indication. It will work with 4-, 6-, and 8-cylinder engines, and can even be used for tuning your engine! Next month, we'll show you how to build a matching speedometer to really jazz up your dash board.

NEXT MONTH

THE JULY ISSUE IS ON SALE JUNE 4

SPECIAL SECTION ON CAR AUDIO
Overview of the newest equipment
Some example installations

BUILD A DIGITAL SPEEDOMETER FOR YOUR CAR
A high-tech dashboard for any car.

BUILD THE R-E ROBOT
A look at the robot control language.

THE STORY BEHIND CET
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COMPUTER DIGEST
Keyboards, keyboards, and keyboards!

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Advertising Sales Offices listed on page 124.

EDITORIAL

Why digital audio tape isn't here.

The biggest story—or should I say *non*-story—of the Winter Consumer Electronics Show was *D*igital *A*udio *T*ape or DAT. Several manufacturers—including Sony, Kenwood, Onkyo, and Mitsubishi—displayed prototype DAT players, and several more manufacturers—including TDK and 3M—displayed DAT tape. But the official word was that the units were prototypes only, and no marketing plans were in place.

Let's hope that following the Summer Consumer Electronics Show (which will be held from May 31 to June 3) we'll be able to announce the introduction of digital audio tape decks for consumer use. Why? Because DAT promises to do for audio tape what CD's have done for audio discs. And because the time—and the technology—is here to bring high-quality digital taping into the home.

Digital audio tapes are about half the size of a compact cassette, but slightly thicker. Yet a DAT cassette can provide two hours of recording time, and recording quality that rivals that of a compact disc. DAT cassettes are convenient: Digital codes stored on the tape permit relatively fast random addressing by program number. The cassettes are easy to handle, and the cartridge protects the tape from dust.

Unfortunately, the CD-player manufacturers and the recording industry don't want DAT, and they could kill the format before it even starts.

The manufacturers are afraid that DAT players would make consumers stop and think about whether they wanted to buy a CD player or a DAT machine—and perhaps buy nothing at all. The manufactures fear that the introduction of DAT now would severely damage the CD market—and perhaps even kill the format.

That's nonsense! Both digital formats have a place, and each has its benefits. Compact discs are durable, and players can access tracks rapidly, in a user-programmed order. Digital audio tapes are not as durable, but they are more portable, and are much easier to handle in an automobile. And, of course, they offer recording capability.

The recording industry is worried about something else: piracy. DAT's recording capability is just so good that a copy would be indistinguishable from the original. They fear the loss of CD sales—and of pre-recorded digital audio tapes.

The RIAA (*R*ecording *I*ndustry *A*ssociation of *A*merica) wants anti-taping IC's to be incorporated into the DAT machines to prevent home recording of commercially recorded material. (The IC's would detect a special signal incorporated into the original recording.)

That would be a misguided effort: Home taping has nothing to do with commercial piracy. Such anti-taping IC's would destroy the main purpose of DAT—to make home recordings. But they would not stop commerical piracy—only prosecution will. Because of the huge illicit profits involved, pirates will find ways to beat anti-taping devices. Undoubtedly, a black market would open up for home-deck conversions as well.

Home taping has become a consumer's right over the last 20 or thirty years. Recording a disc so you can conveniently listen to it in your car is transferring copyrighted material—which you bought the right to listen to—from one format to another. Making such format shifting illegal would be akin to selling recorded material for a specified number of listenings only, after which, you'd be violating a copyright.

Home cassette decks don't contain anti-taping IC's. Why should a new, superior technology be discriminated against? Doesn't it sound silly to prohibit DAT machines from recording just because they do a better job?

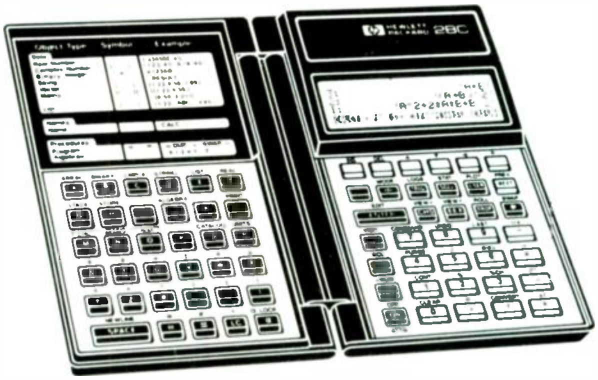
BRIAN C. FENTON
Managing Editor

The UnExpected HP-28C— is this your next calculator?

HEWLETT PACKARD

A first report:

If you're at all like me, this is what you've been holding your breath for (in the calculator direction, of course). Just a few years back, calculators were exciting. Maybe once a year there was a new model that could do startlingly more. Not recently, however.



Now here's the next tantalizing toy and technical tool. I haven't got room here to do it justice, there are so many interesting features and specs for it. I'll sketch it for you, though . . .

You'll have ON-SCREEN MENUS and SOFTKEYS, just like a PC—sensible access to hundreds of functions (128K ROM!) and high-level problem solving. Gamma function, random numbers, . . .

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You'll do no programming to get solutions, either—it will solve for any unknown variable anywhere in your equation.

It will convert between different unit systems, too. The values of 120 units are built-in, and you can add your own. Are you ready for all this right now? (I have them in stock).

You'll use SEPARATE KEYBOARDS, the right hand one for NUMBERS and the left for LETTERS. Later, you can fold it to pop into your shirt pocket.

You can plot graphs of your functions, even two at a time. Then place the cursor near where the graphs cross and press a key to calculate the x-value of the crossing, correct to 12 digits. I was amazed.

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Programmability—You can use all of the built-in functions with your own menus and softkeys, plus sophisticated utilities.

Binary Integer Operations. Decimal, octal, hexadecimal, and binary bases; arithmetic; variable wordsize; bit shift and rotate, byte shift and rotate, arithmetic shift; logical operators; floating-point/integer conversion.

Programming Features. User-defined functions, local variables, indefinite nesting and recursion, IF . . . THEN . . . ELSE, FOR . . . NEXT, DO . . . UNTIL, WHILE . . . REPEAT; halt, continue, abort, single-step, pause, read key, beep, display, error message, error number; set/clear/test 64 user flags; conditionals, logical operators; object type.

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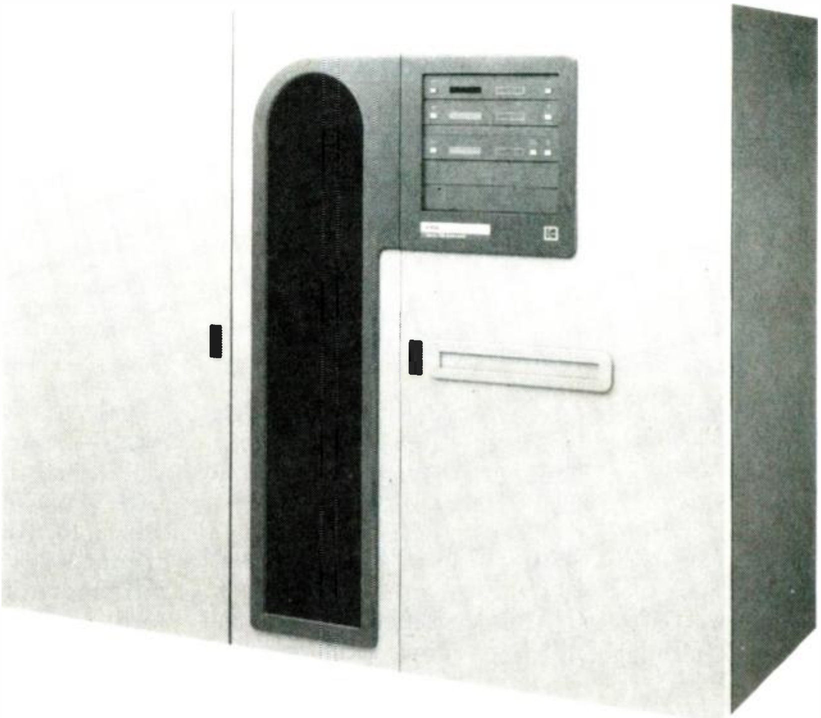
WHAT'S NEWS

Kodak introduces high-capacity, high-speed optical-disc system

Eastman Kodak, long known for its leadership in the field of photography, is dramatically increasing its presence in the information-technology field with the introduction of an advanced optical-disc information storage and retrieval system. The *6800* optical-disc system is a high-capacity data storage and retrieval system that uses Kodak's new 14-inch write-once/read-many-times optical discs. Each disc offers a capacity of 6.8 gigabytes of random-access on-line storage. The basic *6800* library unit consists of a single drive, controller, and 50 optical discs with robotic retrieval equipment in an environmentally controlled cabinet (a mini "clean room"). Three optional add-on units give the user the ability to increase the disc hardware and software capacity to up to 150 discs. At its maximum configuration, the system offers a total storage capacity of one terabyte (one trillion bytes). For example, that is more than enough capacity to store 12 years of records of X-rays, CAT scans, and ultrasound examinations for a 250-bed hospital. Retrieval time for the system is 12 seconds or less.



THE KODAK *6800* OPTICAL DISC SYSTEM is shown here with an optional add-on unit (left) attached.

Kodak's Mass Memory Division will market the *6800* system on a limited basis in late 1987, and in quantity in 1988. It will not be sold directly to end users. "We will work through computer companies, original equipment manufacturers, and others, including business divisions within Kodak," says Frank Strong, group vice president and general manager of Kodak's Diversified Technologies. "These companies will integrate their equipment with ours and market specific products to end users."

One such integrator will be Kodak's own Business Imaging System, which will integrate the 14-inch optical discs into their line of *KIMS* systems. Such system are not inexpensive, however, with one, the *KIMS 5000*, expected to cost in the neighborhood of $700,000. Less ambitious *KIMS* systems will start at about $150,000.

Descramblers and the law

The Cable Home Group of General Instrument, manufacturer of the *VideoCipher* scrambling system, instituted a civil suit last March against Network, Inc., of Piscataway, NJ; Robert Cooper, Jr., well known to readers of this magazine; Dr. Stephen Bepko of Baltimore, and Karen Howes and Shaun Kenney of the *Boresight* satellite program. The suit charges them with distributing illegal descrambling IC's at a "Descrambling Summit" trade meeting held in the British West Indies, and seeks damages including $5 million in "punitive damages" from the defendants.

Two of the defendants, Howes and Kenny, appear in a weekly television program distributed by satellite. *Boresight* is a 60-minute report on activities in the home dish industry, and has—as a matter of viewer information—listed sources outside the United States for *VideoCipher* IC's.

Dr. Bepko is an electronics engineer who appeared as a lecturer at the summit. Cooper, the publisher of Coop's Satellite Digest and a **Radio-Electronics** contributing editor, was the organizer of the meeting, which was held on the island of Providenciales. **R-E**

VIDEO NEWS

• **Kiddie camcorder.** We've seen all kinds of new VCR formats lately—8mm, Super VHS, 4mm, etc.—so why not a VCR that uses a standard audio cassette? That presumably is what Fisher-Price, the toy company, thought when it decided to introduce what it hopes will be next year's hottest Christmas gift for kids—a complete camcorder for less than $150. *Pixelvision* records 11 minutes (5½ minutes per side) of black-and-white video on a C-90 audio cassette. The one-piece unit contains a low-cost fixed-focus video camera and a record and playback deck that will run for five hours on six AA-size alkaline batteries. The entire package, including tape and batteries, weighs two pounds.

The secret behind the unit is that it uses a stationary head and lays down a longitudinal recording track; conventional decks use heads mounted on a revolving drum and lay down a helical track. The tape is recorded at a high speed, virtually equivalent to the fast-forward speed of an audio tape recorder.

Interestingly, Fisher-Price's recording method harks back to the earliest efforts to develop a videotape recorder, back in the 1940's and 1950's. Those early attempts were unsuccessful. But presumably a fixed-head recorder is practical today because of advances in head design, although Fisher-Price currently isn't giving out any technical details on *Pixelvision*.

• **RCA Labs changes hands.** The David Sarnoff Research Center, informally known as "RCA Labs," isn't RCA Labs any more. The nation's leading electronics research organization has been donated as a gift to SRI International by General Electric, which is RCA's new owner.

The Sarnoff Center, in Princeton, NJ, was founded in 1941 to bring together research efforts scattered around RCA's various operations. It was a prime mover in the development of U.S. black-and-white and color television, stereo, injection lasers, high-speed computer memories, and videodiscs.

SRI International, formerly Stanford Research Institute, was originally part of Stanford University, but now is an independent research organization with headquarters in Menlo Park, CA. GE donated the Sarnoff Center to SRI because GE has its own research and development operations, and much of the work would be redundant. To get the newly independent lab off to a good start, GE plans to fund about $250 million in research, much of it in consumer electronics, over the next five years.

• **Super VHS specifications.** Although relatively little still is known about Super VHS, the JVC-developed home-VCR format that can record and play back a picture of better-than-broadcast quality (**Radio-Electronics**, May 1987), JVC has released some specifications for the new system. Super VHS is capable of recording a signal with a horizontal resolution of better than 400 lines. It uses high-band circuitry with a carrier shift of 2.6 MHz in white-peak frequency; white-peak frequency is 7 MHz, as opposed to 4.4 MHz in standard VHS.

Outlining the recording method, JVC says: "Although Super VHS will use the same frequency-modulated recording method used in the conventional VHS format for luminance-signal recording, the FM frequency range has been changed from the conventional format's 3.4–4.4 MHz to 5.4–7 MHz. Frequency deviation has been changed from conventional VHS's 1 MHz to 1.6 MHz. To achieve overall high picture quality for video output signals, separated Y (luminance) and C (chrominance) signals are used in addition to NTSC signals currently used in order to eliminate interference between luminance and chrominance signals."

The tape used for Super VHS is coated with a cobalt-doped oxide and has a coercivity of 850 to 900 oersteds, as opposed to about 750 oersteds for the best standard VHS tapes. A special notch in the cassette tells the recorder that Super VHS tape is being used. The Super-VHS format will be used for camcorders as well as home decks, according to JVC, but only when sufficiently high-resolution pickup devices are available, so that the advantages of the new format may be applied to home-movie making.

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AIR IONIZERS

I've heard a lot about air ionizers and am wondering how effective they really are. What can you tell me?—T.L., Hamilton, OH.

Experience tells me to stay out of this one. Probably more arguments start with the discussion of air ionizers and positive and negative ions than on "the direction of current flow." But I'll try and give you an answer without putting my foot in my mouth.

Research on ionized air and its effects on humans, animals, and plants has been going on since the middle 1930's. Here are some of the "findings" and opinions:

- The concentration of ions in the air does have a pronounced effect on animals and plants. Also, the polarity of ionization has a distinct effect on life.
- Ion depletion is said to cause depression, mental fatigue, headaches, and respiratory problems in man, and has been shown to reduce the survival rate of animals.
- Increasing ion concentration promotes healing, relieves the pain of burns, and promotes plant growth.
- High concentrations of *negative* ions seem to promote mental agility and alertness and, over the long term, greatly reduce employee-days-lost due to respiratory illnesses.
- Positively charged ions tend to promote hostility and aggressiveness while negative ions promote tranquility.
- Atmospheric pollution in cities and industrial areas tends to promote a drastic depletion in air-ion concentration and to increase the critical positive-to-negative air-ion ratio. Perhaps that explains why

suburbanites—breathing the clean country air—escape some of the health and mental problems suffered by city dwellers.

SCA DECODER

I am modernizing my old tube-type FM receiver and would like to add a solid-state SCA decoder so I can receive the programs that some FM stations transmit on a 67-kHz subcarrier. Can you provide an appropriate circuit?—J.C.M., Baldwin, NY.

I have found that replacing a high-performance vacuum-tube circuit with a solid-state version does not always ensure equal or superior operation. It should be done only when no alternatives are available. However, putting together a tube-type SCA circuit is impractical because of its high component count. Instead, use a solid-state circuit like the one shown in Fig. 1. That circuit uses a Signetics NE565 PLL (*P*hase-*L*ocked *L*oop) as a detector to recover the SCA signal; the circuit is taken from that company's data sheet for the device. The input to the SCA decoder circuit is connected to an FM receiver at a point between the FM discriminator and the de-emphasis filter network.

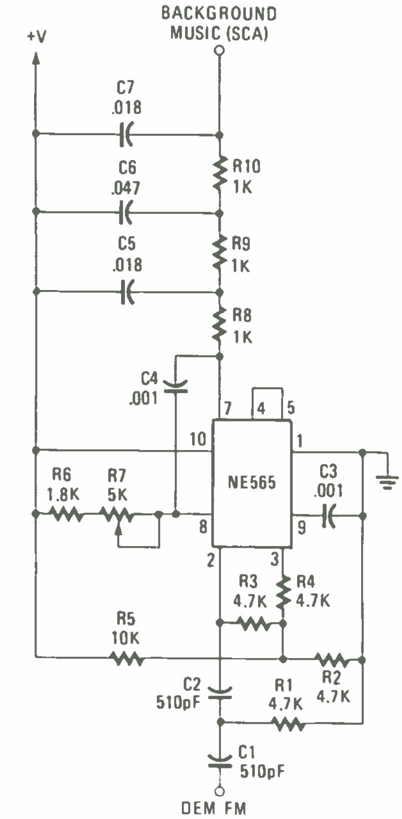

FIG. 1

The early tube-type SCA decoders that I'm familiar with have several resonant circuits that must be tuned and aligned. Since resonant circuits are not used in the circuit shown in Fig. 1 there will be some slight spill from a stereo station's main channel. The PLL, IC1, is tuned to 67 kHz by R7, a 5K potentiometer. Tuning need not be exact since the circuit will seek and lock onto the subcarrier.

The demodulated signal from the FM receiver is fed to the input of the 565 through a high-pass filter consisting of two 510-pF capacitors (C1 and C2) and a 4.7K resistor (R1). Its purpose is to serve as a coupling network and to attenuate some of the main-channel spill. The demodulated SCA signal at pin 7 passes through a three-stage de-emphasis network as shown. The resulting signal is around 50 mV, with the response extending to around 7 kHz. **R-E**

LETTERS

THE POLAPULSE BATTERY

The article, "Using the Polapulse Battery," by Fred Blechman in the February 1987 **Radio-Electronics** was well-written, and the many unique properties of the Polaroid battery line were described very well. There were, however, a few small errors that we would like to correct.

The first paragraph should state that the P500 battery gives 100 mA for 12 hours, not 20 hours. The P70 battery was developed for use in the original SX-70 film. The 600 film pack, which usually must power an electronic flash as well as the camera, uses the new higher-power P80, as described correctly. The special contact described in the article is available from us, but only in minimum lots of 100 pieces. Under carefully controlled conditions only, the P100 battery has been successfully recharged; but under no circumstances should the P500 battery be charged.

Ameritoy has new address: 6039 West Washington Blvd., Culver City, CA 90232. Exergen has moved to 251 W. Central St., Natick, MA 01760; Sinclair no longer sells the P500 batteries at a loss, and a limited number of their TV sets are still available from A+ Computer Response, 69B Island St., Keene, NH 03431.

The article did not mention the Polaroid Safety Flasher, a compact amber flashing light that weighs just 4 oz., but which can be seen for over a mile, and runs over 4 hours on one P100 battery. Those are distributed by Consumer Products Source, 881 Dover Drive,

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12-Band, 75 Channel • Crystalless • AC/DC

Frequency range: 29-54, 118-175, 406-512, 806-950 MHz.

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Regency® Z60-MA

List price $299.95/CE price $184.95/SPECIAL

8-Band, 60 Channel • No-crystal scanner

Bands: 30-50, 88-108, 118-136, 144-174, 440-512 MHz

The *Regency* Z60 covers all the public service bands plus aircraft and FM music for a total of eight bands. The Z60 also features an alarm clock and priority control as well as AC/DC operation. Order today.

Regency® Z45-MA

List price $259.95/CE price $159.95/SPECIAL

7-Band, 45 Channel • No-crystal scanner

Bands: 30-50, 118-136, 144-174, 440-512 MHz

The *Regency* Z45 is very similar to the Z60 model listed above however it does not have the commercial FM broadcast band. The Z45, now at a special price from Communications Electronics.

Regency® RH250B-MA

List price $699.95/CE price $329.95/SPECIAL

10 Channel • 25 Watt Transceiver • Priority

The *Regency* RH250B is a ten-channel VHF land mobile transceiver designed to cover any frequency between 150 to 162 MHz. Since this radio is synthesized, no expensive crystals are needed to store up to ten frequencies without battery backup. All radios come with CTCSS tone and scanning capabilities. A monitor and night/day switch is also standard. This transceiver even has a priority function. The RH250 makes an ideal radio for any police or fire department volunteer because of its low cost and high performance. A *60 Watt* VHF 150-162 MHz. version called the **RH600B-MA** is available for $439.95. A UHF 15 watt version of this radio called the **RU150B-MA** is also available and covers 450-482 MHz. but the cost is $439.95.

Bearcat® 50XL-MA

List price $199.95/CE price $114.95/SPECIAL

10-Band, 10 Channel • Handheld scanner

Bands: 29.7-54, 136-174, 406-512 MHz

The *Uniden Bearcat* 50XL is an economical, handheld scanner with 10 channels covering ten frequency bands. It features a keyboard lock switch to prevent accidental entry and more. Also order the new double-long life rechargeable battery pack part # **BP55** for $29.95, a plug-in wall charger, part # **AD100** for $14.95, a carrying case part # **VC001** for $14.95 and also order optional cigarette lighter cable part # **PS001** for $14.95.

NEW! Scanner Frequency Listings

The new Fox scanner frequency directories will help you find all the action your scanner can listen to. These new listings include police, fire, ambulances & rescue squads, local government, private police agencies, hospitals, emergency medical channels, news media, forestry radio service, railroads, weather stations, radio common carriers, AT&T mobile telephone, utility companies, general mobile radio service, marine radio service, taxi cab companies, tow truck companies, trucking companies, business repeaters, business radio (simplex) federal government, funeral directors, veterinarians, buses, aircraft, space satellites, amateur radio, broadcasters and more. Fox frequency listings feature call letter cross reference as well as alphabetical listing by licensee name, police codes and signals. These Fox directories are $14.95 each plus $3.00 shipping. State of Alaska-**RL019-1**, State of Arizona-**RL025-1**, Buffalo, NY/ Erie, PA-**RL009-2**, Chicago, IL-**RL014-1**; Cincinnati/ Dayton, OH-**RL006-2**, Cleveland, OH-**RL017-1**, Columbus, OH-**RL003-2**, Dallas/Ft Worth, TX-**RL013-1**, Denver/Colorado Springs, CO-**RL027-1**, Detroit, MI/ Windsor, ON-**RL008-2** Fort Wayne, IN/Lima, OH- **RL001-1**, Hawaii/Guam-**RL015-1**, Indianapolis, IN-**RL022-1**, Kansas City, MO/ KS-**RL011-2**, Long Island, NY-**RL026-1**, Louisville/Lexington, KY-**RL007-1**, Milwaukee, WI/Waukegan, IL-**RL021-1**, Minneapolis/St Paul, MN-**RL010-2**, Nevada/E Central CA-**RL028-1**, Oklahoma City/ Lawton, OK-**RL005-2**, Orlando/Daytona Beach, FL-**RL012-1**, Rochester/Syracuse, NY-**RL020-1** San Diego, CA-**RL018-1**, Tampa/St Petersburg, FL- **RL004-2**; Toledo, OH-**RL002-3**. Regional directories which cover police, fire ambulance & rescue squads, local government, forestry, marine radio, mobile phone, aircraft and NOAA weather are available for $19.95 each **RD001-1** covers AL, AR, FL, GA, LA, MS, NC, PR, SC, TN & VI **RD002-1** covers IL, IN, KY, MI, OH & WI. For an area not shown above call Fox at 800-543-7892 or in Ohio 800-621-2513

Regency® HX1500-MA

List price $369.95/CE price $218.95

11-Band, 55 Channel • Handheld/Portable Search • Lockout • Priority • Bank Select Sidelit liquid crystal display • EAROM Memory Direct Channel Access Feature • Scan delay

Bands 29-54, 118-136, 144-174, 406-420, 440-512 MHz

The new handheld *Regency* HX1500 scanner is fully keyboard programmable for the ultimate in versatility. You can scan up to 55 channels at the same time including the AM aircraft band. The LCD display is even sidelit for night use. Includes belt clip, flexible antenna and earphone. Operates on 8 1.2 Volt rechargeable Ni-cad batteries (not included). Be sure to order batteries and battery charger from the accessory list in this ad.

Bearcat® 100XL-MA

List price $349.95/CE price $178.95/SPECIAL

9-Band, 16 Channel • Priority • Scan Delay Search • Limit • Hold • Lockout • AC/DC

Frequency range 30-50, 118-174, 406-512 MHz

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

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★★★ FREE DURACELL' Batteries Included ★★★

★★★★ Free local frequency directories ★★★★

Save even more with this special coupon. As long as your order is **prepaid by money order**, you'll get extra special pricing on items listed in this coupon. In addition, if you order a *Bearcat* 50XL or *Regency* HX1500 scanner with this coupon, you'll get a free set of *Duracell* batteries which we recommend for best performance. If you buy a *Regency* Z60 or Z45 scanner using this coupon, you'll get a free Fox frequency directory worth $14.95. This coupon must be included with your *prepaid* order. *Credit cards and quantity discounts are excluded from this offer.* Offer valid only on prepaid orders mailed directly to Communications Electronics Inc., P.O. Box 1045 - Dept. M3, Ann Arbor, Michigan 48106-1045 U.S.A. Coupon expires July 31, 1987. Coupon may not be used in conjunction with any other offer from Communications Electronics Inc. Be sure to add shipping & handling fees listed in this ad (add $3.00 for shipping free books or batteries).

RH250B-M3 *Regency* 25 W. VHF Transceiver	$299.95
RH600B-M3 *Regency* 60 W. VHF Transceiver	$388.95
RU150B-M3 *Regency* 15 W. UHF Transceiver	$399.95
UC102-M3 *Regency* 1 W. VHF 2 channel trans	$119.95
HX1500-M3 *Regency* 55 channel scanner	$217.95
Z60-M3 *Regency* 60 channel scanner	$158.95
Z45-M3 *Regency* 45 channel scanner	$148.95
BC100XL-M3 *Bearcat* 16 channel scanner	$177.95
BC800XLT-M3 *Bearcat* 40 channel scanner	$278.95
INF1-M3 *Regency* Informant scanner	$249.95
BC210XW-M3 *Bearcat* 20 channel scanner	$168.95
BC50XL-M3 *Bearcat* 10 channel scanner	$113.95
RD55-M3 *Uniden* Radar Detector	$97.95

★★★ SPECIAL SAVINGS COUPON ★★★

Bearcat® 800XLT-MA

List price $499.95/CE price $289.95/SPECIAL

12-Band, 40 Channel • No-crystal scanner Priority control • Search/Scan • AC/DC

Bands 29-54, 118-174, 406-512, 806-912 MHz.

The Uniden 800XLT receives 40 channels in two banks. Scans 15 channels per second. Size 9¼" x 4½" x 12½."

OTHER RADIOS AND ACCESSORIES

Panasonic RF-2600-MA Shortwave receiver	$179.95
RD55-MA *Uniden* Visor mount Radar Detector	$98.95
***NEW!* BC70XLT-MA** *Bearcat* 20 channel scanner	$169.95
BC 145XL-MA *Bearcat* 16 channel scanner	$98.95
BC 140-MA *Bearcat* 10 channel scanner	$89.95
BC 210XW-MA *Bearcat* 20 channel scanner	$169.95
BC-WA-MA *Bearcat* Weather Alert™	$38.95
PC22-MA *Uniden* remote mount CB transceiver	$99.95
PC55-MA *Uniden* mobile mount CB transceiver	$59.95
***NEW!* R1080-MA** *Regency* 30 channel scanner	$118.95
***NEW!* R1090-MA** *Regency* 45 channel scanner	$148.95
***NEW!* INF1-MA** *Regency* Informant scanner	$289.95
UC102-MA *Regency* VHF 2 ch. 1 Watt transceiver	$124.95
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MA518-MA Wall charger for HX1500 scanner	$14.95
MA553-MA Carrying case for HX1500 scanner	$19.95
MA257-MA Cigarette lighter cord for HX12/1500	$19.95
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SMMX7000-MA Svc. man. for MX7000 & MX5000	$19.95
B-4-MA 1.2 V AAA Ni-Cad batteries (set of four)	$9.95
B-8-MA 1.2 V AA Ni-Cad batteries (set of eight)	$17.95
FB-E-MA Frequency Directory for Eastern U.S.A.	$14.95
FB-W-MA Frequency Directory for Western U.S.A.	$14.95
ASD-MA Air Scan Directory	$14.95
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TIC-MA Techniques for Intercepting Comm.	$14.95
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USAK-MA ¾" hole mount VHF/UHF ant. w/ 17' cable	$35.95
USATLM-MA Trunk lip mount VHF/UHF antenna	$35.95

Add $3.00 shipping for all *accessories* ordered at the same time.
Add $12.00 shipping per shortwave receiver.
Add $7.00 shipping per scanner and $3.00 per antenna.

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CIRCLE 79 ON FREE INFORMATION CARD

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MODEL TS-2

MODEL HX 1500

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New NRI home training prepares you for a rewarding career in America's newest high-technology field.

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Keeping this robot army running calls for well-trained technicians . . . people who understand advanced systems and controls. By the end of the decade, conservative estimates call for more than 25,000 new technical jobs. These are the kind of careers that pay $25,000 to $35,000 a year right now. And as demand continues to grow, salaries have no place to go but up!

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Now, you can train for an exciting, rewarding career in robotics and industrial control right at home in your spare time. NRI, with 70 years of experience in technology training, offers a new world of opportunity in one of the most fascinating growth fields since the computer.

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Designed expecially for training, your robot duplicates all the key elements of industrial robotics. You learn to operate, program, service, and troubleshoot using the same techniques you'll use in the field. It's on-the-job training at home!

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Building this exciting robot will take you beyond the state of the art into the next generation of industrial robotics.

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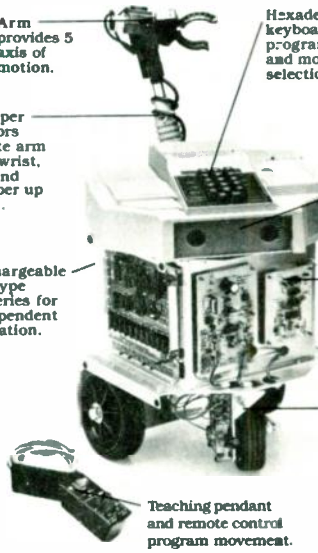

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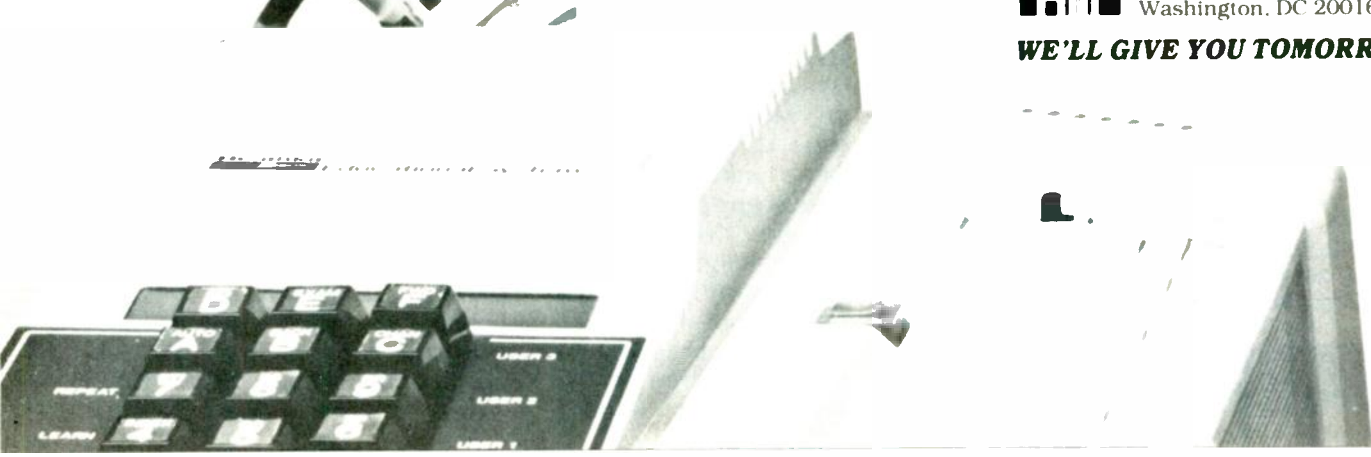


Suite 14, Newport Beach, CA 19663.

The model rockets mentioned in the article are made by Estes Industries, Highway 50 West, Penrose, CO 81240, and use the P100 in their launcher to provide a sudden high-current surge to ignite the chemical engine. The battery is also being used in medical applications, ranging from the cardiac monitor in magnetic resonance imaging, to a portable defibrillator, to hospital thermometers.

Small quantities of the P100 and P500 batteries are available from Time Craft Industries, 1300 Galaxy Way, Concord, CA 94520. (In California, call 1-800-642-0232; those outside of California, should call 1-800-227-2480.)
FRED COHEN
PowerCard Corporation

TESLA, FATHER OF RADIO

I have followed with interest **Radio-Electronics'** "Antique Radios" column, but I was disappointed with the treatment of Tesla in the installment that appeared in the March issue. Far from being among the inventors "who worked with electricity, but were not involved with wireless," Yugoslav-born Nikola Tesla, as early as his lecture at the Franklin Institute, in Philadelphia, in March, 1893, suggested a system consisting of "an electrical oscillator, or source of alternating current," one of the terminals of which would connect to Earth, the other to "an insulated body of large surface." That, he thought, might be used to transmit "intelligence, or perhaps even power, to any distance....I am firmly convinced that this can be done and hope that we shall live to see it done."

Tesla continued, taking out several patents, and in 1899 gave a demonstration of radio remote control in Madison Square Garden, New York City. Model boats in a large tank were started, steered, and stopped by radio waves from a short distance.

If that is so, why then isn't Tesla hailed as the inventor of radio? Hugo Gernsback had the answer. In his article "Nikola Tesla, the Father of Wireless," written on the occasion of Tesla's death, (January 7, 1943) he says:

"By 1900 Tesla had patented a wireless system, much of which was used later to make commercial wireless possible....These very means were used much later by Marconi and others who appropriated Tesla's ideas.

"Tesla in due time brought suit against Marconi, but could not establish his patent rights in court and blamed his failure on the paucity of technical knowledge of the times, of the lawyers and the court. When, many years later, his language had become clear, even to a mediocre technician, his patents had run out. Nevertheless, there would have been no wireless transmission without Tesla's fundamental work."

Gernsback did not know it, but at that very time, proceedings that would rectify the injustice were under way. On June 21, 1943, the Supreme Court disallowed Marconi's fundamental patent, on the basis of "earlier work by Tesla" and others. It's a true pity that Tesla did not live six more months!

Not only did Tesla outline the concepts—he was active in developing the instruments used in practical work. He devised the rotary spark gap and was the inventor of the oscillating arc, later adapted and used by de Forest for phone and in much marine telegraphy. He pioneered the high-frequency generator, used by Fessenden in the first telephone broadcast, and which became the standard high-power transmitter until it was superseded by tubes in the 1920's.
FRED SHUNAMAN(former Editor, **Radio-Electronics**)

ENERGY STORAGE IN 2001

Here's an addendum to my article, "Energy Technology in the 21st Century," which began on page 107 of the May 1987 issue of **Radio-Electronics**:

Recently, a new superconducting oxide material has been discovered by two university research teams. That material maintains zero electrical resistance at temperatures as "high" as −150°F; contrast that with the maximum superconducting temperature of niobium-tin wire, which is −450°F,
continued on page 29

EQUIPMENT REPORTS

Leader LCD-100 Portable DMM/Storage Oscilloscope

CIRCLE 9 ON FREE INFORMATION CARD

Here's a 200-kHz digital storage scope you can (almost) fit in your pocket.

HAVE YOU EVER WISHED FOR A COMPACT AND PORTABLE TEST instrument that combined the features of a digital multimeter with those of a storage oscilloscope yet weighed only about two pounds? Probably not—it sounds too good to be true. But Leader Instruments Corporation (380 Oser Avenue, Hauppauge, NY 11788) has developed just such an instrument: their *LCD-100*.

Not everyone needs an oscilloscope that can be held comfortably in the palm of his hand. But if portability is important to you, the *LCD-100* is worth looking at. When you first see it, you'll be tempted to say, "Gee, that's *cute!*" But when you look more closely, you'll be impressed by what it can do.

Basic specifications

The scope has a bandwidth of 200 kHz, a vertical sensitivity of 10 millivolts/div, and a rated accuracy of ±4%. Its multimeter section offers autoranging measurements of resistance, voltage, and current. The input impedance is 1 megohm.

The oscilloscope display is a 64 × 192-pixel dot matrix LCD. The settings of the scope's controls are

. . .Challenge Continued

highway with engineers and equipment to verify the results.

And oh yes, we'll have the $20,000 check (pictured) to hand over if you beat us by more than 10 feet in either X or K band detection with the Escort, or by 2 seconds at 55mph with the Passport.

BOB SAYS MAXON IS BETTER

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

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

So, since I've never been one to be in second place, I said, "Would you bet $20,000 that you can beat Escort?" And, as they say, the rest is history.

By the way, Bob is about 6'9" tall, so if we can't beat Escort, we can sure scare the you know what out of them. But, Bob and his engineers are deadly serious about this 'duel'. And you can bet that our $20,000 is serious.

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

3) The same car be used in both tests. 4) We'd like an answer from Escort no later than July 31, 1987 and 60 days notice of the time and place of the conflict. 5) If Escort can prove that there are 1,000, or even 500 Rashid units in operation, we will present them with the appropriate $10,000 or $5,000 check at the beginning of the conflict. And, 6) We'd like them to come with a $20,000 check made out to DAK if we win.

HOW'S THIS FOR FAIR

Cincinnati Microwave will be deemed the winner and given the check if **either** Escort beats Maxon by 10 feet in both uninterrupted and initial alerts, **OR** if Passport beats Maxon by 2 seconds at 55mph in both uninterrupted and initial alerts. So, DAK wins **only** if we beat both Escort and Passport.

A tie will exist only if **both** the $295 Passport and $245 Escort fail to beat Maxon's $99⁹⁰ Dual Superheterodyne RD-1 Radar Detector.

SO, WHAT'S DUAL SUPERHETERODYNE?

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

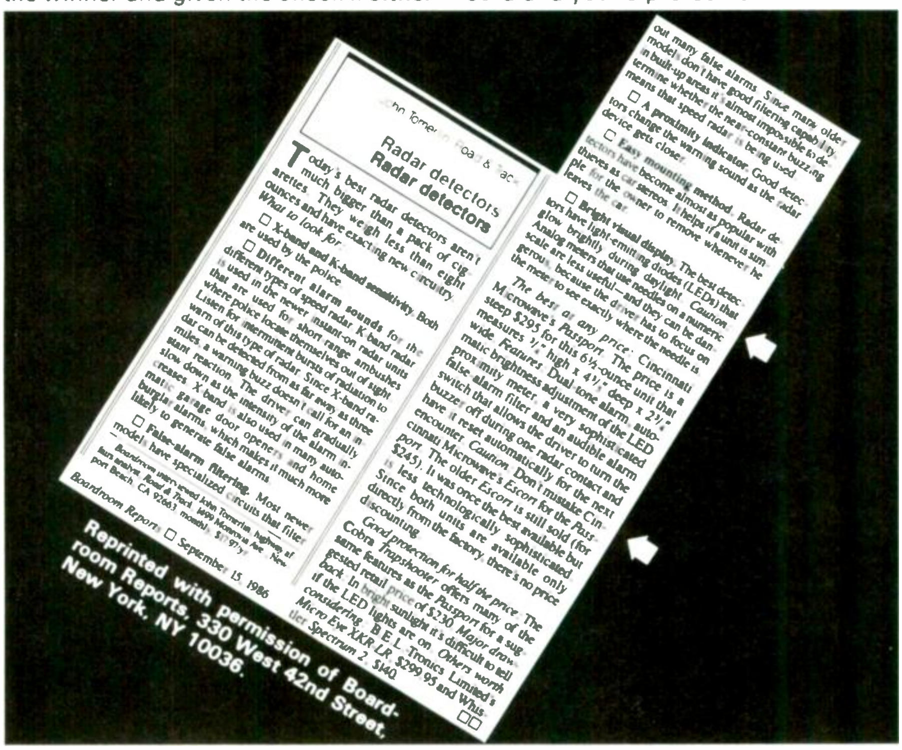
It's a technology that tests each suspected radar signal 4 separate times before it notifies you, and yet it explodes into action in just 1/4 of one second.

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

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

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

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



John Tomerlin, Road & Track

Radar detectors

Today's best radar detectors aren't much bigger than a pack of cigarettes. They weigh less than eight ounces and have exacting new circuitry. What to look for:

☐ **X-band and K-band sensitivity.** Both are used by the police.

☐ **Different alarm sounds** for the different types of speed radar. K-band radar is used in the newer instant-on radar units that are used for short range ambushes where police locate themselves out of sight. Listen for intermittent bursts of radiation to warn of this type of radar. Since X-band radar can be detected from as far away as three miles, a warning buzz doesn't call for an instant reaction. The driver can gradually slow down as the intensity of the alarm increases. X-band is also used in many automatic garage door openers and home burglar alarms, which makes it much more likely to generate false alarms.

☐ **False-alarm filtering.** Most newer models have specialized circuits that filter out many false alarms. Since many older models don't have good filtering capability in built-up areas it's almost impossible to determine whether the near-constant buzzing means that speed radar is being used.

☐ **A proximity indicator.** Good detectors change the warning sound as the radar device gets closer.

☐ **Easy mounting method.** Radar detectors have become almost as popular with thieves as car stereos. It helps if a unit is simple for the owner to remove whenever he leaves the car.

☐ **Bright visual display.** The best detectors have light-emitting diodes (LEDs) that glow brightly during daylight. Caution: Analog meters that use needles on a numeric scale are less useful—and they can be dangerous, because the driver has to focus on the meter to see exactly where the needle is.

The best at any price: Cincinnati Microwave's *Passport.* The price is a steep $295 for this 6½-ounce unit that measures ¾" high x 4½" deep x 2¾" wide. *Features:* Dual-tone alarm, automatic brightness adjustment of the LED proximity meter, a very sophisticated false-alarm filter and an audible alarm switch that allows the driver to turn the buzzer off during one radar contact and have it reset automatically for the next encounter. *Caution:* Don't mistake Cincinnati Microwave's *Escort* for the *Passport.* The older *Escort* is still sold (for $245). It was once the best available but is less technologically sophisticated. Since both units are available only directly from the factory, there's no price discounting.

Good protection for half the price: The Cobra *Trapshooter* offers many of the same features as the *Passport* for a suggested retail price of $230. *Major drawback:* In bright sunlight it's difficult to tell if the LED lights are on. *Others worth considering:* B.E.L.-Tronics Limited's *Micro Eye XKR LR,* $299.95 and Whistler *Spectrum 2,* $140. ☐☐

Boardroom interviewed John Tomerlin, highway affairs analyst, *Road & Track,* 1499 Monrovia Ave., Newport Beach, CA 92663, monthly, $17.97/yr.

Boardroom Reports ☐ September 15, 1986

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

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

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

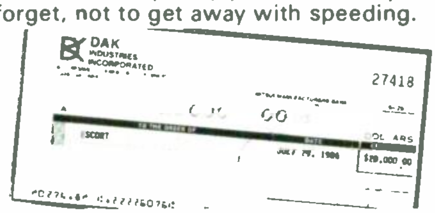
So, when the lights and X or K band sounds explode into action, take care, there's very likely police radar nearby. You'll have full volume control, and a City/Highway button reduces the less important X band reception in the city.

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

It's much smaller than Escort at just 3½" Wide, 4¾" deep and 1½" high. But, it is larger than Passport. It's backed by Maxon's standard limited warranty.

Note from Drew: 1) Use of radar detectors is illegal in some states.

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



CHECK OUT RADAR YOURSELF RISK FREE

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

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

To get your Maxon, Dual Superheterodyne, Anti-Falsing Radar Detector risk free with your credit card, call toll free or send your check for just **$99⁹⁰** ($4 P&H). Order No. 4407. CA res add tax.

Special Note: Now that we're challenging Passport, we've added an optional suction cup windshield mount and extra coiled power cord. (Sorry we can't afford to throw them in for free.) They're just **$5⁹⁰** ($1 P&H) Or. No. 4800.

OK Escort, it's up to you. We've got $20,000 that says you can't beat Maxon on the road. Your answer, please?

Escort and Passport are registered trademarks of Cincinnati Microwave. Rashid VRSS and Rashid Radar Safety Brake are registered trademarks of Vehicle Radar Safety Systems, Inc.

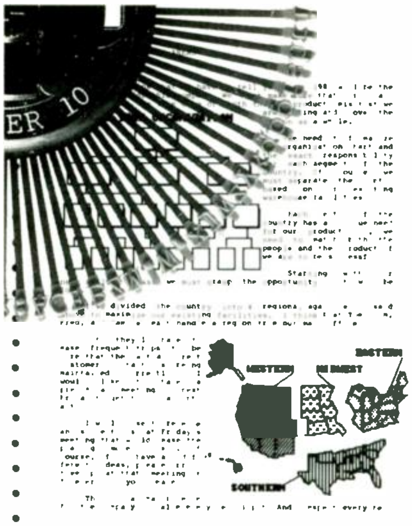
DAK INDUSTRIES INC.

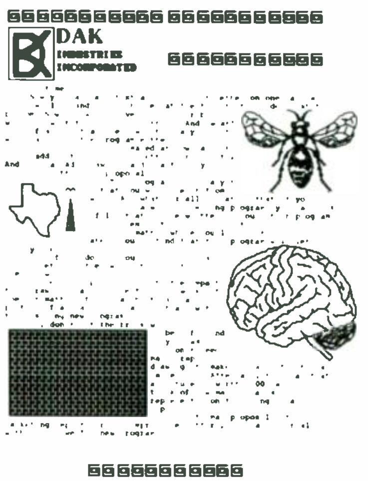
Call Toll Free For Credit Card Orders Only
24 Hours A Day 7 Days A Week

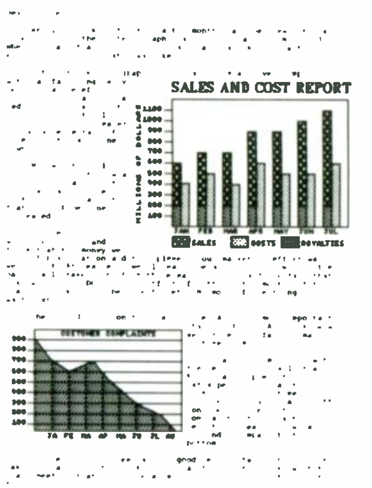
RE64 **1-800-325-0800**

For Toll Free Information, Call 6AM-5PM Monday-Friday PST

Technical Information. . . .1-800-272-3200
Any Other Inquiries. 1-800-423-2866
8200 Remmet Ave., Canoga Park, CA 91304







For Daisy Wheel, Dot Matrix & Ink Jet Printers

$89⁹⁰ Desktop Publishing Breakthrough

Imagine using a word processing and drawing program that lets you integrate charts and pictures that you 'paint' or 'clip' into your text. Well, if you use an IBM PC or Clone, now you can have graphically dramatic documents, from business or personal letters, to proposals, to organization charts, even with a daisy wheel printer.

By Drew Kaplan

It's easy. It's impressive. And, now your thoughts can be powerfully illustrated in both words and graphics.

After all, for illustrating abstract data and thoughts, nothing beats a dramatic chart or drawing. So, let your ideas leap off the page by using integrated text and graphics. Your thoughts are sure to make an impressive impact.

Whether you write letters, bank proposals, term papers, company manuals or news letters, you can forget complicated and expensive laser printing. And, you can forget complicated expensive desktop publishing programs.

Now for just $89⁹⁰, you can use your daisy wheel, dot matrix or ink jet printer to print normal text. Plus, you can integrate simply fabulous graphs and drawings into your creations.

INCREDIBLY EASY

Savtek, a brain trust group, has developed an easy to use yet incredibly sophisticated integrated word processing and graphics program.

Just create your letters, proposals, or reports as you would with any other word processor. In fact, if you **already** have a document created in virtually any other word processor, you can 'grab' it into Savtek's instantly.

You'll produce visually powerful technical papers and manuals with drawings and charts, and dramatic marketing reports with graphs. You'll produce sales proposals with panache.

And since there's no complicated training needed (if you can run a word processor, you can run Savtek), you'll make great impressions, fast.

Anyway, once you've created the written part of your report, using Savtek's sophisticated automatic word processing features, you're ready to add pictures, charts and graphs.

Just select from the over 100 supplied changeable pictures or draw your own, using the automated ICON based drawing program.

Later, you'll learn much more about the sophisticated drawing program that lets you draw, paint, fill, expand, reduce, copy, and move your pictures.

And, you'll form squares, circles and triangles automatically. Anyone can draw with it because it's totally automated and uses arrow keys and doesn't require a mouse. But, read on.

Once you've selected a picture, the computer will produce an automatically sized box representing it. Just position the box wherever you want the picture to be in the text.

Like magic, the actual picture will appear and the text will automatically reformat itself around it.

And, speaking of reformatting, this program will automatically make page-breaks and recalculate each page as you write or edit. If you make an addition to page 1 of a 10 page report, the effect will ripple through all 10 pages.

So, whatever length you've chosen for each page (including headers, footers and automatic page numbering), will automatically be preserved.

You'll particularly like the cut and paste features of this word processing program which allow you to copy, move or delete sections of your text.

Of course, you'll have automatic Word-wrap, Hidden Hyphenation, Justified Smooth Right or Ragged Right text. Plus, you'll have Find, Replace and Search.

And look how you can format your document. There are 5 page templates called rulers which allow you to automatically set up your page.

You can select any right and/or left margins, your tabs, one, two or three line spacing, and the number of blank lines at the top and bottom of your page.

Each of the 5 rulers comes with different default settings. But, you can adjust and save them or change them and even use several at one time on a page.

HOW DO THE PRINTERS WORK?

I use a daisy wheel printer because I like my letters to look personal. I've always had to switch to a dot matrix printer for graphs and illustrations. Unfortunately, I couldn't have my graphics on the same page as my text.

Now, because this program can use the period on the daisy wheel to create all the charts and graphic symbols you see within this ad, I don't need to switch printers any more.

And while it doesn't create the graphics as fast as a dot matrix, the quality is superb. Now my graphics can be impressively integrated into my text.

Note: Every single sample page shown in this ad, was printed out on my EXP 400 Silver Reed daisy wheel printer.

Note: This program does not produce two column news letters in a single action. Simply create a double length column and cut it when you have it printed.

No matter what printer you use, daisy wheel, dot matrix (with or without near letter quality printing) or ink jet (color or single color), you'll have powerful looking documents to really present your ideas in the most professional manner.

DESKTOP PUBLISHING

Desktop publishing is about the hottest category of computer programming. It seems that everyone has discovered the impact of combining text and graphics.

And **very** impressive presentations are just what Savtek's ETG Desktop publishing system provides for you.

Imagine leveraging the capabilities of your own IBM or Clone, your own printer and your own keyboard to produce the documents you see on these pages, with nothing else to buy.

THE 1000 WORD PICTURE

First a confession. I can't draw. That's why you don't see drawings in DAK's catalogs. But I've been amazed at how creative I can be with this paint program.

It's easy. You do everything with the arrow keys and the return key. By using the arrow keys you can draw in any direction with a choice of 12 brush shapes.

There's an erase function to eliminate anything you don't like. And here's my favorite function. UNDO is a function that works throughout this program.

. . .Next Page Please

...Publishing Continued

It simply removes the last thing you did. So, no matter what you do wrong, you're a button away from removing it.

If you don't want a solid line, just spray an area. It's like using a spray can.

Let's say you want to connect two points with a straight line. Use the Angle Line. It produces a computer generated straight line between any two points.

What if you want a circle? Just touch the return key. Then use the diagonal arrow key to enlarge or reduce the circle. If you use the up/down or right/left arrows, you'll get an ellipse.

In the same way you can create squares, rectangles or triangles. And you'll be amazed how many things, from houses to technical drawings, are made up of squares, rectangles, circles and triangles.

But, that's not all. You can choose any of 32 background patterns to fill in enclosed areas or broad lines. And if 32 isn't enough, you can design your own.

There's so much more. You can juggle a picture. Imagine, turning it over or sideways with the touch of a button.

You can copy or move a picture or even part of a picture right on the screen. So, draw it once and copy it or move it.

But, here's my favorite. You can enlarge or reduce any picture or part of a picture right on the screen. So you can change its size equally, or you can stretch it out or make it tall and thin. Wow!

There are 12 included font/sizes. So you can have large or small type in your choice of styles within a picture or integrated with your text.

And, each of the 12 font/sizes can be shown on the screen and printed normally, in bold, in italic, in outline, or in shadow. Plus, you can write normally across the page, up the page, down the page or upside down.

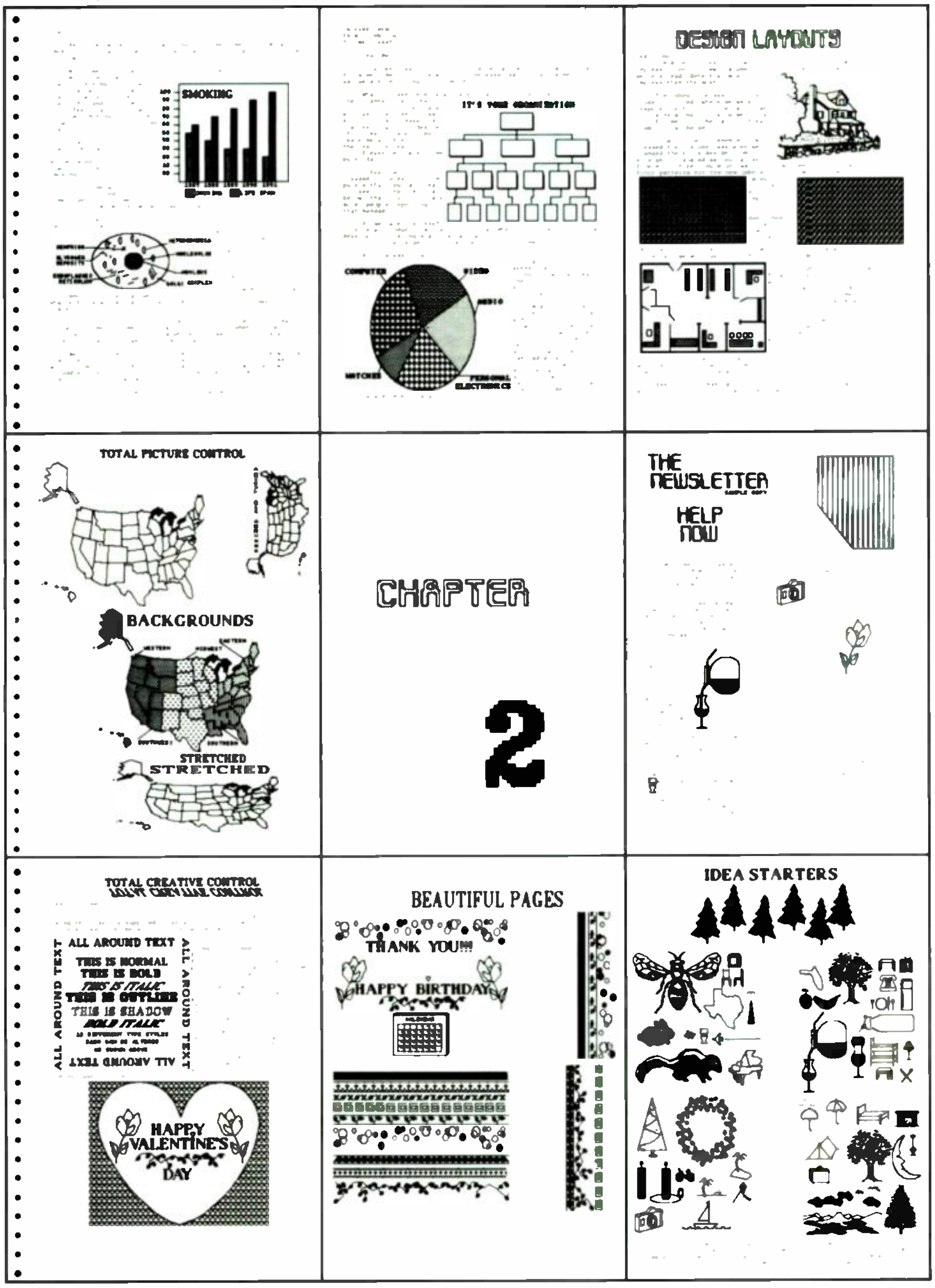
Finally, you can zoom into any small section of the screen and edit your pictures, pixel by pixel. With this kind of power, you don't need to be an artist, just have the ability to push a button.

You can operate this Paint program independently. Or, you can access any picture from within word processing.

So, for banners and pictures, you can print directly from the Paint Program. Or, for everything previously described, simply access your pictures, captions, graphs or charts through the desktop publishing section.

This program is incredibly powerful, yet you'll be comfortable using it within just a few hours.

Every picture in this ad was created with this program. And, you haven't even seen the tip of the iceberg of its capabilities. For example, if you have a picture on the screen, you can bring a second picture up and join them together.



WHO CAN USE THE SYSTEM

All you need is an IBM PC, AT, XT or 100% compatible with standard IBM CGA or EGA graphics capability. It must have at least 256K, and either two floppy disk drives or one floppy and a hard disk.

Below is a list of some of the dot matrix, ink jet and daisy wheel printers that have been tested with this program. If your printer is compatible with any of these printers, it should work too.

Special Note: Most daisy wheel printers are Diablo 620/630 compatible, so they will work with this program.

Special Note: With a color printer you can print 3 colors plus black text.

C.Itoh 8510, Epson Fx-80, FX-85, FX-185, JX-80 (color), LQ-800, LQ1500, LX80, MX80 with Graftrex Plus or Graftrax, RX-80, Hewlett Packard 2225C Think Jet or QuietJet, LaserJet, or LaserJet Plus, IBM 80CPS Graphics Printer, IBM Proprinter, IBM 3852 Jetprinter (color), Juki 6100, Mannesmann Tally Spirit 80, NEC 3500, 3510, 3520, 3530, 3550, 5500 series, 8023A, NEC Pinwriter P5XL, P6, P7, (single or color), OKIDATA Microline 92, ML92, w/IBM Plug & Play, Microline 193, 20 (color), Panasonic KX-P1091, KX-P1091i, Quadram Quadjet (color), Radio Shack DMP-200, Silver Reed EXP 400, 800, 800 and all EXP series, Star Micronics SG-10, Texas Instruments 855, 865, Xerox (Diablo) 620, 630.

FINAL FACTS

There's a pop down calculator which lets you deposit your results right into your text. A clock/timer picks up the time from your computer, and there's a 7,300 year calendar. They are all available as pop-down windows. Savtek's program is backed by a standard limited software warranty/license. It comes with a superb, easy to use reference manual.

DESKTOP PUBLISHING FOR YOU RISK FREE

Make your ideas explode in front of your readers. When you send out a letter or proposal, let it be really dramatic. They will be your ideas, but you'll be presenting them like never before.

If you're not 100% satisfied, simply return it in unused condition within 30 days for a courteous refund.

To order Savtek's ETG Integrated Word Processing and Graphics Desktop Publishing System for your IBM PC or Clone, call toll free or send your check for the breakthrough price of just **$89⁹⁰** ($4 P&H) Order No. 4801. CA add tax.

Look at the 12 sample pages I created. You'll see graphs, pictures and charts mixed into my text. I even designed a logo for my newsletter. Just think about the impact you'll make when you present your ideas with a combination of text and graphics. And oh, it's so incredibly easy to use.

DAK INDUSTRIES INC.

Call Toll Free For Credit Card Orders Only
24 Hours A Day 7 Days A Week

RE65 **1-800-325-0800**

For Toll Free Information, Call 6AM-5PM Monday-Friday PST

Technical Information....1-800-272-3200
Any Other Inquiries.......1-800-423-2866
8200 Remmet Ave., Canoga Park, CA 91304

Authorized COMB **Liquidator**

XEROX® 6064 PERSONAL COMPUTER

XEROX®... They Set the Standards!

For over 20 years Xerox® has been the world leader in office products and copying equipment. They have set standards that others can only imitate. The Xerox® 6064 Personal Computer was designed to meet the demands of business, professional, and personal computing today, and into the future! We are proud to offer this complete Xerox® System at a remarkably **LOW price**! Compare for yourself... then buy your Xerox® 6064 from C.O.M.B.!

Get the Xerox® Advantage! The Xerox® PC offers you the advantage of running IBM™ compatible MS™-DOS, so you can run the hundreds of business and professional software programs available today! And the Xerox® PC is easy to use! It's designed to get you up and running as quickly as possible with computer-aided instruction and superior documentation covering all aspects of personal computing.

Xerox®... Service You Can Count On! If you're considering an IBM™-compatible, don't be misled by price alone! The system we are offering is a **complete** system... very easy to hook up and use... and very affordable. But more than that, each system we sell is backed by Xerox® service and support. When you buy this system, your name and computer's serial number is automatically registered with Xerox®. Should you need service or advice, a network of over 150 service centers stands ready to help you. Before you buy... compare! Xerox® is your best value! Check all these features:

- IBM™-PC/XT Compatibility.
- 256KB Memory Features an 8MHz Intel 8086-2 Microprocessor for Faster Speed, Less Waiting Time.
- Two 5¼" Floppy Disk Drives, 360K Each.
- Seven Expansion Slots, Plus a Serial Port for Communications or Printer, and Parallel Printer Port.
- High-Resolution 640 x 400 Pixels Monochrome Monitor, with 12" Diagonal Non-Glare Screen, Swivel and Tilt Base.
- Standard 83-Key PC Keyboard with Mouse Interface (Mouse Not Included.)
- Comes with ScreenMate™, a User Friendly Guide to the Functions of the MS™-DOS Operating System. ScreenMate™ is Menu Driven... No Need to Remember Complicated Commands! Lets You Select from a Menu and Provides Clear On-Line Instructions If You're Confused About Your Next Step.

Complete Tutorial Software and Manuals Included:

- "Getting Started" Booklet.
- Four Reference Guides.
- Four Software Programs: Two X-Cel™ Training Disks, Two Diagnostic Disks, GW™-BASIC Interpreter, and MS™-DOS/ScreenMate™ Operator's Guide.
- Twenty Blank Disks.

Over 150 Service Centers Nationally.

Manufacturer's Limited 90-Day Warranty on Parts/Labor.

List Price **$2224.80**

Priced At Only **$999**

Item H-2483-7129-232 Shipping, handling: $49.00 ea.

Memory Expansion Board for Xerox® 6064 Personal Computer: Expands the memory to 640K.

List: $249.00

Priced At **$129**

Item H-2483-7128-978 Shipping, handling: $3.50 ea.

XEROX® ScreenMate™ and the identifying numbers herein are trademarks of Xerox® Corporation.
IBM™, IBM™ PC, and PC™-DOS are trademarks of International Business Machines Corporation.
MS™-DOS is a trademark of Microsoft Corporation.

Toll-Free: 1-800-328-0609 Credit Card customers can order by phone, 24 hrs. a day, 7 days a week.

VISA MasterCard DISCOVER AMERICAN EXPRESS

SEND TO: Item H-2483
C.O.M.B. Direct Marketing Corp.
1405 Xenium Lane N/Minneapolis, MN 55441-4494

Send __ **Xerox® Personal Computer(s)** Item H-2483-7129-232 at $999 each, plus $49 each for ship, handling.

Send __ **Xerox® Memory Expansion Board(s)** Item H-2483-7128-978 at $129 each, plus $3.50 each for ship, handling.

(Minnesota residents add 6% sales tax. Sorry, no C.O.D. orders.)

☐ My check or money order is enclosed. (No delays in processing orders paid by check.)

Charge: ☐ VISA® ☐ MasterCard® ☐ Discover℠ ☐ American Express®

Acct. No. __________ Exp. __/__

PLEASE PRINT CLEARLY

Name __________

Address __________

City __________

State __________ ZIP __________

Phone ( )

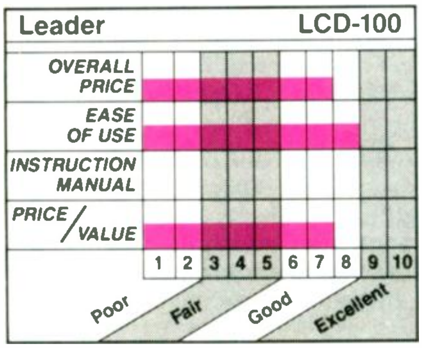
Sign Here __________

Sales outside the 48 contiguous states are subject to special conditions. Please call or write to inquire.

COMB COMB COMB COMB COMB COMB COMB

indicated on the left side of the LCD, leaving a 64 × 160 dot matrix to display the waveform on a 4 × 10-division graticule. The display measures about 4½ × 1½ inches and dominates the front panel of the *LCD-100.* (The entire front panel measures about 8¼ × 5¼ inches, and the unit is 1½ inches deep.) The rest of the panel is broken into five major control groupings: vertical amplifier, sweep, trigger, memory, and DMM.

The vertical amplifier controls, on the bottom right of the panel include an AC-DC/GND input-coupling switch, a position control, and the vertical attenuator control. The



vertical sensitivity can be varied from 10 mV/div to 20 V/div division.

The sweep controls of the *LCD-100* are different from those of a conventional oscilloscope. The sweep rate can be varied (from 5 µs/div to 20 s/div in 21 steps) by using SLOW and FAST pushbuttons. The selected rate is indicated on the scope's display. An AUTO RANGE button can be used to automatically select the timebase that provides an optimal display of input signals between 50 Hz and 200 kHz.

When the horizontal sweep is set at 50 ms/div or slower, the *LCD-100* automatically switches to the *roll* mode, which turns the screen into a strip-chart recorder—without the paper, of course. If you see something on the display that you want to examine more closely, you can press the HOLD button to freeze the display.

The trigger controls include LEVEL, SLOPE, and SOURCE, which operate as on any other scope. There are three trigger modes available: automatic, normal, and single-shot.

The DISPLAY POSITION pushbuttons can also be used in the trigger mode to vary the amount of *pre-trigger information*—one of the benefits of digital storage scopes. It allows you to see transients that occur before the trigger.

Memory storage

Another advantage that the *LCD-100* has over a conventional oscilloscope is the ability to store waveforms in non-volatile memory. In the field, that could prove to be a very convenient feature; the unit could be used as a sort of logging device, to store waveforms for later analysis. Conversely, reference signals could be stored before the unit was taken into the field for comparison against the device under test. An internal lithium battery holds the memory even when the main batteries die.

The *LCD-100* isn't only a digital storage scope: flipping a function switch transforms the scope into an autoranging DMM. Three input jacks (V, COM, and MA/Ω) are located at the top right of the front panel. Three pushbuttons select either the voltage, resistance or current functions of the meter, and another pushbutton selects either AC or DC inputs (in the voltage and current modes) or standard or low-power resistance modes. The DMM has top ranges of 1000 volts DC, 750 volts AC (40 Hz–500 Hz), 320 milliamps, and 32 megohms. Unfortunately, the the DMM section can't be used at the same time you're using the scope section, and it uses different probes.

We examined an early version of the *LCD-100*, and had only a preliminary instruction manual. Our rating chart, therefore, does not include a manual rating.

The *LCD-100* will never replace your bench scope—but it doesn't try to. Its $950 price should stop you from even thinking about buying it unless portability is the most important feature you need in a scope. As a portable scope, The *LCD-100* is fantastic: It's small, light, easy to use, and it's designed for portability right down to its convenient carrying case. **R-E**

LETTERS

continued from page 20

and that's quite a difference.

The new discovery should have a dramatic impact on the size and cost of superconducting coils. Household-sized units costing as little as $1500 are now feasible. Future developments may bring that cost even lower.

Dr. STEPHEN B. KUZNETSOV

ON ELECTRONS

I would like to make a comment on something in the March 1987 issue of **Radio-Electronics.** On page 61, in the article "The Evolution of VHSIC," we read: "Electrons move through the IC at the speed of light."

That is not true; only light travels at the speed of light. Electrons can be accelerated to very high speeds in a vacuum, but not to the speed of light. In a circuit, an electron's motion is slower, because of collisions with atoms. Reducing the trace width moves the components closer together, thereby decreasing the number of time-consuming collisions.

JONATHAN E. DARMSTADT
Potsdam, NY

FROM A HOBBYIST

I have been a reader of the various Gernsback publications since 1946. They have gone through high and low periods of usefulness to both electronics professionals and hobbyists alike.

I would like to congratulate you on your present content and format. It is first rate: the magazine proves to be informative and impressive, without forgetting the hobbyist's interests.

Particularly, I thank you for your PC Service feature. That innovative approach section makes it far easier for a hobbyist to fabricate his or her own circuit boards. I read several electronics magazines, and to my knowledge, **Radio-Electronics** is the only publication that has gone to the extent that you have done consistently, year after year, to help the builder. Keep up the good work and thank you.

J.L. BROWNING
Buena Park, CA

NEW PRODUCTS

CIRCLE 30 ON FREE INFORMATION CARD

RADAR DETECTOR, the model *G-300S* uses microprocessor-based superheterodyne circuitry and a GaAs diode mixer to provide top sensitivity. That bonus extra edge provides maximum time for a driver to check speed and slow down if required.

Among its other features, the *G-300S* includes circuitry that analyzes incoming signals to eliminate false alerts. One circuit looks for and eliminates false alerts caused by other radar detectors in nearby vehicles. Another singles out the fixed frequency of police radar signals from random background signals. In urban areas, a six-second delay can be switched in to prevent triggering by weak X-band signals that may be caused by electronic door openers, security systems, etc. However, the unit responds instantly to strong signals. For full protection, full sensitivity is retained at all times for shorter range K-band signals.

Both audio and visual alerts are issued. The audio alert has a selectable volume level and features auto shut-off after four "beeps." It identifies the radar band via the alert's tone. Visual alerts are issued using a bank of six LED's. The LED's flash in sequence, with the flash rate increasing as the radar source is approached.

Measuring only 3¼" × 4½" × 1", the unit is small enough to be carried around in a briefcase or a coat pocket; it can be easily hidden to prevent theft. The model *G-300S* carries a suggested retail price of $260.00—**GUL Industries Corporation**, 23970 Craftsman Rd., Calabasas, CA 91302.

SATELLITE RECEIVER, the model *ESR924i*, incorporates both an Earth-station receiver and an antenna-positioning system in one unit. It features priority view, which allows the user to preprogram up to 9 channels for instant viewing; parental lockout, whereby channels that parents do not want the children to explore can be locked out on the remote-control module; enhanced stereo,

CIRCLE 31 ON FREE INFORMATION CARD

which allows the user to choose either narrow or wide bandwidths for best audio reception; and positioning programmability, whereby the viewer sets the alphanumeric designations for the satellite wanted, and the dish moves into place automatically. The unit can be programmed for up to 21 channels.

The model *ESR924i is priced at $980.00.*—**R. L. Drake Company,** PO Box 112, Miamisburg, OH 45342.

MICRO-MINI RECORDER, records three hours (ninety minutes per side) on a special Angrom tape cassette (included). The unit has a detachable microphone for use with a tie clip. The recorder measures ⅞ × 2 × 4 inches, and uses two AAA batteries. It also operates on AC power using an AC adaptor (which is included).

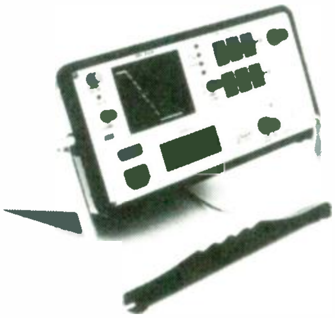
CIRCLE 32 ON FREE INFORMATION CARD

The *Micro-Mini* has two-speed capability with *silent* automatic stop; one-touch recording; tape counter, and many other features not found in other miniature recorders. Extras that come with the unit include tie-pin cord, microphone capsule, earphone, and carrying case.

The *Micro-Mini* is priced at

$179.00 plus $4.00 shipping and handling.—**AMC Sales, Inc.,** Box 928, Downey, CA 90241.

OPTICAL-CABLE FAULT LOCATOR, the model *213S*, handles single-mode fibers at 1300 nm wavelength up to 24-mile distances.



CIRCLE 40 ON FREE INFORMATION CARD

The locator has a dynamic range of 20 dB; attenuation can be measured to better than ±0.1 dB accuracy by positioning the dial cursors on the integral CRT display. The unit has ergonomic easy-to-use front-panel controls combined with a bright CRT screen and LCD. Splice- or connector-loss measurement is fully automatic.

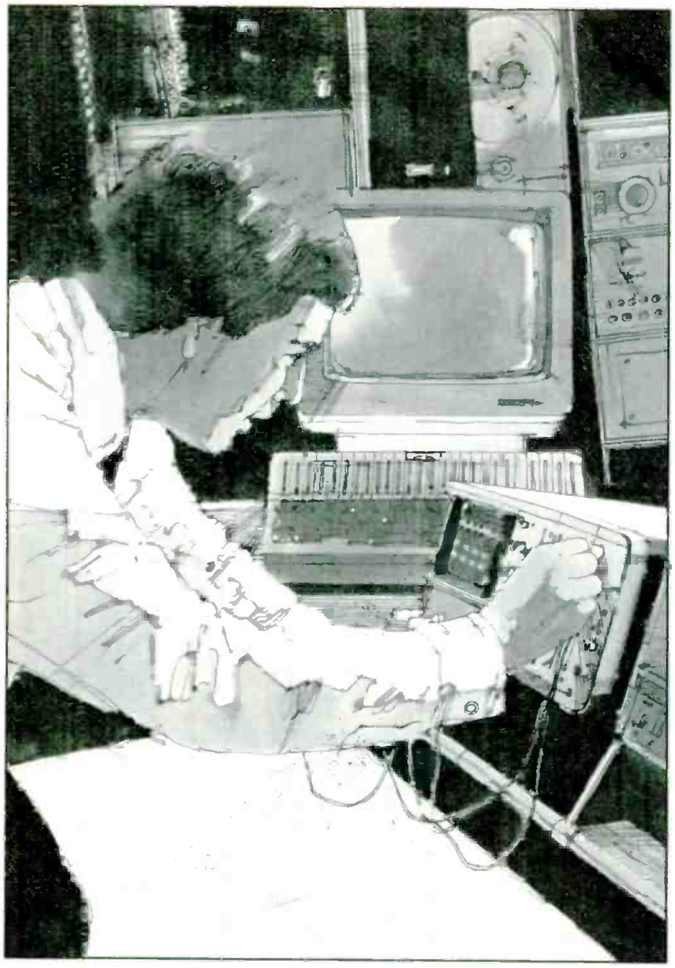
Intended for use in the field, the portable device weighs only 17.6 pounds and measures 11.6" × 11.6" × 6". It can be powered from rechargeable batteries to provide a minimum of 3 hours' continuous use.

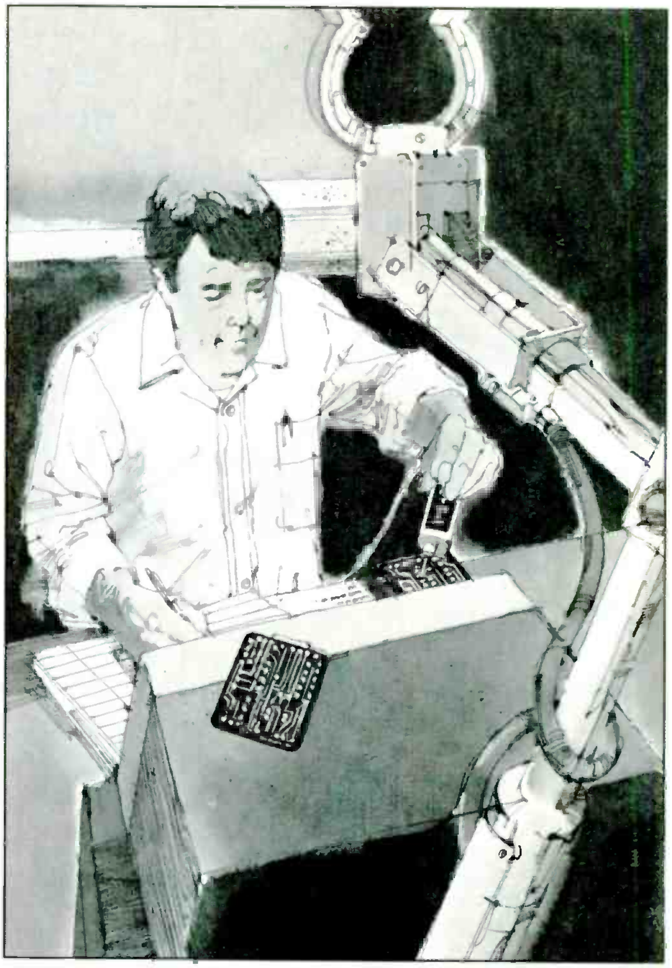
For further information and price, you can write to **Cossor Electronics Limited,** The Pinnacles, Elizabeth Way, Harlow, Essex CM19 5BB, England.

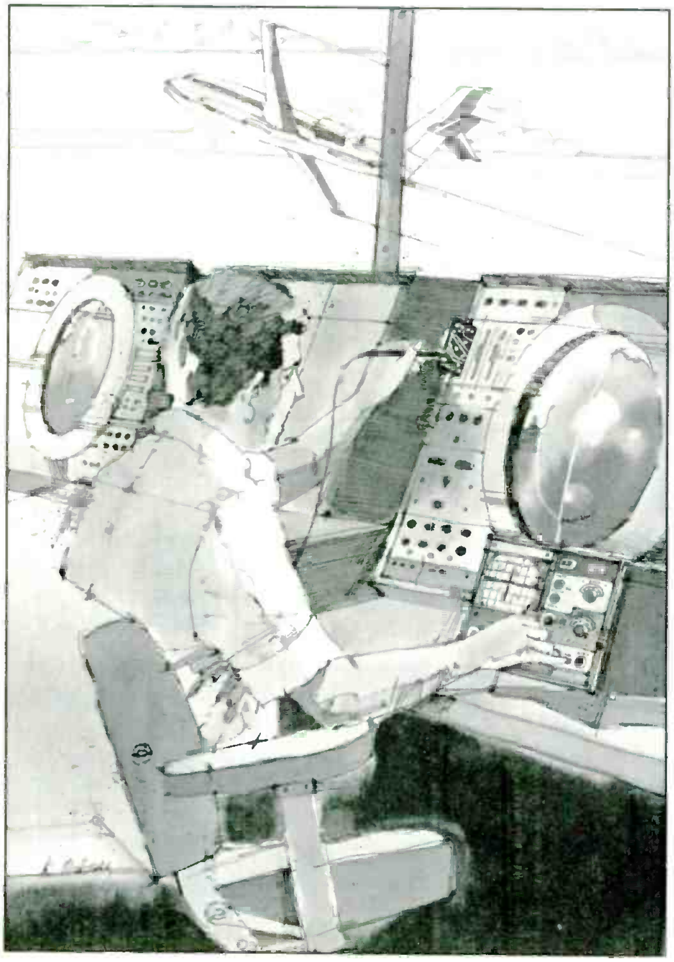
BAR-CODE READER, the *300C*, offers the user either single-code decoding or auto-recognition at the flip of a switch. In the single-

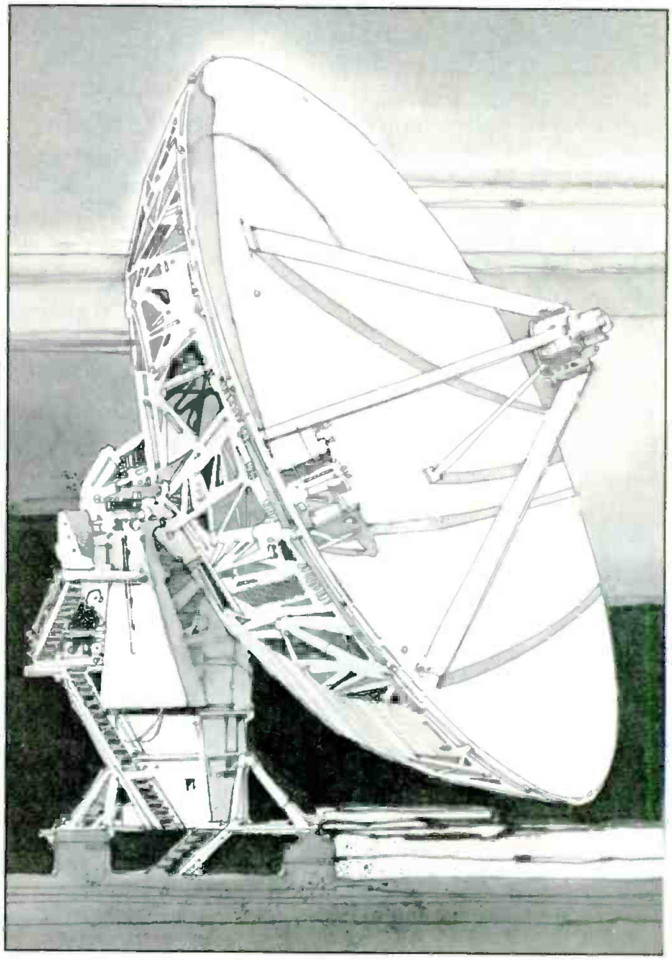
CIRCLE 33 ON FREE INFORMATION CARD

code state, the unit decodes any one of the following: Code 39, the most common alphanumeric bar









Discover Dick Smith Electronics - for Fun & Profit!

New from SAMS Books!

Hundreds of Great Projects!

Would you like to build a miniature laser system or experiment with state-of-the-art optical fibers? You can master these and many other electrical circuitry challenges with this exciting new collection of columns (originally published in *Popular Electronics, Computers & Electronics,* or *Modern Electronics* magazines) by noted electronics author Forrest Mims III. All circuits in this book were either designed by the author or adapted from manufacturers' application notes & other sources. Included are MOSFET, analog & digital circuits; LED's, laser diodes & optoelectronics; lightwave communications, control & telemetry; radio control & remotely triggered camera; sensors; thermoelectronics, experimental circuits & more!

Forrest Mims' Circuit Scrapbook II $19.95 B-3001

New from DAETRON!

Have you ever seen a Cap Meter this powerful?

This compact, handheld 4-digit LCD capacitance meter measures the full range from 0.1 pF to 1 FARAD (999.9 mF) in completely autoranging or manual modes. Check out these features:
● Extended resolution ● Calculates true capacitance ● Shows leakage ● Calculates time constants ● Reads dielectric absorption ● Auto or manual zeroing ● Sorts capacitors ● Calculates cable lengths ● Hold function ● Transistor, zener diode & rectifier tests ● Identifies transistor type & leads ● Diode clamp & fuse protected inputs ● Includes 3 test leads & manual

Requires 9V alkaline or AC adaptor

$169.95 Q-1560

4-Digit Auto-Range Cap Meter

Give your projects that pro finish at minimal cost!

SPEEDY BOXES

Quality plastic project cases with PCB slots on all 4 sides; 4 screws & aluminum lid. Interior dimensions shown.

3⅛" x 2" x ⅞" (H-2755)	$1.25		
4⅜" x 2½" x 1½" (H-2753)	$1.75		
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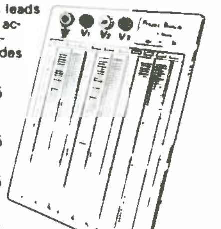

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The *300C* offers either an RS-232C serial or IBM keyboard interface, and the list price is $635.00, including a high-grade sealed-tip metal wand.—**Peripheral Connections,** 2190 W. 11th St., Eugene, OR 97402.

CAR VIDEO SYSTEM, the American Audio *In-Dash Car Video System,* features a stereo cassette player with auto reverse, AM-FM stereo radio, 50-watt sound system, digital readout, and digital clock, plus a 2" black-and-white TV set with zoom (enlarging the picture 30%) and a VCR input. The unit can be installed easily; for automotive in-dash applications, the system must be wired, so that the TV picture only works in the key's accessory position.

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The *In-Dash Car Video System* can be installed on any 12-volt system. It is priced at $299.00.—**Bould Electronics,** 1325 Broadway - 222, Boulder, CO 80302.

PORTABLE PATTERN GENERATOR, the model *LCG-409,* is battery-operated and is designed to be a precision NTSC signal source for field adjustments to VTR's, VCR's, large-screen TV receivers and monitors, and other video systems, as well as for bench operations.

Housed in a metal cabinet measuring 8 × 3 × 10 inches, weighing approximately 6.6 lbs, including the four C cells for power, the unit features full-field 75% color bars, dot, crosshatch, and full raster sig-

continued on page 42

NEW IDEAS

Sound-effects generator

HERE'S A CIRCUIT THAT PROVIDES GREAT fun for kids. It can generate a European police-car siren, bird noises, spaceship sounds, etc. In addition, it can be put to serious use as a doorbell, an alarm, etc. It's easy to build, uses readily-available parts, and is inexpensive.

How it works

A block diagram of the circuit is shown in Fig. 1. As you can see, the circuit consists of four parts: a binary counter, a D/A converter, a VCO, and an audio output amplifier. The speed at which the counter counts depends on the frequency of the output of the VCO, which in turn is determined by the output of the counter. That feedback loop is what gives this circuit its characteristic output.

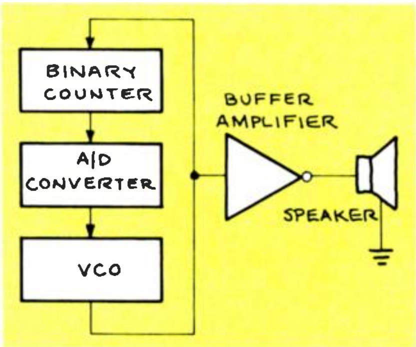


FIG. 1

Referring to the schematic in Fig. 2, the initial frequency of oscillation is determined by potentiometer R11. The VCO first oscillates at a relatively low frequency, and gradually picks up speed as the control voltage supplied by the D/A converter increases.

The D/A converter is simply the group of resistors R1–R8. When none of IC1's outputs is active, little current will flow into the base of Q1, so the VCO's control voltage will be low. As more and more counter outputs become active, base current increases, and thereby so does the VCO's frequency of oscillation.

The VCO itself is composed of IC2-a, IC2-b, Q1, and the timing network comprising D1–D4, C1, R10, and R11. The diode bridge functions basically as a voltage-controlled resistor.

The buffer amplifier is made up of the four remaining gates from IC2, all wired in parallel. Volume is sufficient for experimental purposes, but you may want to add an amplifier, speaker, or both.

Construction

Use any convenient means of wiring the circuit—point-to-point, wirewrap, etc. Layout is not critical; just be sure to connect the power supply to the IC's correctly.

Press S1; you should get a sound from the speaker. The sound you get will depend on the position of R11. To vary the effect, try tapping on S1.—*Edwin B. Tupue*

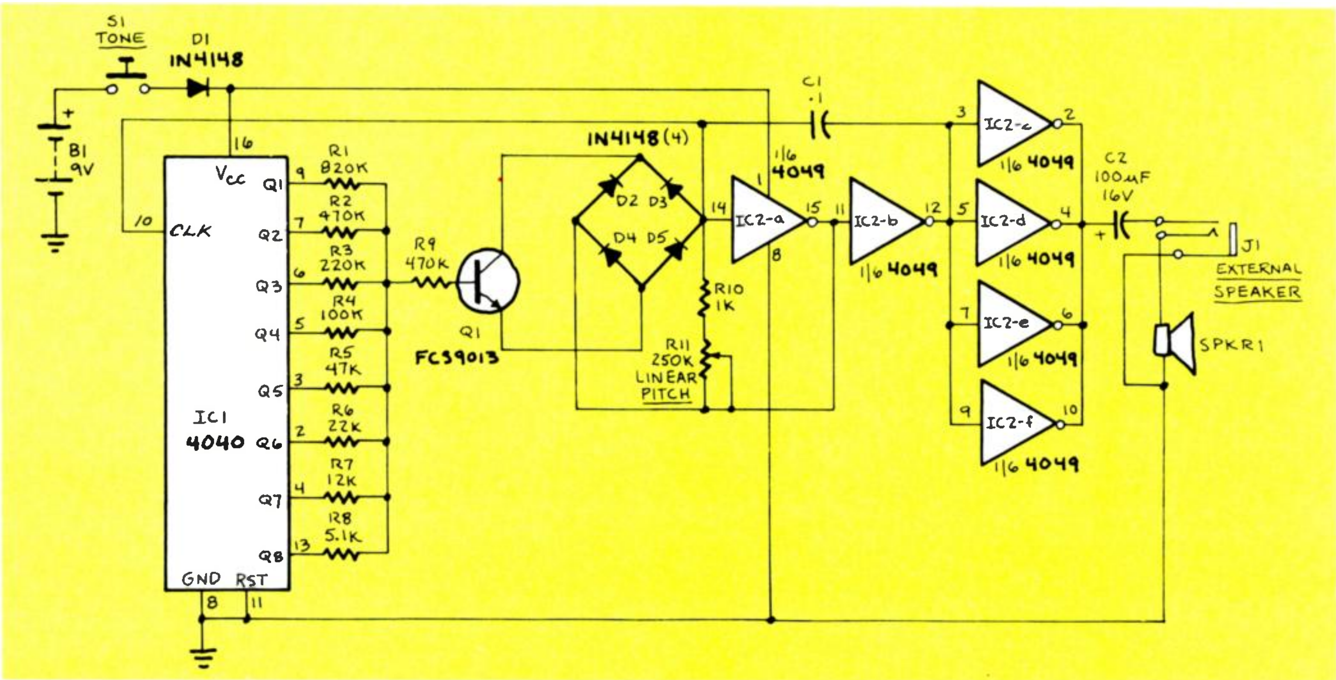
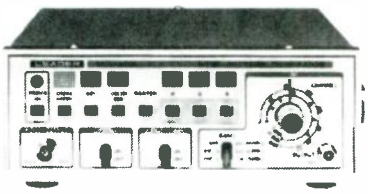


FIG. 2

NEW PRODUCTS

continued from page 39



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nals of 100% white, red, green, blue, yellow, cyan, magenta, and black burst.

In addition to 1-volt p-p video output into a 75-ohm load, the unit features RF output on all U.S. broadcast VHF and UHF channels, on-off switchable FM sound carriers with internal 1-kHz modulation, and on-off control of chrominance.

The model *LCG-409* is priced at $499.00.—**Leader Instruments Corporation,** 380 Oser Avenue, Hauppauge, NY 11788.

PORTABLE ELECTRONIC LAB, the model *4444,* essentially combines five different types of measuring equipment into a portable, fully integrated test-station.

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The model *4444* is priced at $750.00.—**ET&T Corporation,** 3001 Redhill Avenue, 1-219, Costa Mesa, CA 91626. R-E

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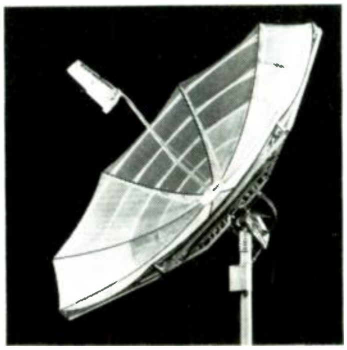

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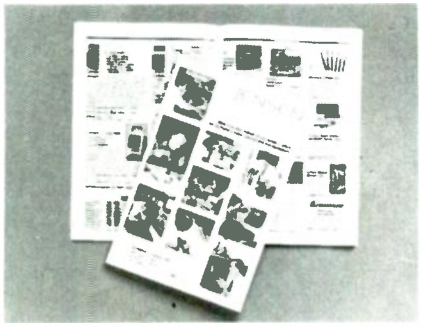

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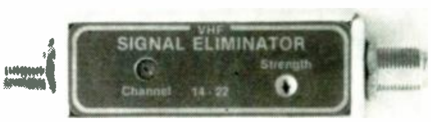

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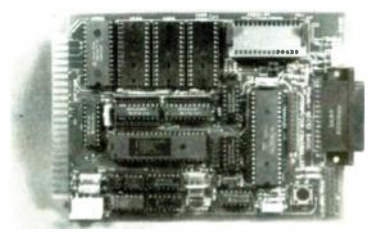

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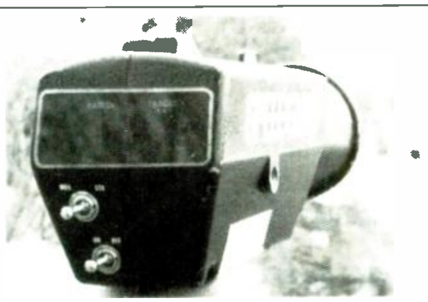

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ROSS ORTMAN

DIGITAL TACHOMETER FOR YOUR CAR

Monitor your car's engine speed with digital accuracy and analog readability.

UNTIL RECENTLY, THE DIGITAL dashboard has been seen only in movies and custom show cars. Automobile manufacturers now incorporate digital displays in selected models, but only as an extra-cost option. But that leaves the rest of us in the dark—literally! So here's an inexpensive, easy-to-build tachometer that displays engine speed in both analog and digital form. The circuit is versatile enough to be adapted for use as a speedometer; we'll show how to do so in a future issue.

Why did we provide both analog and digital displays? Mainly because a digital readout can be harder to read and interpret under rapidly changing engine speeds than an analog dial. After the circuit is calibrated, you can get a good idea of engine speed just by glancing at the gauge. After calibration, the digital readout will display accurately from 0 to 9990 RPM in increments of 10 RPM.

Theory of operation

The tachometer works by counting pulses from the distributor points for a period of time, and then scaling and displaying that number. The digital display has three significant digits; the forth (and least significant) digit always displays "0," so that RPM's can be read from the display directly.

Breaker-point frequency is determined by this formula:

$$f = \text{RPM} \times (\text{Number of cylinders} / 120)$$

For example, with a speed of 600 RPM on an eight cylinder engine, breaker-point frequency is $600 \cdot (8/120) = 40$ Hz. At 3000 RPM, it is 200 Hz.

Now let's use the 600-RPM value to establish how to display the correct value on the tachometer. With an input frequency of 40 Hz, the display must read 600. Because the least-significant digit is zero and the counter section controls only the three active digits, we need to end up with a value of 60 in our counter. With a timebase of 0.5 second (2 Hz), 60 pulses must be read within 0.5 second. Dividing 0.5 by 60 gives us 8.33 ms; the reciprocal of that is 120 Hz—the value we must feed the counter section to obtain the correct reading. So we must multiply the 40-Hz incoming frequency by 3. The circuit that does that will be described later.

Following the same procedure, we find that, to obtain accurate readings for a 4-, 6-, or 8-cylinder engine, the input frequency must be multiplied by a value of 6, 4, or 3, respectively.

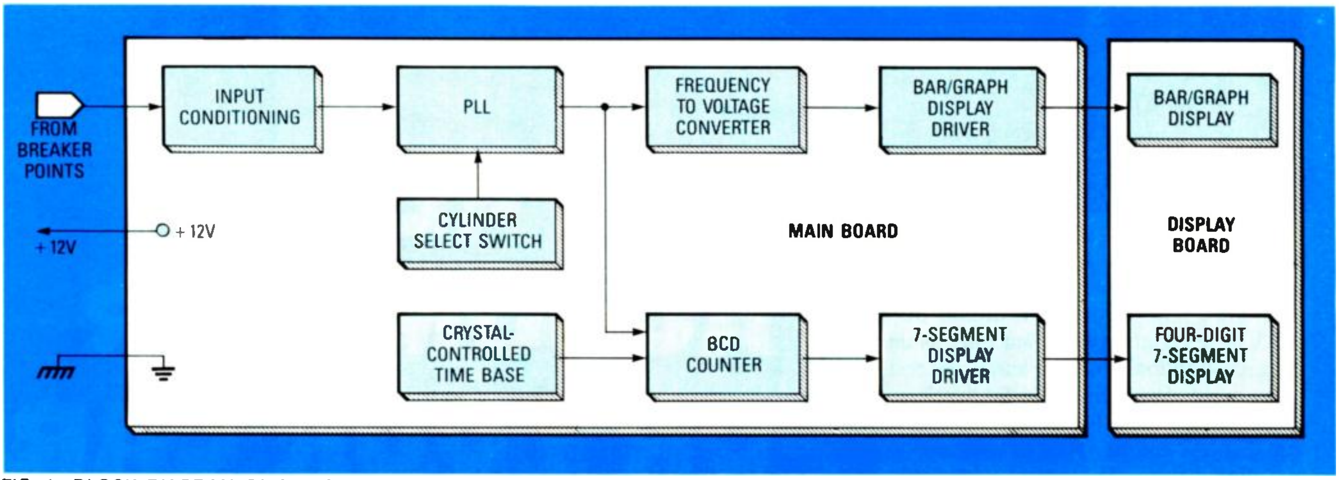


FIG. 1—BLOCK DIAGRAM OF THE TACHOMETER: The PLL scales the breaker-points signal for display directly in RPM.

Circuit overview

A block diagram of the circuit is shown in Fig. 1. After conditioning the noisy input signal, a PLL (*P*hase-*L*ocked *L*oop) is used to multiply the incoming frequency by the value set by the cylinder-select switch (S1). The output of the PLL drives both the analog and digital sections that follow.

The BCD counter is the heart of the digital circuit; it counts the multiplied input signal. After a predetermined sampling interval, a latch pulse latches the number present in the counter at that instant. Immediately following the latch pulse, a clear pulse resets the counter so that counting may start from zero for the next sampling period. The readout is updated every 0.5 second. Figure 2 shows the circuit's timing diagram.

The latch and clear pulses that control the counter are derived from a crystal-controlled oscillator. The oscillator uses a 3.58-MHz TV color-burst crystal to generate a 0.5-second gate time that is stable over a wide range of temperatures.

To produce the analog display, the output of the PLL section is converted to a voltage by a frequency-to-voltage converter. That relative voltage is then displayed on a row of twenty LED's that are driven by a pair of bar/graph display-driver IC's.

Circuit description

The input-conditioning circuit, PLL, and timebase are shown in Fig. 3. Pulses from the points (or tachometer hookup on an electronic ignition system), are fed through a coaxial cable to the input circuit. Waveshaping is accomplished by rectifying the pulses, filtering out spikes, and squaring the signal up by using a comparator with hysteresis. The input circuit limits the amplitude of the 200–300-volt pulses from the points to about nine volts in order to avoid damaging the PLL. Negative pulses are clipped by D1, and positive pulses are filtered by C1 and C2.

Pulses are next squared by IC1, an LM741 op-amp that functions as a comparator. The comparator uses positive feedback via resistor R6 to produce hysteresis, which helps square up the signal.

The PLL section is made up of IC5 (a 4046), its associated circuitry, and IC6, a 4018 presettable divide-by-*n* counter. The setting of IC6 is what determines the PLL's multiplication factor. If IC6 is set to divide by 3, the output frequency of the PLL section will be locked at 3 times the input frequency. Switch S1 determines the number by which IC6 will divide the PLL's output frequency.

The clock is built around an MM5369 17-stage programmable oscillator/divider (IC2); it uses a 3.58 MHz crystal to produce an output of 60 Hz. The 60-Hz output is then divided down to 2 Hz by IC3. The 50-millisecond latch pulse is produced by IC7-a; a delayed version of that pulse is generated by C11, C12, R14, R15, IC7-b, and IC7-c. The delayed pulse functions as the clear signal that was described earlier.

Now let's examine the digital display section (shown in Fig. 4). Counting, latching, and display multiplexing is done by IC9, an MC14553 three-digit BCD counter. The common-cathode LED segments are driven by IC8 (a 74C48); the LED's common cathodes are driven by the three PNP transistors (Q1–Q3).

The analog display (shown in Fig. 5) is based on a frequency-to-voltage converter IC12, an LM2917. It produces a voltage that is proportional to the frequency of the signal fed to its pin-1 input. That voltage is fed to the two bar/graph display drivers, IC10 and IC11, through potentiometer R34, which allows the display to be calibrated. The display drivers are cascaded to drive the 20 discrete LED's. Cascading is accomplished by referencing IC11's internal comparator reference voltage to the final reference voltage of IC10. Resistor R29 limits the amount of current the drivers must dissipate.

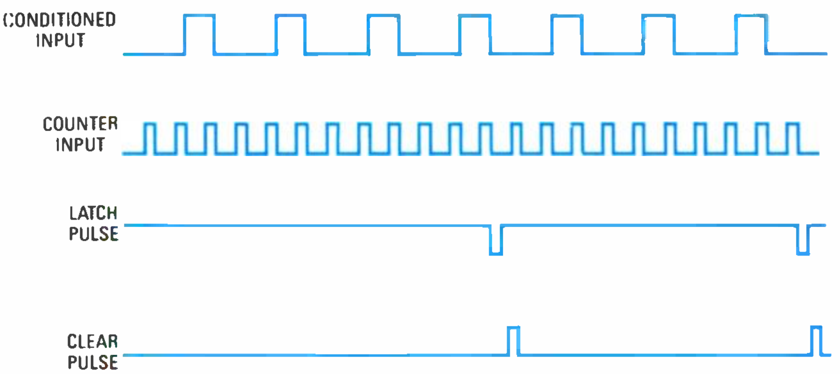


FIG. 2—THE SIGNAL FROM THE POINTS is multiplied by the PLL and counted until a latch pulse is received. The counter is then reset.

Construction

The tachometer is built on two PC boards, a display board, and a main board. The display board (Fig. 6) contains four seven-segment LED displays, twenty discrete LED's, and several current-limiting resistors. The main board (Fig. 7) contains the remainder of the circuitry. The PC boards can be made using the foil patterns shown in PC Service, or a set of boards with plated-through holes can be bought from the supplier mentioned in the Parts List. If you etch your own boards, be sure to solder both sides of the board wherever necessary. If possible, use machined-type IC sockets that don't have plastic bodies, as they can be soldered on both sides of the board easily.

PARTS LIST

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

R1—4700 ohms
R2, R3, R5, R12, R14, R15, R30, R33—10,000 ohms
R4, R7, R8, R10—100,000 ohms
R6—470,000 ohms
R9—22 megohms
R11—2.2 megohms
R13—1 megohm
R16, R17, R18, R27—1000 ohms
R19–R25—220 ohms
R26, R31—470 ohms
R28, R36—22,000 ohms
R29—50 ohms, 5 watts, wire-wound
R32—33,000 ohms
R34—10,000 ohms vertical trimmer pot
R35—2200 ohms

Capacitors

C1—0.22 µF disc
C2—0.022 µF disc
C3—0.01 µF disc
C4—10 µF, 16 volts, electrolytic
C5—33 pF disc
C6—22 pF disc
C7, C8, C15—1 µF, 16 volts electrolytic
C9—0.1 µF disc
C10—0.05 µF disc
C11, C12, C13—0.µF 001 disc
C14—0.022 µF mylar

Semiconductors

IC1—LM741 op-amp
IC2—MM5369 17-stage oscillator/divider
IC3—CD4518 dual synchronous up counter
IC4—CD4081 quad AND gate
IC5—CD4046 micropower phase-locked loop
IC6—CD4018 presettable divide-by-*n* counter
IC7—CD4001 quad NOR gate
IC8—74C48 BCD to 7-segment decoder/driver
IC9—MC14553 three-digit BCD counter
IC10, IC11—LM3914 bar/graph display driver
IC12—LM2917N frequency-to-voltage converter
D1–D3—1N4004 rectifier
D4—1N4739A, 9.1 volts, 1 watt Zener
D5—1N4148 switching diode
D6—1N4001 rectifier
Q1–Q4—2N3906 PNP transistor
LED1–LED10—0.125" green diffused LED
LED11–LED16—0.125" yellow diffused LED
LED17–LED20—0.125" red diffused LED
DISP1–DISP4—7-segment common-cathode display (Panasonic LN516RK, Digi-Key P351, P352, P353, & P354 may also be used.)

Other components

S1—DP3T slide switch (CW Industries GPI154-3013, Digi-Key SW115-ND)
XTAL1—3.58 MHz color-burst crystal
F1—1 amp slo-blow automotive fuse
P1, P2—0.1" 2-pin Molex connector

Note: The following are available from Dakota Digital, R. R. 1 Box 83, Canistota, SD 57012: Single-sided display board, $6.95; double-sided (with plated-through holes) main board, $12.95. All orders add $1.50 for shipping and handling. South Dakota residents and 4% sales tax.

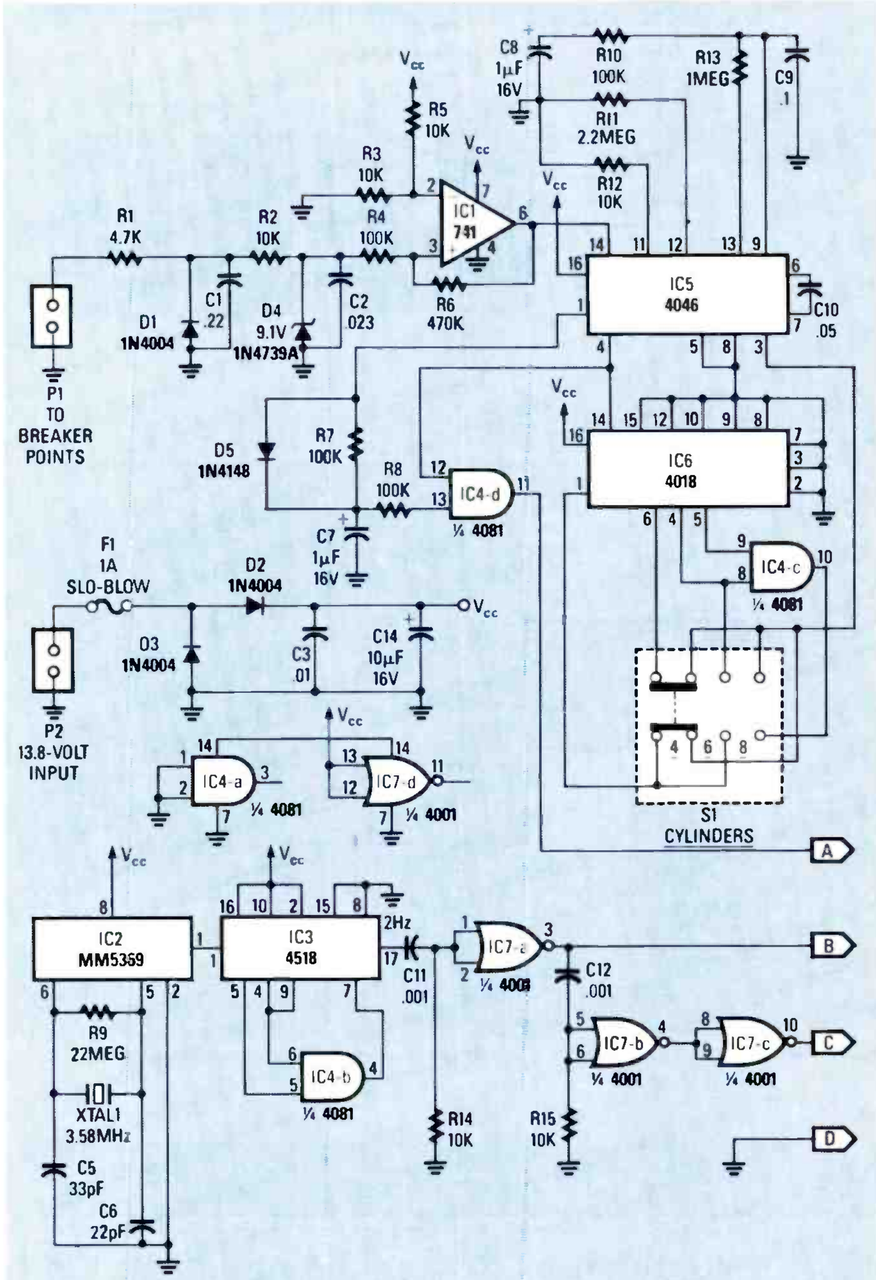


FIG. 3—THE TIMEBASE, INPUT CONDITIONING, and PLL circuits are shown here. Op-amp IC1 functions as a comparator that squares up the input signal for processing by the PLL.

When stuffing the display board, begin with the eight resistors and the three jumpers; then install the four seven-segment displays. Next, insert the twenty LEDs into their respective holes. Pay close attention to the polarity of the LED's. The cathode (or flat side) goes toward the row of holes at the lower edge of the board. After the LEDs have been set in place, carefully turn the board over and lay it down on a flat sturdy surface. Now position the LED's and the displays so they are the same height above the board. If they're not, the LED's must be inserted into their mounting holes further. After the LED's and displays are at the same approximate height, solder one lead of each LED to the board. Then turn the board over and align the LED's so they stand up straight and follow a smooth curve. Now, finish soldering the LED's and set the display board aside.

The next step is to stuff the main board. Begin with the smaller parts: resistors and diodes. Next install the IC's. Because they're mainly CMOS IC's, the use of sockets is recommended, but not essential. If you don't use sockets, insert the IC's carefully, and solder only a few legs at a time to keep heat to a minimum. If sockets are used, install them now and insert the IC's later. Doing so will lessen any chances of static damage. Remember, if you don't use boards with plated-through holes, you'll have to solder most components on both sides of the board.

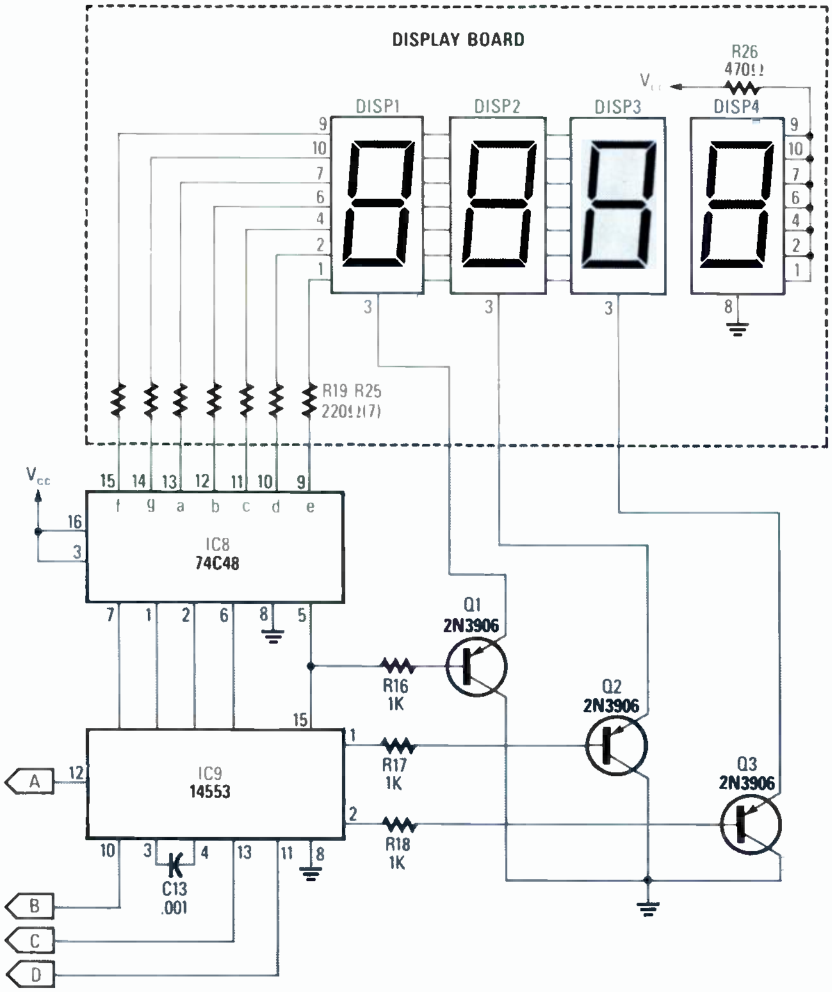


FIG. 4—THE TACHOMETER'S DIGITAL DISPLAY is a conventional decoder driver circuit.

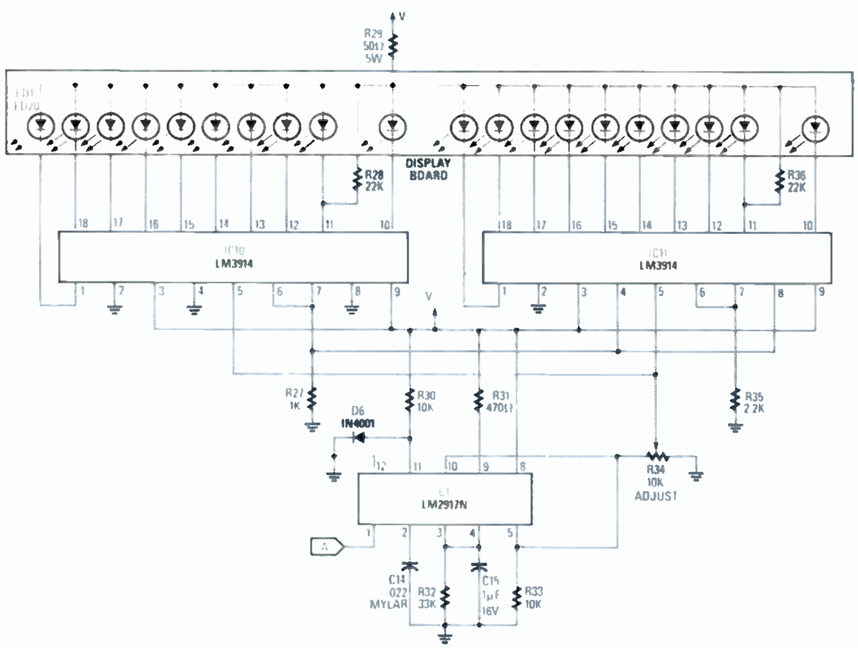


FIG. 5—THE TACHOMETER'S ANALOG DISPLAY is built around a frequency-to-voltage converter (IC12) that drives two bar graph drivers (IC10 and IC11).

Install the remaining components (capacitors, connectors, and transistors). The base or center leg of each 2N3906 is bent toward the flat side of the package; the transistor should rest about ¼ inch off the board. Install the remaining parts on the board and double-check both boards for errors.

Mechanically, the boards are mounted back to back, separated by ½-inch standoffs. Note that each PC board has a row of 35 holes along the lower edge. The boards were designed so that corresponding holes in each should be connected electrically using short pieces of bare wire. Trimmed resistor legs work admirably. If troubleshooting should prove necessary, you can separate the boards by bending those wires carefully.

Before soldering the wires, connect the boards together using stand-offs and #6 hardware. Assemble the boards with the foil side of each facing that of the other. Then lay the assembly down and insert a bare wire through each hole in the top board and into the corresponding hole in the bottom board. Insert and solder several wires at a time; continue until all wires have been inserted and soldered.

Testing

After the two boards are stuffed and connected together, apply 12 volts to P2 using a power supply or battery. The three right-hand digits should display zero's, and the left hand digit should show nothing. Also, no LED's should be lit. Now, using an audio-frequency function generator, apply a 9-volt peak-to-peak 40-Hz squarewave to the junction of D4 (the 9.1-volt Zener diode) and R2. If your generator cannot supply a squarewave with a DC offset, you may have to feed the test point through a 1K resistor and use a higher-amplitude signal.

Set the cylinder-select switch to 8. The readout should now display something close to 600. Change the cylinder-select switch to 6; the display should read 800. Last, set the switch to 4; the display should read 1200.

Now we'll calibrate the analog display. Set the cylinder-select switch to the setting you plan to use. Next, set the generator to the frequency that will produce the "redline" RPM reading for your engine (i.e., the speed above which the manufacturer recommends you not run the engine.) For an eight-cylinder engine, that speed is typically 5000 RPM. When the redline reading is obtained on the digital readout, adjust R34 so the first red LED lights up. The tachometer is now calibrated and ready for installation.

Installation

First decide where the tachometer will be installed. You'll have to find a spot that provides a good view, that doesn't interfere with pre-existing components, and

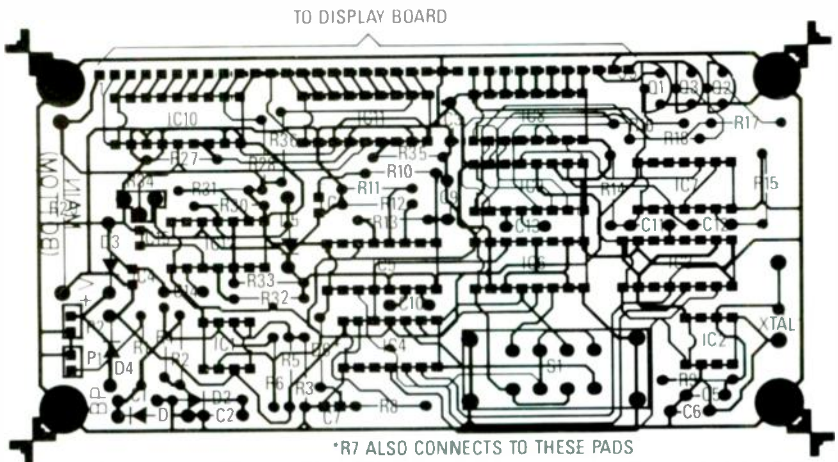


FIG. 6—STUFF THE TACHOMETER'S MAIN BOARD as shown here. Use clipped resistor leads to make the connections to the display board.

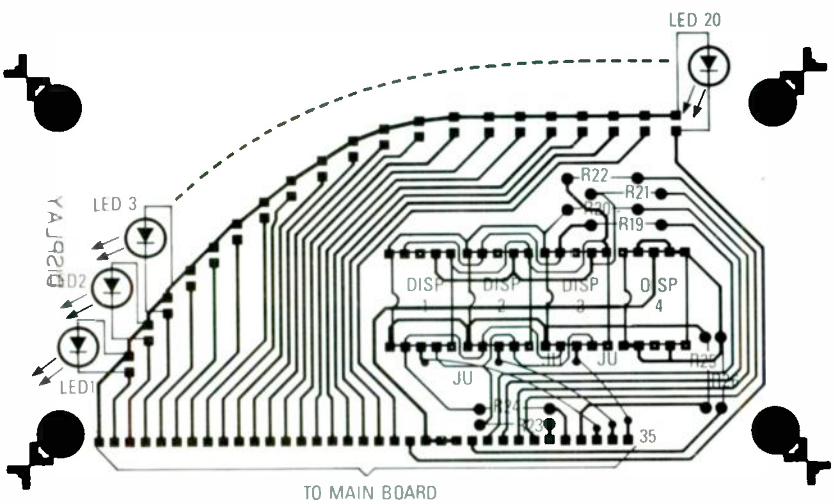


FIG. 7—STUFF THE DISPLAY BOARD as shown here. The flat side of each LED should point toward the bottom of the board. The two boards are sandwiched together, and corresponding pads on the boards are connected with short pieces of stiff wire.

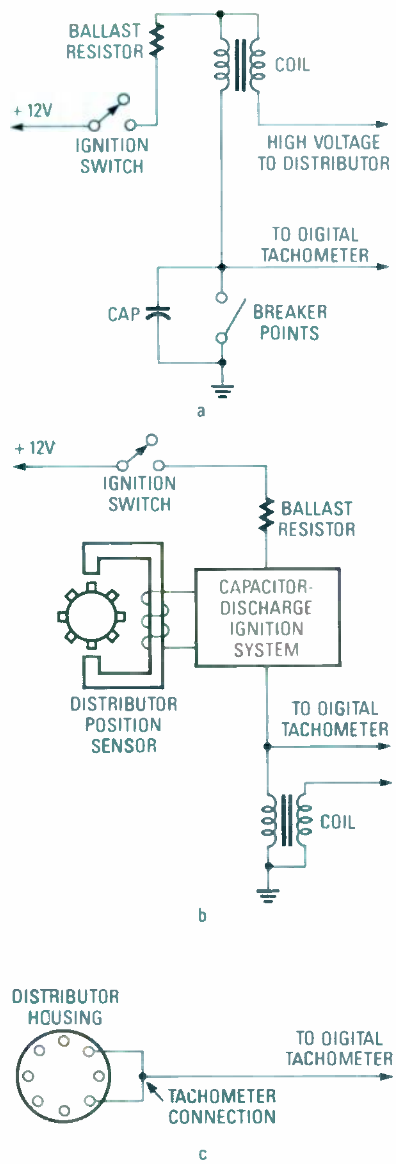


FIG. 8—TO INTERFACE THE TACHOMETER, follow one of these circuits. A conventional (Kettering) ignition system is shown in (*a*), a capacitor-discharge system in (*b*), and a General Motors hook-up in (*c*).

one that you can get to without being a Chinese contortionist!

When a suitable mounting site has been chosen, run a wire from your ignition system to the PC-board assembly. Three possible wiring schemes for different types of ignition systems are shown in Fig. 8-*a*, Fig. 8-*b*, and Fig. 8-*c*. Whatever type of ignition system you have, run a piece of coaxial cable from the distributor points or tachometer hookup to the mounting location. An easy and reliable way to make the connection is to attach the center conductor of the coax to the terminal labeled DIST or - on the ignition coil. Many electronic ignition systems also use a conventional coil, and the connection is made in the same manner as to a distributor/points system. Some electronic ignition systems do not use a conventional coil, so the connection must be made by fastening the center conductor of the coax to the terminal marked TACH.

After putting a connector on the opposite end of the signal coax, connect the power wires. Connect the black wire to chassis ground and the red one to a source that is on only when the ignition key is in the ON position.

Now you're ready to install the tachometer. A case can be built from just about any type of material, but an attractive, durable front panel is important. The use of bronze-colored Plexiglass for the front panel will not only protect the displays, but also make them more visible. Don't use red filter plastic because it will wash out the green and yellow LED's of the bar/graph display. To enhance appearance further, the front panel can be masked on the inside to allow only the LED's and displays to show, thus hiding the rest of the display board. Masking can be done by taping over the area through which the displays will show, and painting the uncovered area black. You may also want to label the front panel using using white dry-transfer lettering.

After building your enclosure, mount the PC-board assembly in it and then install the enclosure in your vehicle. Be sure to install it and the connecting wires so they will not present a safety hazard. Now plug in the power and signal connectors. The installed digital tachometer is now ready to display your engine's speed with both digital accuracy and analog readibility.

Conclusions

The circuit can be used in a car, truck, boat, or wherever an accurate and reliable tachometer is needed. If you're interested in adding other digital display equipment to your car, see the July, August, and September 1983 issues of **Radio-Electronics**. Those issues contain circuits for displaying voltage, water temperature, and oil pressure in digital form. In addition, the circuit shown here can also be adapted for use as a speedometer—we'll show you how to do it next time. **R-E**

NEW LIFE FOR OLD CAR RADIOS

Hear the world with this deluxe shortwave converter!

GARY McCLELLAN

Part 2 LAST MONTH, WE showed you how to turn a car radio into a fine home receiver. But perhaps you're tired of hearing the same old music, news, and sports from your local stations. If so, take heart! This month we're going to show you how to build a shortwave converter that will let you hear the latest news from the places where it happens, while it happens. With it, you'll also hear the kinds of music and cultural events that are popular in many faraway places.

Our converter adapts any analog (dial type) AM car radio to receive international shortwave stations. It covers the two most popular bands, namely 49 (6 MHz) and 31 (9 MHz) meters, plus WWV (5 MHz); WWV is a frequency measurement service that also broadcasts time signals, making it great for setting your household clocks very accurately, among other things.

But why is using a converted car radio so important to this project? First, as outlined last time, those radios feature sensitivity and selectivity that is superior to what is offered by conventional home radios; a car radio modified for home use and outfitted with our shortwave converter will provide performance that is far superior to that of the low-cost multiband radios often seen at discount stores. Also, car radios are well shielded, so noise pickup is reduced resulting in quieter reception.

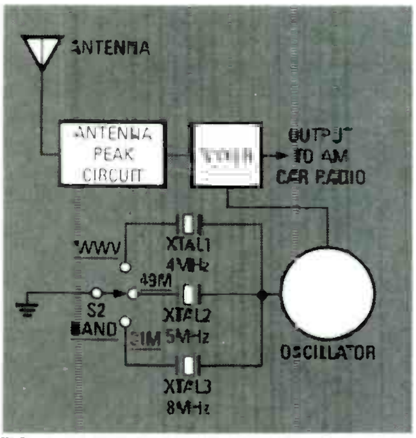


FIG. 4—THE SIGNAL FROM THE ANTENNA is mixed with a locally generated signal and the difference mixer-output frequency is output to the radio.

Considering those advantages, and the ease and low cost of converting a car radio to home use (as demonstrated last time), using a modified car radio for this project makes perfect sense.

Exploring the bands

If you've never listened to shortwave radio, you are probably wondering about the stations that you might discover and their programs. Of course, what you hear will vary due to broadcast conditions and what time of day you tune in; but here is a typical sample of what to expect: Radio HCJB (Ecuador), the BBC (UK) and Radio Deutsche Welle (Germany) offer music and news programs with a perspective not heard on U.S.-broadcast news reports. Other stations that you may find interesting include the Voice of Free China (Taiwan), Radio Havana Cuba (Cuba) and the Voice of America (U.S.). Those stations also offer music and cultural-affairs programs that are very entertaining. Surprisingly, those stations, and many more, were heard using only the equipment described here, plus a 4-foot antenna!

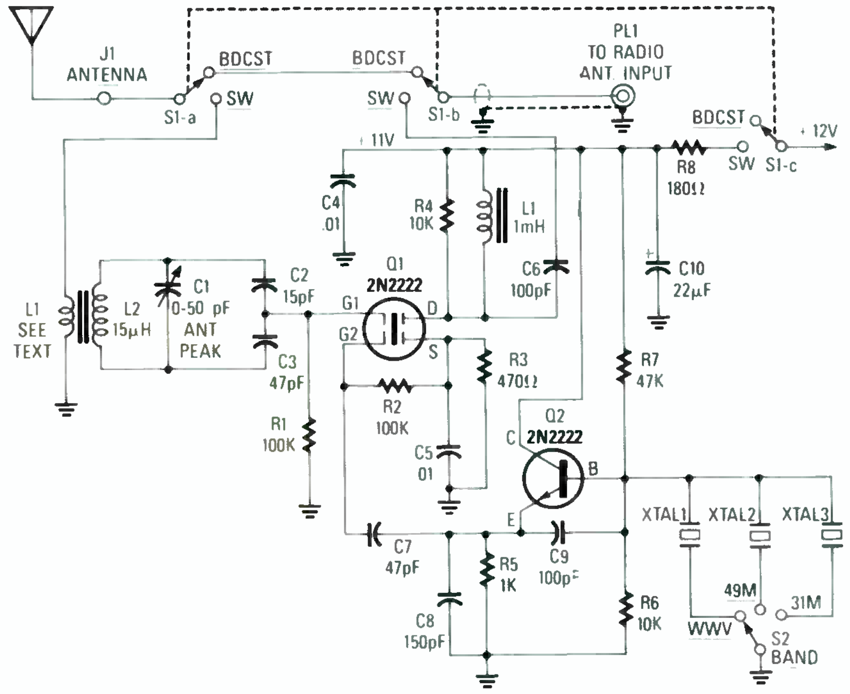


FIG. 5—COMPLETE SCHEMATIC for the shortwave converter. Few of the parts are critical, so feel free to make appropriate substitutions.

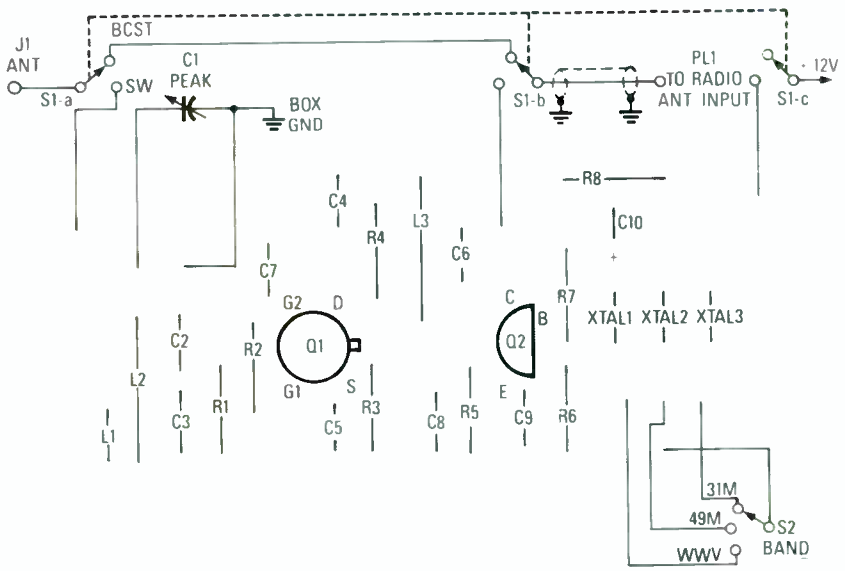


FIG. 6—USE THIS GUIDE when mounting the components; we recommend following it even if you are using perforated construction board.

PARTS LIST

All resistors ¼-watt, 5%
R1, R2—100,000 ohms
R3—470 ohms
R4, R6—10,000 ohms
R5—1000 ohms
R7—47,000 ohms
R8—180 ohms
Capacitors
C1—50 pF, variable, see text
C2—15 pF, ceramic disc
C3, C7—47 pF, ceramic disc
C4, C5—0.01 μF, ceramic disc
C6, C9—100 pF, ceramic disc
C8—150 pF, ceramic disc
C10—22 μF, 16 volts, electrolytic
Semiconductors
Q1—40673 dual-gate MOSFET (RCA)
Q2—2N2222 NPN transistor
Other components
L1—4 turns, 28-gauge wire over L2, see text
L2—15-μH RF choke, JW Miller 9310-40 or equivalent
L3—1-mH RF choke, JW Miller 70F103AI or equivalent
J1—5-way binding post
PL1—Motorola-type auto-radio plug
S1—3PDT toggle switch, see text
S2—three-position rotary switch
XTAL1—4-MHz crystal, 32-pF parallel mode, HC-18 case
XTAL2—5 MHz crystal, 32 pF parallel mode, HC-18 case
XTAL3—8 MHz crystal, 32 pF parallel mode, HC-18 case
Miscelaneous—PC board or perforated construction board, knobs, 2- × 4- × 4-inch aluminum project box (LMB CR-442 or equivalent), RG-59 coax cable, hardware, hookup wire, solder, etc.

How it works

The circuit downconverts signals from WWV, 49 meters, and 31 meters to frequencies in the AM-broadcast band. With it, it is possible to tune in worldwide shortwave stations just like the conventional AM broadcasts you normally hear on your radio. A block diagram in Fig. 4 shows the basic details of the converter circuitry.

The shortwave converter consists of mixer and crystal oscillator circuits. The mixer combines signals picked up by the antenna with a locally generated signal. The result is output signals in the 540–1600 kHz range; those are the frequencies that are normally received by the car radio.

The local signal is generated by the oscillator. Three crystals, 4 MHz, 5 MHz, and 8 MHz are used to provide coverage of the bands previously mentioned. Selection of the appropriate crystal, and hence the band to be received, is done using a three-position switch, S2.

Now that we know how the converter works, let's examine the circuitry in a little more detail; a complete schematic is shown in Fig. 5.

Signals from an antenna are input to the circuit via J1, a five-way binding post. A three-pole switch, S1, is used to select or bypass the converter. When that switch is in the broadcast position, your radio will operate as normal; in the shortwave position, power is fed to the converter (via S1-c) and shortwave frequencies are then easily received.

Assuming that shortwave reception has been selected, signals are first fed to a tuned circuit made up of L1, L2, and capacitors C1–C3. That circuit is set to pass only the frequency of interest and reject all others. The circuit is included to prevent AM-broadcast signals from reaching the radio and causing interference. Capacitor C1 should be peaked for best reception once the circuit is fully assembled and tested.

The output across C3 is fed to the mixer circuit, which is built around Q1, a dual-gate MOSFET that functions as an RF amplifier and mixer, thereby reducing the number of parts required.

The local oscillator signal from Q2 is also fed to the mixer, via capacitor C7. The mixer output appears across L3 and R4 and is coupled to the output via C6. Resistor R4 limits the output level; it is needed because strong signals could otherwise cause distortion in the radio.

The local oscillator circuitry is simple and straightforward. It uses a standard Colpitts oscillator circuit built around Q2, with C8 and C9 providing feedback for oscillation. Crystals XTAL1–XTAL3 provide the proper operating frequencies as described earlier.

That about does it for the theory. Let's get started with construction.

Building the converter

The circuitry is simple, and easy to build, too. As we've shown, only two transistors and a few other assorted parts are used. While we've provided a PC pattern (see PC Service) and a placement guide (see Fig. 6), they are not strictly required. If you wish, you could wire up the circuit on a small piece of perforated construction board with good results. And best of all, no alignment of any kind is needed. That is great news for those of us who lack an RF test generator.

Probably the only hard-to-find part in the project will be variable capacitor C1. Those units are becoming scarce, because many of the original manufacturers are out of business. Try surplus stores for C1, or else substitute a higher-value unit. A 100-pF capacitor should work fine.

The semiconductors aren't too critical. Other MOSFET's, such as members of the 3N200 series, can be used if the RCA 40673 isn't available; the RCA component is preferred, however, since it is overload-resistant. For Q2, most garden-variety silicon NPN transistors such as the 2N3904, 2N4124, and others, should work just as well.

The coils may be almost any type available, providing that the inductances are the same. The miniature units specified were used simply because they were handy.

As for the crystals, low-cost computer types were used here; there is no need to order them custom made and wait for delivery. You can use surplus units of slightly different frequencies, if desired; all that will do is to change dial calibration on the car radio. However, with the values specified, 5 MHz (WWV), 6.0 MHz (49M), and 9.0 MHz (31M) tune in at exactly 1000 kHz on the radio. That is desirable, because it makes finding specific frequencies easier.

Moving on, the rest of the parts aren't especially critical. But you should assemble the project in a metal project box to avoid pickup of local AM-broadcast signals. The switches may be any combination of rotary or toggle types available.

Once you have all of the parts it's time to start construction. Here are some suggestions to help you do the job:

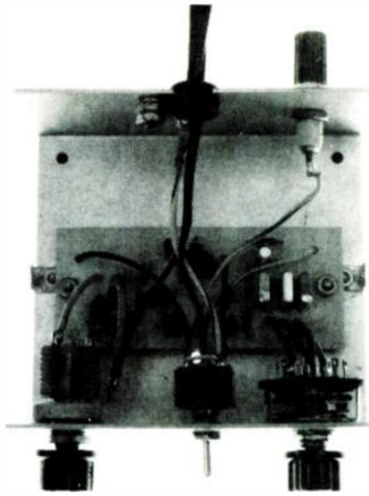
At this point there are two possible routes: First, you can turn to PC Service and fabricate the board for this project shown there. Otherwise you can mount the components on a 1.5- × 3.5-inch piece of perforated construction board and use point-to-point wiring.

If you choose to go the PC-board route, a parts-placement diagram is shown in Fig. 6. Those using point-to-point wiring will find that diagram useful, too; for best results we recommend following roughly the same layout on the perforated construction board.

Start construction by winding coil L1. That is an easy task. Simply wind four turns of 28-gauge magnet wire over one end of L2. Then twist the wire ends together to hold the coil in place, secure the coil with nail polish, and let dry. Finish up by untwisting the wires and then tinning the ends.

Continue by installing the major components, such as the coils and crystals, on the board as shown. Then follow with the resistors and capacitors; be sure to keep all leads as short as possible. When done, install the semiconductors. Note carefully the tab positioning on Q1 and the flat side of Q2. Finish up by checking your work and correcting any errors.

Set the assembled board aside for a moment and prepare the aluminum box. Refer to Fig. 7 for a suggested panel layout, then drill your box accordingly. No dimensions are given for the layout because it will vary with the sizes of the parts you are using. Although not shown, you'll also have to drill a mounting hole for J1, as well as a hole for the output cable and the power lead; those holes should be located on the rear panel. When all holes are drilled, mark the functions with press-on labels and coat the box's exterior with clear plastic spray.



MOUNT THE BOARD inside the enclosure using ¼-inch spacers and 4-40 hardware.

When the cabinet preparation is complete, mount C1, S1, and S2 on the front panel, and J1 on the rear panel. After that, install the board in the enclosure. Use ¼-inch spacers and 4-40 hardware to secure the board in place. Be sure to install the knobs, too. Note that on C1, the pointer should be in the 9-o'clock position when the capacitor plates are fully closed.

Wire the board to the cabinet-mounted components using using stranded hookup wire; be sure to cut each wire as short as possible. Don't forget to install the bypass wire between S1-a and S1-b, and install a 3-foot length of hookup wire at S1-c for power. Feed that wire and a length of RG-59 coax through the rear-panel hole intended for that purpose. Solder the coax's center conductor to S1-b and the braid to ground. Attach plug PL1 to the other end of the cable and you are finished!

Using the converter

The unit is easy to hook up. Simply plug PL1 into the antenna jack of your car radio. Then connect the power lead to the power supply (as described last month). After that, connect a short antenna to binding post J1. A simple antenna such as a 4 foot piece of hookup wire should be sufficient.

Set switch S1 to the broadcast position and turn on the radio; you should hear regular AM-broadcast stations as before. Then set the band switch, S2, to the WWV position and turn S1 to the shortwave position. Tune your radio carefully around 1000 kHz and you should hear the WWV time clicks at least weakly. Adjust C1 for maximum volume and then you are all set!

Reception on 49 and 31 meters works the same way. Set the band switch to the band of interest, then tune in stations from 1000 to 1600 KHz on your radio. Adjust C1 for maximum volume on each station. That's all there is to it, so enjoy! R-E

FIG. 7—THE COMPLETED CONVERTER. If you wish, follow the design shown here when laying out your front panel.

PHONLINK

INTER-ACTIVE REMOTE CONTROL

Rule the world by telephone!

GENE ROSETH

Part 2 NOW THAT WE KNOW A little bit about how our telephone controller works, it's time to look at the circuit in greater detail. So let's get to work.

Circuit details

Figure 5 shows the microprocessor section. The EPROM (IC6) is enabled whenever a read is done to the Z80's memory (not I/O) space. Note that there is no RAM in the system: the abundance of Z80 registers and some careful programming have allowed us to dispense with RAM and associated address decoders.

The gates in the lower-left corner of the schematic (IC4-c–IC4-f, IC5-a, IC5-b, IC7-c, IC7-d) decode the I/O space for the speech synthesizer, the PIO, and the ADC. The Z80's clock input is driven via the clock output of the *Touch-Tone* decoder (shown in Fig. 6).

Figure 6 shows the analog interface circuitry. Data to the speech synthesizer and from the ADC is transferred via the data bus; data from the *Touch-Tone* decoder is transferred via the PIO. The control inputs of the analog switch are driven by the PIO and serve to connect the appropriate signal source to the telephone-line interface circuitry via terminal U13.

The speech synthesizer is a complex device that can be viewed as a storehouse of fundamental speech sounds called phonemes. The microprocessor causes the speech synthesizer to ouput individual phonemes along with appropriate delays to form complete words and phrases.

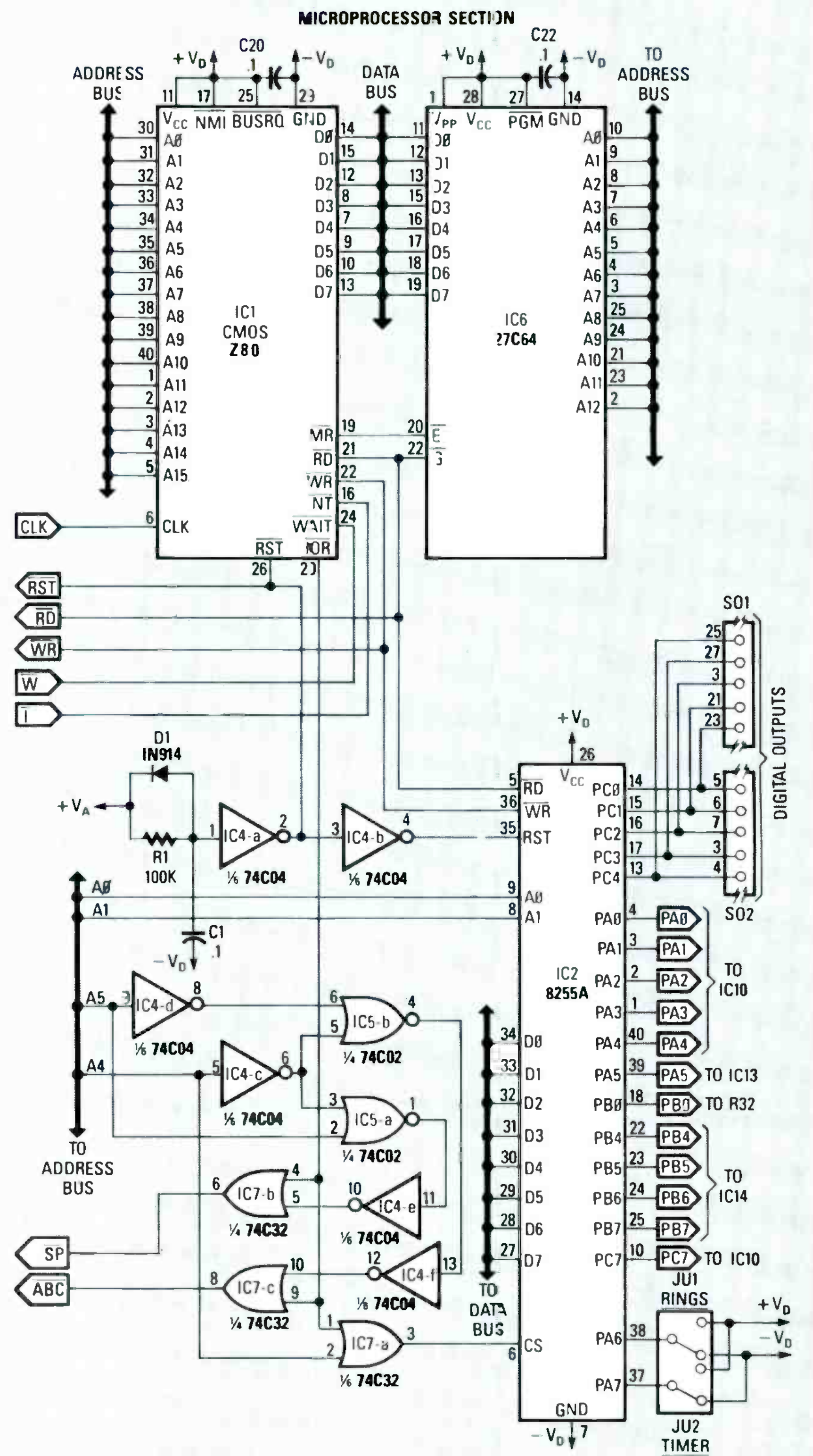


FIG. 5—THE CONTROLLER IS BASED ON A CMOS Z80; the design uses no RAM external to the Z80!

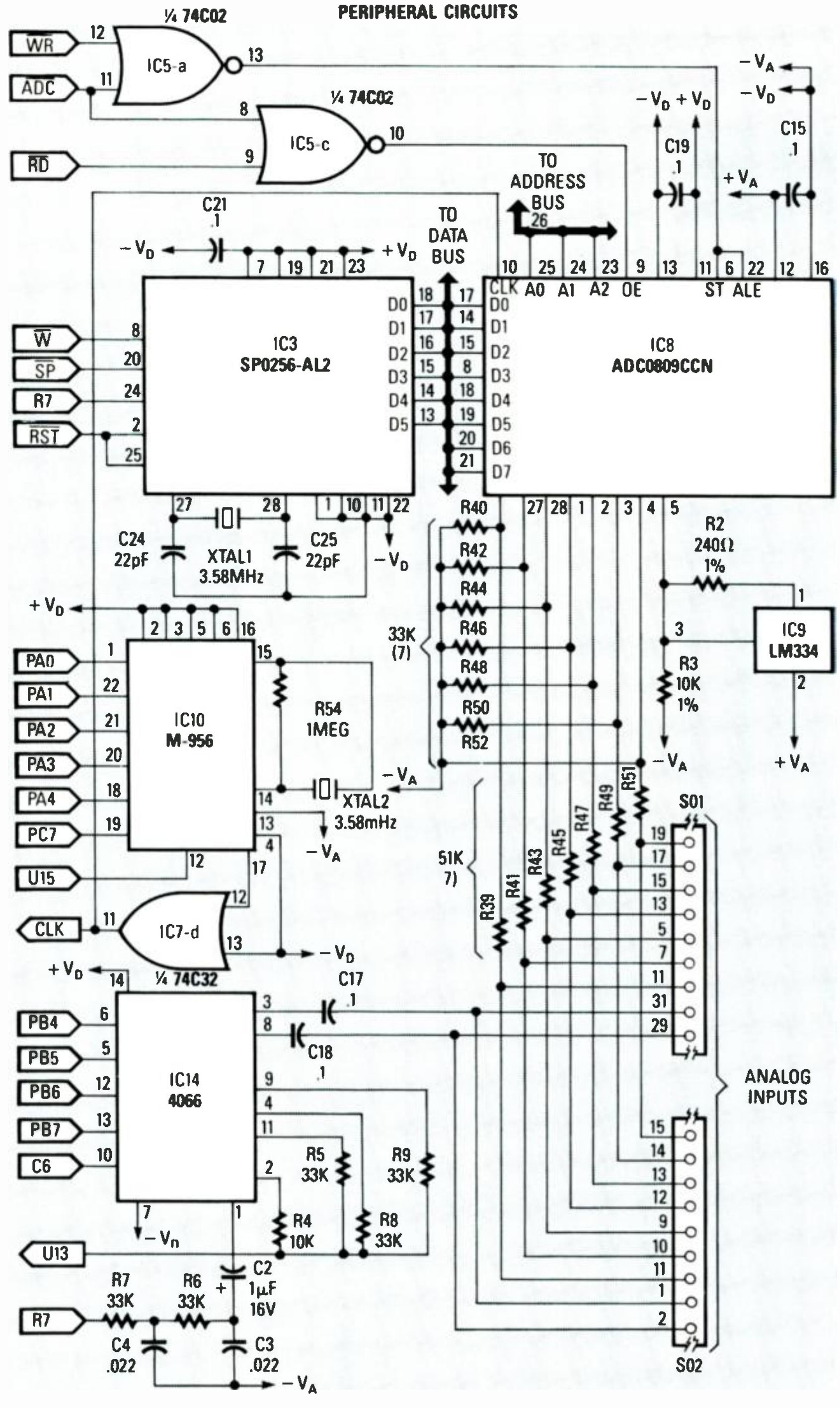


FIG. 6—THE ANALOG-INTERFACE CIRCUITS, including a speech synthesizer (IC3), an A/D converter (IC8), and a DTMF decoder (IC10) are shown here.

WARNING

PLEASE NOTE THAT, ALTHOUGH THE CONtroller presented here has been designed to meet the interface requirements of the telephone system, it is not FCC type-approved. Connection of such a device to your operating company's line is subject to the regulations of that company. It is *your* responsibility to ascertain the pertinent regulations for your area.

The ADC is a successive-approximation type; the resistive voltage divider connected to each of the first seven inputs (pins 1–5 and 26–28) is in the proper ratio to allow the microprocessor to translate a 0–5-volt input to a 0–100 percent output. For other input-voltage ranges, those resistors must be changed accordingly. The eighth input is connected to IC9, a precision current reference that produces a voltage proportional to ambient temperature.

Turning to Fig. 7, note first of all that there are two separate five-volt power supplies, one for the analog and one for the digital circuits. Now you know why the power connections to some IC's in the previous figures are labeled $\pm V_D$ and to others, $\pm V_A$. The analog and digital grounds are connected together, but only at one point; analog and digital ground runs around the board are separate.

The remainder of the circuitry provides the telephone-line interface. Line isolation is achieved through the use of opto-isolators. Opto-isolator IC16 and its associated passive components comprise the ring detector. Each time a ring occurs, a negative-going pulse is generated at pin 5 of IC16; that pulse is applied to pin 2 of IC13-a. The output of that op-amp is then applied to the PIO where it can be detected by the CPU.

Driving the remainder of the interface is BR1, a fullwave bridge rectifier that ensures proper operation of the controller even if the controller is connected to the phone lines backwards. Relay RY1 serves as the hook switch, which is equivalent to the cradle switch on any telephone. The relay is controlled by Q1, which in turn is controlled via the PIO by the Z80.

A closed-loop feedback circuit is composed of IC12, IC17, IC19, IC13-c, and the C9/R16 lowpass filter; that circuit compensates for temperature drift. The data or voice signal is modulated onto the phone line by IC13-c and IC19, but the rest of the feedback loop is needed for stability and to optimize the operating point of IC19. The purpose of IC18 is to detect the disconnect pulse from the tele-

TABLE 1—I/O CONNECTIONS

Function	Pin Number SO1	SO2
Self-cancel function 2	31	1
Self-cancel function 1	29	2
Output 4	27	3
Output 5	25	4
Ouput 1	23	5
Output 2	21	6
Output 3	3	7
Ground	*	8
Input 3	5	9
Input 2	7	10
Input 1	11	11
Input 4	13	12
Input 5	15	13
Input 6	17	14
Input 7	19	15
+5 volts, 200 mA	33	16

*All even numbered pins are grounded.

Note: Pin 1 and pin 9 are not connected.

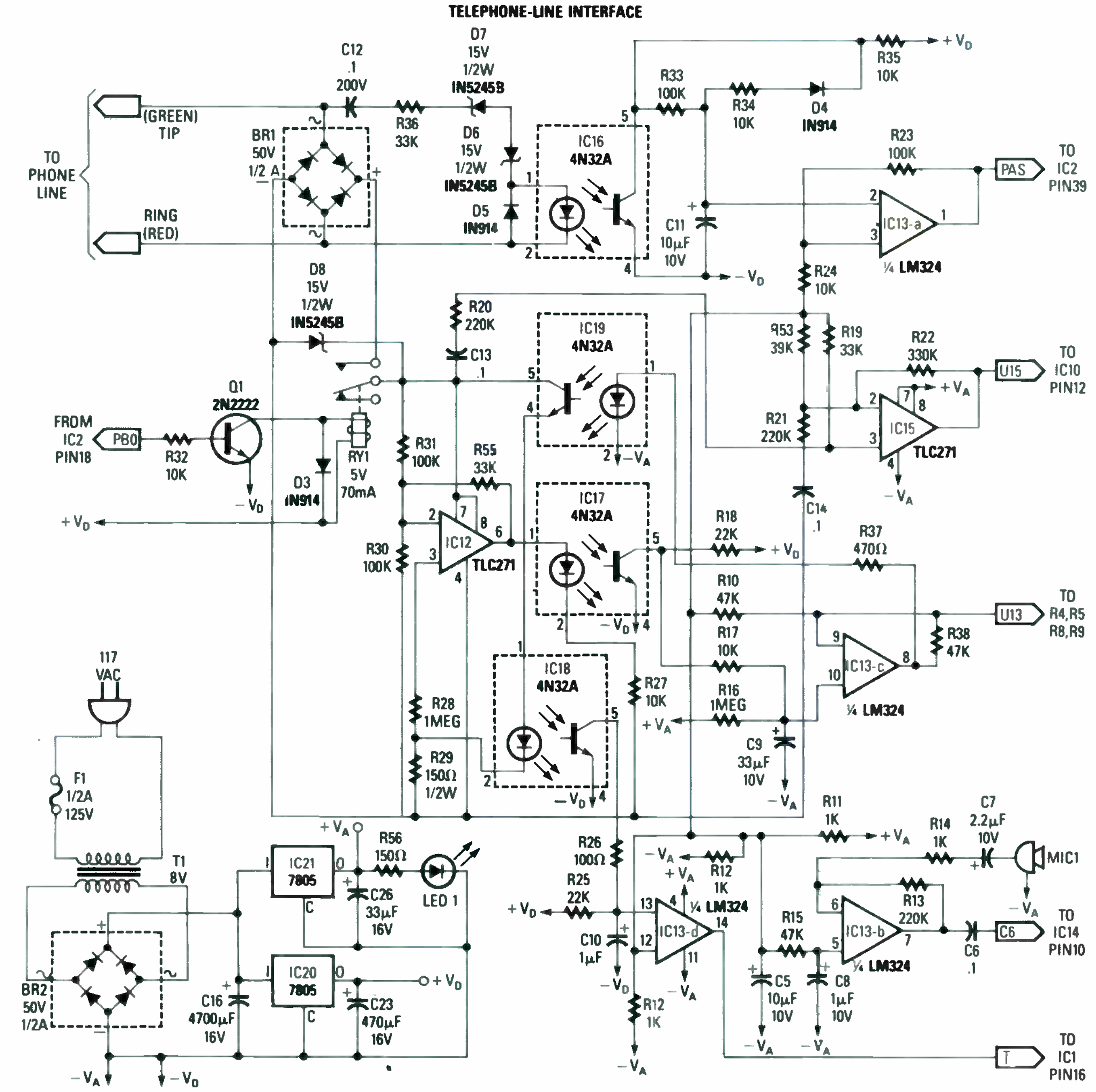


FIG. 7—THE POWER SUPPLY AND TELEPHONE-LINE INTERFACE are shown here. There are separate supplies for the analog and digital circuits.

phone exchange if the caller hangs up. That pulse causes an interrupt to the microprocessor, which then terminates the current session, re-entering the program near the top of the flowchart that was shown in Fig. 1 last time (**Radio-Electronics**, May 1987).

Software

The controller's software is written in Z80 assembly language; it comprises about 1800 lines of code. Due to space limitations, we can't print the listing here, but we have posted it on our BBS. The file is called PHONLINK.AQM, and it has been squeezed, so you'll have to unsqueeze it to use it.

LISTING 1

```
;              *ENTER8* MCOULE
;
ENTER8  LO       A,04H           ;PA5
        OUT     (SPCHPT),A       ;PRE-DELAYS
        OUT     (SPCHPT),A       ;  "    "
        OUT     (SPCHPT),A
        OUT     (SPCHPT),A
        OUT     (SPCHPT),A
        LD      HL,RTRN85
        JP      ENTER            ;"ENTER"
RTRN85  LD       HL,RTRN86
        JP      EIGHT            ;"EIGHT"
RTRN86  LD       HL,RTRN87
        JP      TWO              ;"TO"
RTRN87  LO       HL,RTRN88
```

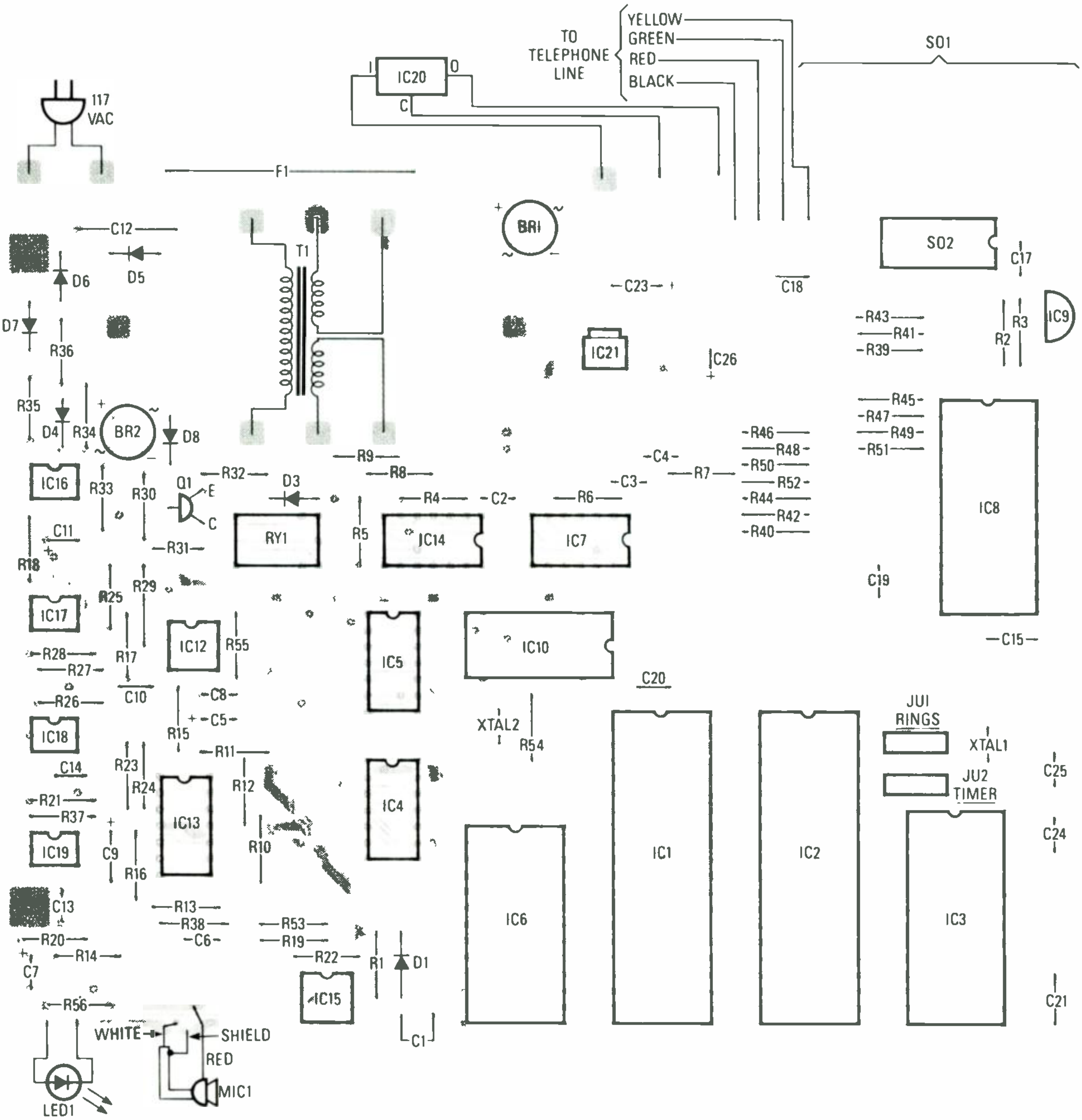


FIG. 8—STUFF THE PC BOARD as shown here. Be sure to mount all electrolytic capacitors, semiconductors, and the power transformer in the correct orientation.

To get an idea of how we use the Z80's registers rather than RAM to store subroutine return addresses, examine the routine in Listing 1.

The routine shown there causes the speech synthesizer to say "Enter eight to end or seven to repeat." After executing several delays (by outputting a 4 to the speech port), the address of the routine that speaks the word *Enter* (RTRN85) is loaded in the HL register. Then the program jumps to the routine that pronounces the word.

That routine returns to the location pointed to by HL—the next line in the routine shown in Listing 1. It in turn calls the routine that speaks the word *eight* and continues in the same manner.

Construction

Use of a PC board is not absolutely necessary, but is strongly recommended, in order to minimize crosstalk and other problems. The commercially available PC board is double-sided, has plated-through holes, and is silk-screened, which greatly simplifies construction. Alternatively, you can etch your own board using the patterns shown in PC Service.

To stuff the board, follow the parts-placement diagram (shown in Fig. 8). Observe all polarity markings and make sure that the transformer is mounted correctly! Mount IC20 (the 7805 regulator that supplies power to the digital circuitry) on the rear panel of your case, or some other heatsink. The power-on indicator (LED1) and the microphone (MIC1) should be inserted through holes in the front panel. Don't forget to solder the two jumpers in the desired positions.

Interfacing

There are two basic approaches to interfacing the controller with external circuitry. The simpler method, which is suitable for small, low-power circuits, is to mount a small piece of perfboard inside the cabinet. The board can be secured to the top half of the cabinet with #4 screws. DIP connector SO2 on the main board allows an easy interface to the user board. The pinouts of SO1 and SO2 are shown in Table 1. The wires connecting the user board to the real-world inputs and outputs

PARTS LIST

All resistors are ¼-watt, 5% unless otherwise noted.
R1—100,000 ohms
R2—250 ohms, 1%
R3—10,000 ohms, 1%
R4, R17, R24, R27, R32, R34, R35—10,000 ohms
R5–R9, R19, R36, R40, R42, R44, R46, R48, R50, R52, R55—33,000 ohms
R10, R15, R38—47,000 ohms
R11, R12, R14—1000 ohms
R13, R20, R21—220,000 ohms
R16, R28, R54—1 megohm
R18, R25—22,000 ohms
R22—330,000 ohms
R23, R30, R31, R33—100,000 ohms
R26—100 ohms
R29—150 ohms, ½-watt, 5%
R37—470 ohms
R39, R41, R43, R45, R47, R49, R51—51,000 ohms
R53—39,000 ohms
R56—150 ohms

Capacitors
C1, C6, C13–C15, C17–C22—0.1 µF, ceramic disc
C2, C8, C10—1 µF, 16 volts, electrolytic
C3, C4—0.022 µF, ceramic disc
C5, C11—10 µF, 16 volts, electrolytic
C7—2.2 µF, 16 volts, electrolytic
C9, C26—33 µF, 16 volts, electrolytic
C12—0.1 µF, 200 volts, disc
C16—4700 µF, 16 volts, electrolytic
C23—470 µF, 16 volts, electrolytic
C24, C25—22 pF, disc

Semiconductors
IC1—TMPZ84COOP, CMOS Z80 (Toshiba)
IC2—8255A, PIO
IC3—SP0256-AL2, speech synthesizer
IC4—74C04, hex CMOS inverter
IC5—74C02, quad CMOS NOR
IC6—27C64, 8K CMOS EPROM
IC7—74C32, quad CMOS OR gate
IC8—ADC0809CCN, A/D converter
IC9—LM234Z, precision current reference
IC10—M-956, DTMF decoder (Teltone)
IC11, IC22—unused
IC12, IC15—TLC271, op-amp
IC13—LM324, quad op-amp
IC14—4066, quad analog switch
IC16–IC19—4N32A, opto-isolator
IC20—LM7805CK, five-volt regulator, TO3 case
IC21—LM7805CT, five-volt regulator, TO220 case
BR1—200 volts, ½ amp
BR2—50 volts, ½ amp
D1, D3–D5—1N914, switching diode
D6–D8—1N5245B, 15-volt, ½-watt Zener diode
Q1—2N2222, NPN small-signal transistor

Other components
F1—125 volts, ½ amp, pigtail leads
MIC1—Electret microphone (Radio Shack 270-092B or equivalent)
RY1—Relay, five volts, 70 mA, (Radio Shack 275-243 or equivalent)
S01—16-pin DIP socket
S02—34-pin edge-card connector
T1—12.6 volts, 0.6 amp (Tria F-158XP)
XTAL1, XTAL2—3.58 MHz

Note: The following items are available from STG Associates, 2705-B Juan Tabo Blvd. N. E., #117, Albuquerque, NM 87112: Complete kit of parts, including cabinet, PC board, and programmed EPROM (KPL-1), $195; etched, drilled, and silk-screened PC board (KPL-2), $36; programmed EPROM (KPL-3), $19; printout of source code (KPL-4), $8. Add 5% for postage and handling. New Mexico residents add appropriate sales tax.

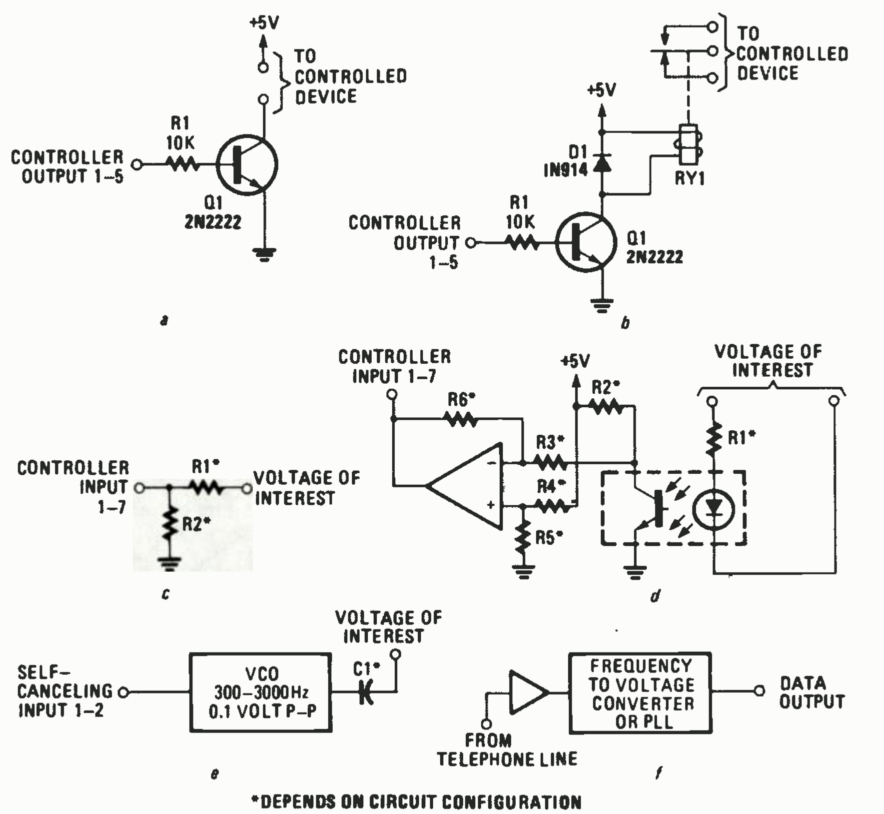


FIG. 9—A VARIETY OF INPUT/OUTPUT CIRCUITS: at *a*, an unisolated digital output; at *b*, an isolated digital output; at *c*, an unisolated analog input, at *d*, an isolated analog input. Shown in *e* and *f* are one means of transmitting digital data over the phone lines.

can be routed out an opening in the rear panel. The internal power supply can provide a maximum of about 200 mA to user circuitry. If that's not enough for your applications, use another method.

The other method of interfacing is required when the application demands devices that are too big or too power-hungry to be mounted internally. Here a separate box should be built that contains its own internal power supply. The edge-card connector identified as SO1 in the schematics can be used to connect the controller to the interface box.

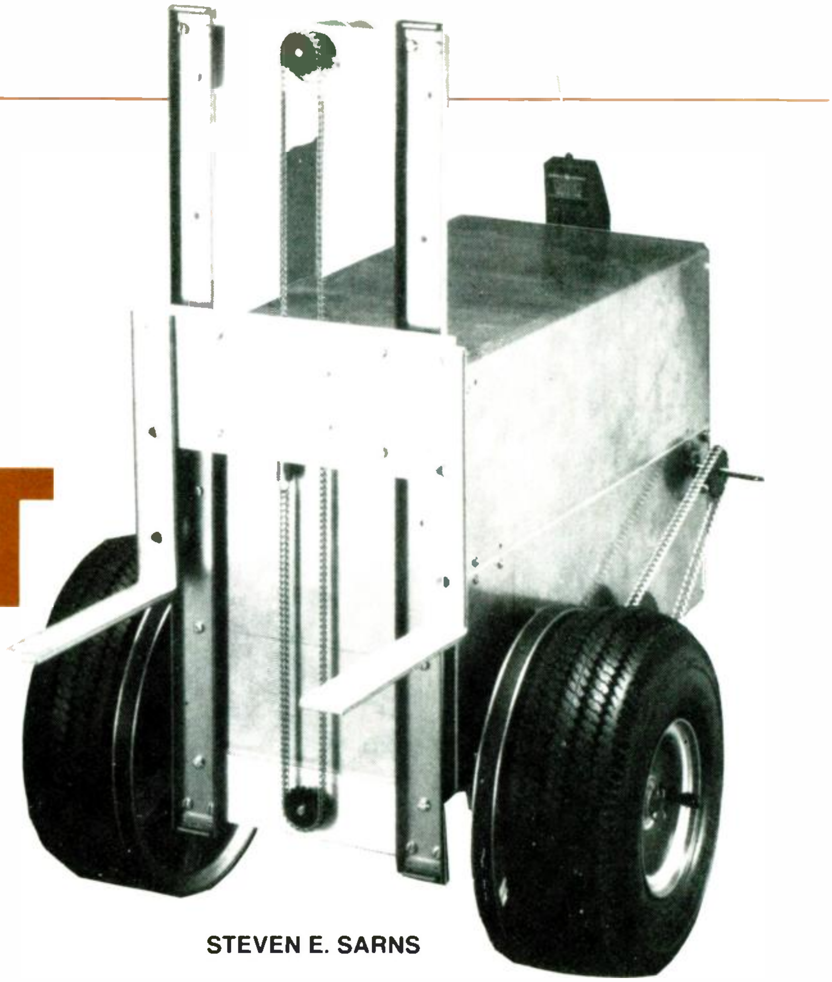
Construction aside, the type of circuit you'll need will depend on your inputs and outputs. Figure 9 shows ideas for several types of interfaces. Component values are not given for most of the circuits because those values can only be determined based on the voltage levels you'll be dealing with. But the circuits shown provide a good starting place.

Figure 9-*a* and Figure 9-*b* show two simple digital-output circuits. Neither can supply much current; the relay in Fig. 9-*b* should be a low-current type. The Fig. 9-*a* circuit is suitable for applications where isolation is unimportant; otherwise, use the Fig. 9-*b* circuit.

Figure 9-*c* and Figure 9-*d* show two simple analog-input circuits. As with Fig. 9-*a* and Fig. 9-*b*, the Fig. 9-*c* circuit is suitable for applications where isolation is unimportant; otherwise, use the Fig. 9-*d* circuit.

Last are circuits for transmitting digital data over the telephone lines. As shown in Fig 9-*e*, the remote voltage of interest should be processed by a VCO (*V*oltage-*C*ontrolled *O*scillator) so that a tone suitable for phone-line bandwidth (3000 Hz) will be generated. The signal applied to either of the converter's self-canceling inputs should be in the range of 50–100 mV p-p. As shown in Fig. 9-*f*, the tone can be recovered at the receiving end after suitable isolation and buffering by a voltage-to-frequency converter or a PLL (*P*hase-*L*ocked *L*oop). **R-E**

R-E ROBOT



More on the electronics that makes our robot go.

STEVEN E. SARNS

Part 7

THIS MONTH WE'LL continue our look at the robot's control electronics. You'll need to refer to the schematic that appeared last time ("R-E Robot, Part 6," **Radio-Electronics**, May 1987), so have it handy as we proceed.

Analog-to-digital converter

An *A*nalog-to-*D*igital *C*onverter (ADC) is required to convert information about the torque output of the drive motors and the state of the batteries to a digital signal that can be processed by the RPC (*R*obotic *P*ersonal *C*omputer). Additionally, an ADC is needed to convert the outputs of environmental sensors to digital form; almost all such sensors have analog outputs.

Because it is easily interfaced with our microprocessor bus, the ADC we selected is the ADC0804 (National). That IC is self-clocking, uses an internal ratiometric reference, and needs only +5-volts DC to operate. The input-voltage range of that IC is adjustable; we've set it for 0 to +5-volts DC.

The ADC's input channel is selected using two 4051 8-channel multiplexer IC's. The input channels are allocated as follows: Two channels are connected to amplifiers monitoring each drive motor's current. Two channels are connected to the RERBUS (*R*adio-*E*lectronics *R*obot *BUS*) connector; we'll discuss the structure of the RERBUS in a moment. Two channels are dedicated to internal heat-sensing. Eight channels are available at the user connector for external sensors or other peripherals you may add later.

The analog-to-digital conversion process is started by writing to port 150H. The desired input channel is selected by placing the appropriate data on the data bus and then writing it to IC4, the 74LS377 parallel latch discussed last time. About 200 µs later, the requested data is placed on the data bus by reading port 150H.

For example, let's assume that we wanted to check on the battery. Battery condition is monitored on channel 3. By selecting that channel we can learn of the state of the battery's charge; if it has dropped too low the appropriate action can be taken. The following line of computer code, written in FORTH, returns the state of the battery:

```
: BATT? 2 150 PC! 2 DELAY 150 PC@ ;
```

Speaking of FORTH, we realize, of course, that we have not discussed the language in any detail yet. Undertaking such a task would require devoting several complete *issues* of **Radio-Electronics**, and the job would still be incomplete, at best. Therefore, for space reasons, we must assume that the reader is familiar with the language. On that premise, when we present FORTH routines in future installments of this series, we will explain what the routine does in general terms, but not the function of each term or line.

RERBUS user interface

If circuit designers always knew in the beginning what would be needed in the end, the concept of a bus would never have been developed. Since we lack such foresight, however, a simple interface bus is provided to allow you to expand the robot easily and at low cost. That interface bus has been named the RERBUS; it uses 26-conductor ribbon cable that carries 8 data lines, 4 address lines, 2 control lines, and power.

The RERBUS interface is derived from IC7, a 74LS374 output latch. That latch was chosen over the 74LS377 used earlier because it has greater output drive capacity. The price of that added drive capacity is the need to add an additional OR gate (IC15-b, ¼74LS32) to the clock line. A second 74LS374 (IC8) is used to buffer the address and control lines for the interface. Data is read from the interface using IC6, a 74LS541 octal buffer/line driver.

The advantage of that implementation is that we have complete control over the access time of any circuits connected to the bus. The read or write lines can be enabled as long as the external circuits require. That is particularly important when a flexible cable is used instead of a backplane because a flexible-cable bus requires slow access times because of its high inter-conductor capacitance.

Motor controllers

Before describing our motor-control

circuit, remember that we are dealing with DC brush-type torque motors. Those motors are characterized by poor speed regulation, lack of an integral tachometer, and, consequently, low-cost; the last characteristic explains why they were selected. Stepper motors with the torque capability we need would have been difficult to locate and would have cost much more. Brushless motors, though less expensive, require so much support circuitry that they wind up costing as much to use as steppers. Servo motors with an integral analog tachometer could have been used, but they too are much more expensive than lowly torque motors. Remember, any automobile starter motor will deliver around ½ horsepower, just about what we need.

Motor controllers fall into two general classifications; linear and switching. In a linear controller, the terminal voltage of the motor is varied to keep the motor speed constant. A switching controller keeps motor speed constant by regulating the duty cycle of the power applied to the motor. Bear in mind that our motor controllers may have to handle up to 500 watts. Examining the power-dissipation requirements of typical series-pass transistors we see that there will be a power-dissipation problem if linear controllers are used. The worst case is at high-torque loads and low motor speeds. Then the series-pass transistors must conduct maximum current while withstanding nearly full battery voltage. The result is over 1 kW of power dissipation in the series-pass transistors.

A switching controller, on the other hand, is either fully conducting or fully off. In either case, power dissipated by the series-pass transistors is zero. Actually, it'a very near zero. During transitions between off-to-on and on-to-off, power is lost, but the total dissipation is many orders of magnitude lower than that of a linear controller.

Some form of feedback is required in all motor-control circuits. That can be derived from an analog generator attached to the motor shaft, as is done with servo motors. Sometimes the motor itself is used as an analog tachometer by measuring the back EMF generated. In our case, optical encoders will be attached to the motor shafts to obtain motor-speed information. The information from the encoders is brought to the controller via connectors PL2 (right motor) and PL6 (left motor); it is decoded by a pair of 74LS74 dual flip-flops (IC28 and IC29).

The final stage of each motor controller is the output driver. That stage must deliver the power to the motor. It must also be capable of reversing and stopping the motor. One method of doing that requires two power supplies of equal voltage and opposite polarity. The motor is connected to the positive supply to run in one direction and to the negative supply to operate in the opposite direction. That solution does not use batteries efficiently, so it is not used.

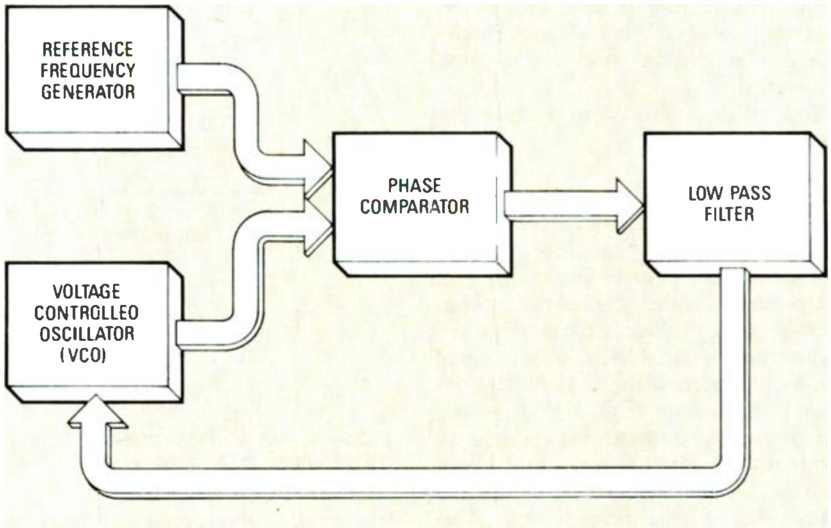


FIG. 1—THE PLL IS THE KEY CIRCUIT comprising the motor controllers. Here, the operation of a PLL is shown in block diagram form.

Another alternative would be to use an H bridge. In that scheme each motor is surrounded by four switches (transistors) that direct the current through the motor in the desired direction. Although efficient in terms of power usage, the circuit requires four high-power transistors and associated circuitry, all of which increases the cost.

Finally, the classic approach is to connect the motor to the center arm of two SPDT relays and to use the relays to establish the direction of the current in the motor. That approach is simple and inexpensive; it is the approach used in our robot.

Design considerations

It is important that the motor controller be able to operate as independently as possible. We could design a motor-control system in which a microprocessor controls the power delivered to the drive transistors and counts the incremental revolutions of the drive wheels. That is an ideal application for a slave processor, and, in fact, that is how the *HERO 2000* works. Unfortunately, however, developing a dedicated slave-microprocessor system for our robot was a luxury that we could not afford.

On the other hand, it is important that we do not load the RPC down with too many tasks. Therefore, our motor controller will have to be smart enough to operate without constant attention from the microprocessor.

We also need an accurate system that can keep track of how far the robot has moved. The drive wheels will be used to steer the robot, so, not only must the motors be capable of accurate differential actions, they must be well-behaved at low (maneuvering) speeds. The robot's arm has just one degree of freedom. The other two degrees of freedom are obtained from the base unit. Therefore, the motor controls must be able to move the unit in small forward, backward, or rotational steps to enable the arm to grasp its target.

The wheel-derived distance will be used as our first-approximation navigational system. However, no matter how accurate our wheel-based navigation is, there is no solution to the "bump in the road" problem. For example, if our robot were traveling in a straight line, maintained by equal distance traveled by each wheel, and one wheel went over a bump, the robot would turn towards the bump. That is because the wheel that went over the bump went farther to achieve the same linear distance that the wheel that missed the bump. In spite of that problem, it would simplify later problems if the robot were able to go where it is told reliably.

The motor controller designed for the robot meets those specifications. We have designed a totally digital, *Phase-Locked Loop* (PLL) motor-control system that uses a single pulse-width modulated transistor. The controller board has two such circuits, one for each drive motor. Directional control is achieved with two relays, a big cost saving compared to the H-bridge approach at high current levels. Feedback is fully quadrature-decoded assuring accurate positional information. Torque information is available to the computer so that stall or high-load conditions can be detected. And it is all done economically.

Now, let's examine the major building blocks of the system.

The PLL

The key to the design of the motor controller is the use of a phased-locked loop. A block diagram of a PLL is shown in Fig. 1. Essentially, a PLL consists of a reference-frequency source, a frequency comparator and a variable-frequency signal that is produced using a *V*oltage *C*ontrolled *O*scillator (VCO). In operation, the frequency comparator constantly compares the variable-frequency signal with the reference-frequency signal and adjusts the variable-frequency signal so that the two match.

By now you may be getting an idea about how our controller works. A reference frequency that is proportional to the desired speed is generated. That frequency is compared with the the output of an optical encoder that is linked to the motor; the encoder plays the part of the VCO in this PLL. If the controlled voltage is lower than the reference voltage, the PLL circuit will turn the drive transistor on more; if it is higher, the PLL will turn the drive transistor on less.

A block diagram of the system is shown in Fig. 2. As mentioned, two such systems are required by the robot, one for each drive motor. To keep things simpler in the following discussion, we will examine the circuit for the left motor only; the right-motor controller works identically.

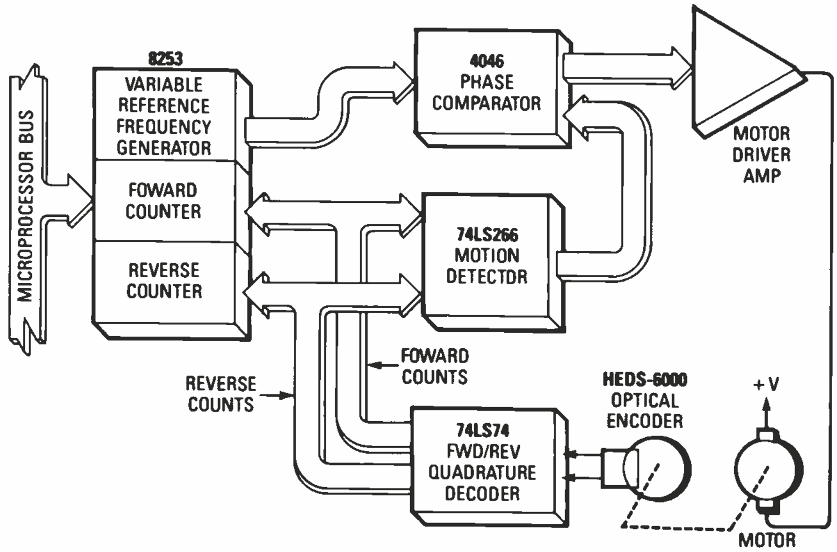


FIG. 2—IN OUR MOTOR CONTROLLER, the optical encoder takes the place of a VCO in the PLL circuit. As the voltage to the motor increases, the output frequency of the encoder increases.

Reference frequency

The reference frequency is derived from the 80188 microprocessor clock (on the RPC) and one of the three independent timers of IC13, an 8253 programmable 16-bit counter. The clock signal is divided by 16 to produce a 500-kHz clock for the 8253. The 8253 then divides the input clock by a 16-bit number to produce an output frequency between 2 Hz and 250 kHz, depending on the number selected. That output is used as the reference frequency by the PLL. The reference frequency can be turned on and off via pin 11, GØ, by writing to port 124H. When the reference frequency is off, the motor must stop completely.

Frequency comparator

The frequency comparator used by our PLL is the internal type-II comparator in the 4046 PLL, IC23. A sophisticated digital-memory circuit outputs a 1 (logic high) if the phase of the reference signal leads that of the controlled signal. A Ø (logic low) is output if the phase of the reference signal lags that of the controlled signal. As you can see, the circuit is actually a phase comparator. However, in our description we will continue to refer to the circuit as a frequency comparator because in our system it is used to control the frequency of the optical-encoder feedback signal rather than the phase.

The output of the frequency comparator is a pulse train whose duty cycle will vary from 0 to 100%, depending upon the difference in phase between the reference frequency and the optical-encoder outputs. The frequency of that pulse train will be equal to the reference frequency. If you examine the output of the 4046 with an oscilloscope while applying a load to the motor you will see the duty cycle of the comparator's output increase, but its frequency will remain the same.

Motor driver

Like the reference frequency, the motor driver is gated on and off via port 124H. When the driver is gated on, the output of NAND gate IC24-a drives transistor Q1 into saturation. That 2N3906 small-signal PNP transistor drives a Darlington pair. Note that rather than a single unit, in our circuit we use a Darlington pair fashioned from discrete transistors (Q2 and Q3). That approach is used because it offers you much flexibility in matching drive transistors and motors. The 2N3772 transistor used for Q3 in our circuit is rated at 30 amperes; that means it can deliver up to 1 kilowatt to the motor at the maximum recommended battery voltage (36 volts × 30 amps).

The motor is connected to the center position of two SPDT power relays. A single flyback diode, D2, protects the driver transistor from damage due to motor inductance. The use of two relays instead of an H-bridge output-driver circuit allows us to reverse motor directions, yet saves three expensive power transistors, several level-matching components, and three flyback diodes. Maximum dynamic braking of the motors is achieved when both relays are in the de-energized position, an important consideration when the robot is parked.

It is possible to perform regenerative braking with the circuit, wherein the kinetic energy of the robot in motion is used to generate electricity in the motor and charge the batteries. However, due to the complexity of the control algorithms and the small amount of energy recovered, we did not implement that feature.

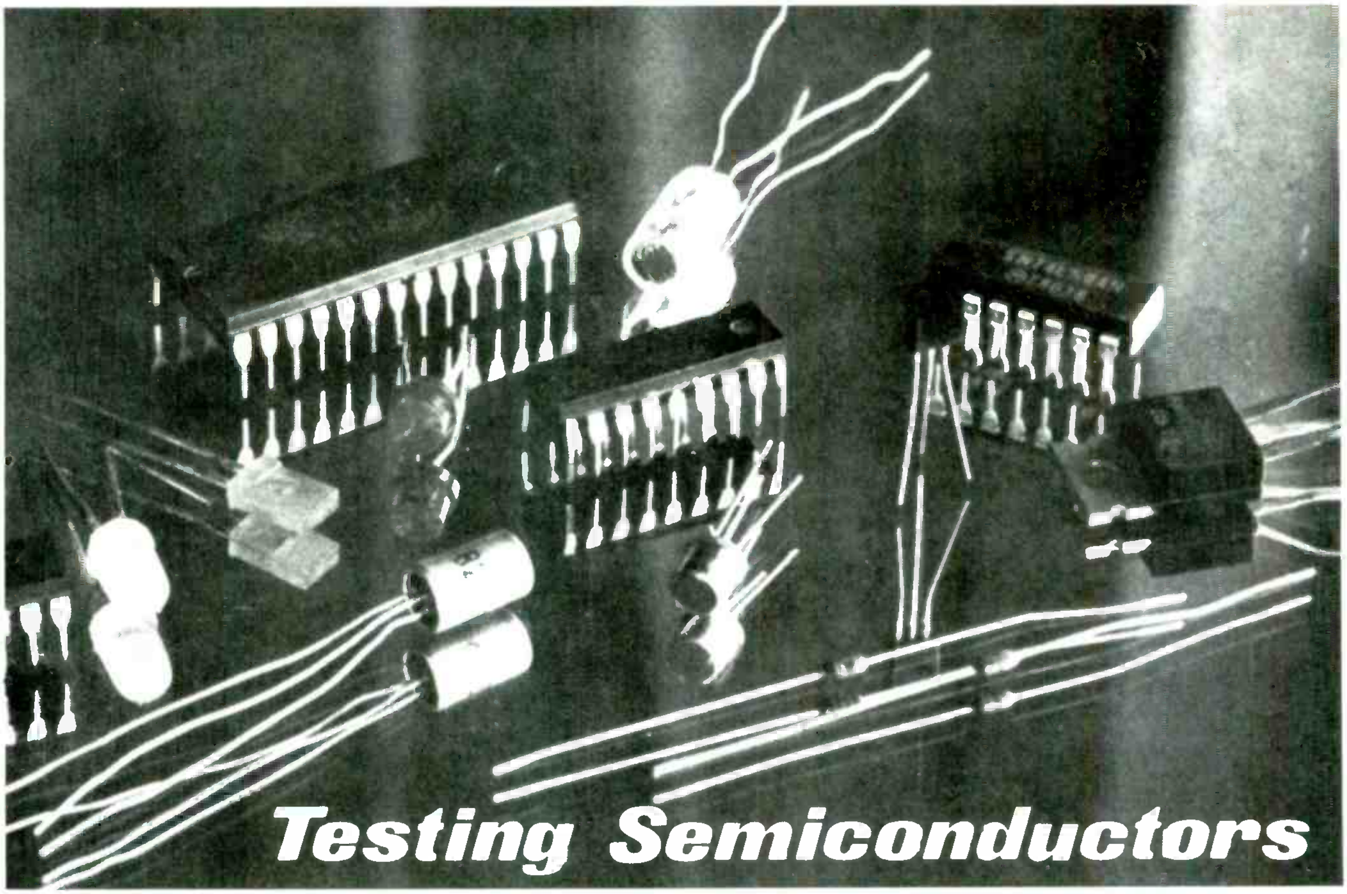
Motor current is sensed at the 0.01-ohm resistor, R21, amplified and filtered by the LM358 operational amplifier, IC20, and presented to the ADC. In a given motor, the relationship between load and current is linear irrespective of motor speed. Once that relationship has been determined, the information can be used by the RPC to sense the grade or surface that the robot is operating on.

Shaft encoders.

We used a Hewlett Packard HEDS 6000 optical encoder for our robot. That unit has a quadrature output of 500 counts-per-revolution.

Note that the HEDS 6000 is one of the most expensive components in the system. You have two choices if you do not want to follow our lead in using that encoder. You can make your own encoder, either with or without quadrature outputs,

continued on page 90



Testing Semiconductors

Our back-to-school series continues this month with a discussion of a transistor's AC parameters.

TJ BYERS

Part 5 ALTHOUGH STATIC (DC) measurements address a wider range of conditions and are easier to make than dynamic (AC) measurements, dynamic measurements are actually more realistic because they apply directly to normal usage.

As you recall from the first installment of this series, dynamic tests are performed by measuring a semiconductor's influence on an AC input signal when the device is operating under DC conditions. Let's take a look at why that is so, and begin with an analysis of bipolar-transistor dynamic measurements.

Transistor gain

The dynamic parameter of primary interest to the design engineer and the hobbyist alike is undoubtedly h_{fe}, which is called beta, and which is often represented by the symbol β. Commonly referred to as *beta*, h_{fe} is the AC short-circuit forward-current gain of a bipolar transistor in the common-emitter configuration. In plain terms, h_{fe} is the ratio of the change in collector current to a corresponding change in base current brought about by an AC signal. h_{fe} can be expressed by the equation:

$$h_{fe} = \frac{\Delta I_C}{\Delta I_B}$$

where I_B is the change in base current and I_C is the change in collector current.

Keep in mind that the key word in the above equation is *change*. (The Δ symbol is used to indicate a change) Let's say, for example, that a transistor is DC-biased with a base-emitter current of 1 mA, which results in a corresponding collector current of 50 mA. Those values are called the *static* conditions of the circuit.

The static conditions that determine the operating parameters of a transistor are established by a constant-voltage power supply across the collector and emitter, and a constant-current source for the base-emitter junction. A test circuit having those conditions is shown in Fig. 1. Meter M1 indicates base current (I_B), meter M2 indicates collector current (I_C). Resistor R_L is the collector's load.

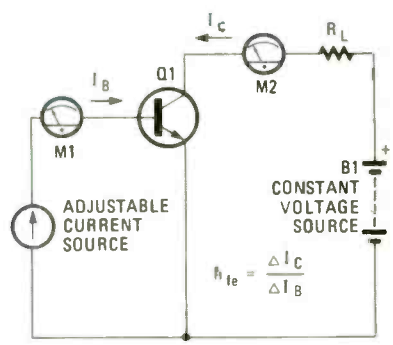


FIG. 1—A basic configuration for testing transistors to determine h_{fe}.

After noting the static base and collector currents, make a change in the base current and note the resulting shift in the collector current. For illustration, assume we apply an input signal of 1 mA to the base (in addition to the static 1 mA current, for a total of 2 mA) and see what happens. Assume that the increase in base current causes the collector current to increase from 50 mA to 100 mA.

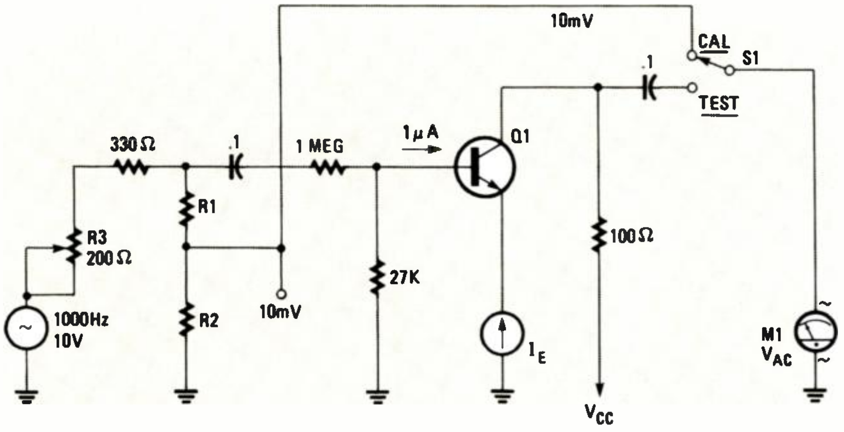


FIG. 2—A laboratory-type h_{fe} test configuration. Resistors R1 and R2 are selected so that AC voltmeter M1 indicates 10 mV when switch S1 is in the CAL position.

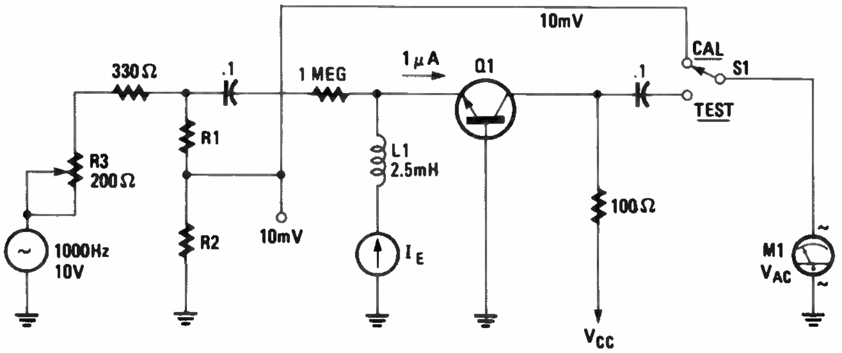


FIG. 3—A laboratory-type h_{fb} tester. h_{fb} always measures less than unity.

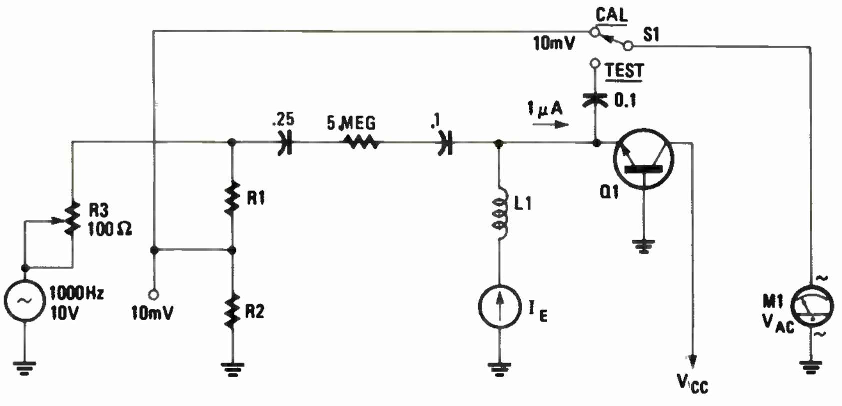


FIG. 4—A laboratory-type h_{fb} test configuration.

If we subtract the new values from the static values, we see that a 1-mA change in base current produces a 50-mA change in collector current. By entering those values into the equation above we can determine that the transistor has an h_{fe} of 50.

Testing h_{fe}

Although the preceding test procedure is acceptably accurate, it is also rudimentary. Normally, a transistor is tested with an AC input signal having a specific frequency, a procedure that more accurately describes the conditions under which the transistor will operate.

Two test frequencies are commonly used: 60 Hz (because it is readily available), and 1 kHz. The higher frequency gives slightly more accurate measurements and has become the standard test frequency throughout the industry. The nomenclature for β tested at 1 kHz is h_{feo}. More often than not, however, the "o" is left out (not used), and the data-sheet listing is shown as h_{fe}. Beta values derived by testing at frequencies other than 1 kHz are noted as such.

A commonly used circuit for testing h_{fe} at 1 kHz is shown in Fig. 2. Q1 is the transistor under test. (Only the functional AC-measurement circuit is shown. The constant-current generator connected from emitter-to-ground represents Q1's base-emitter biasing; it eliminates having to clutter the illustration with the DC biasing circuit.) The test circuit measures h_{fe} by comparing the AC input voltage to the AC output voltage. The meter's scale is specifically calibrated so that it directly indicates Q1's β. (The conversion between current and voltage is made in the voltage divider consisting of resistors R1 and R2. The values for those components were selected so that 10 mV appears across resistor R2 when 1 μA flows into transistor Q1's base.)

A calibration level of 10 mV was chosen so that an h_{fe} in the range of 0 to 100 can be read directly from a meter (M1) that normally indicates 0–10 mV full-scale. The meter's calibration works this way: Switch S1 is set to its CAL position and resistor R3 is adjusted so that meter M1 indicates full scale (10 mV). The switch is then set to its TEST position and the meter reading, which indicates the transistor's β, is noted. Keep in mind that a full-scale reading respresents a beta of exactly 100.

The h_{fe} value obtained by that method will probably agree very well with h_{FE}, the static (DC) gain parameter, but not every time or for every transistor. The parameter h_{fe} is frequency dependent and can fluctuate widely from the measured static (DC) values, a fact that is especially true of high-frequency transistors.

Alpha gain

Another commonly-used parameter is α (*alpha*), which represents the AC short-circuit forward-current gain for a transistor operating in the grounded-base mode. Its nomenclature is h_{fb}. While the α value is not as familiar to some as β, it is often used to establish gain parameters for high-frequency circuits that require a grounded-base configuration.

Alpha can be determined in two different ways: either by direct tests, or by mathematical derivation from other parameters, such as h_{fe}. The formula for converting h_{fe} into h_{fb} is:

$$h_{fb} = \frac{-h_{fe}}{1 + h_{fe}}$$

Be aware that the conversion only yields an approximation for α. Circuit factors such as distributed capacitance and inductance are not taken into consideration by the formula.

To arrive at a more accurate value for alpha, the transistor must be tested in a circuit such as the one shown in Fig. 3. Once again, the constant-current source in Q1's emitter lead represents the biasing circuit. As before, the ratio between the input signal and the output signal is used to determine alpha. The formula is:

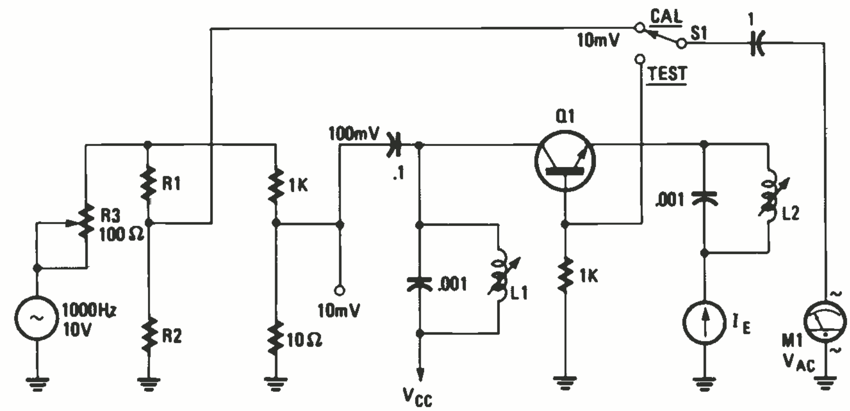


FIG. 5—A laboratory-type h_{ob} tester.

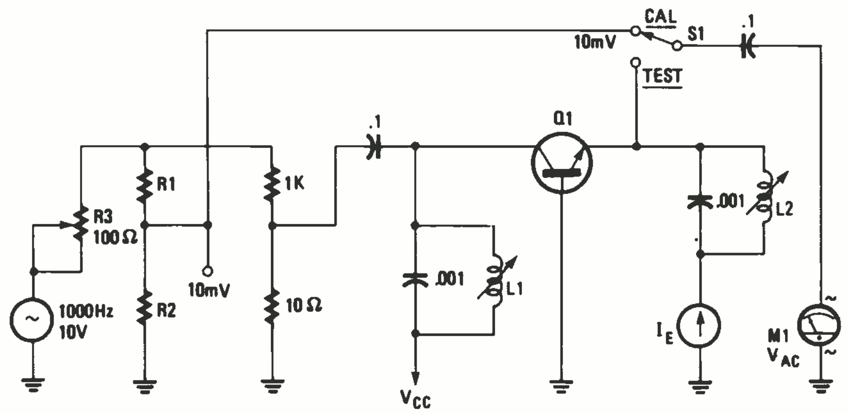


FIG. 6—A laboratory-type h_{rb} tester.

HYBRID FUNCTIONS

The hybrid system of testing is a black-box method for analyzing system parameters. The parameters pertaining to bipolar transistors are listed in Table 1. It is usually possible to convert from one parameter to another mathematically without having to actually perform the test. The formula for converting h_{fe} into h_{fb}, for example, is:

$$h_{fb} = \frac{-h_{fe}}{1 + h_{fe}}$$

TABLE 1

Element	h_{11} Input impedance	h_{12} Reverse voltage	h_{21} Forward current	h_{22} Output admittance
Emitter	h_{ie}	h_{re}	h_{fe}	h_{oe}
Base	h_{ib}	h_{rb}	h_{fb}	h_{ob}
Collector	h_{ic}	h_{rc}	h_{fc}	h_{oc}

$$h_{fb} = \frac{\Delta I_C}{\Delta I_E}$$

By again establishing the transistor's input signal at 1 µA, we can read the value of h_{fb} directly from the meter.

The value of h_{fb} is always less than unity. If that puzzles you, examine the test configuration in Fig. 3 more carefully. Notice that the emitter current, I_E, is composed of two elements: a collector current (I_C), and a base current (I_B). For α to be equal to one, the emitter current must not exceed the collector current, which is impossible. Consequently, unity gain can only be achieved if no base current flows, a situation that renders the transistor useless. Obviously, the higher the transistor's gain, the closer α approaches one.

Like h_{FE}, the values of h_{fe} and h_{fb} vary according to the established V_{CE} and I_C values. Higher currents and lower voltages result in a decrease in gain. The transistor's data sheet will show clearly under what DC conditions the h parameters were measured. Otherwise, the data sheet would be useless.

Understanding the parameters

Parameters designated by the lower case h, such as h_{fe} and h_{fc} are called *hybrid* parameters, meaning they are derived from a black-box method of testing and analyzing system parameters. Although we have concentrated on the α and β hybrid (h) parameters, data sheets often list other h parameters. Individual h parameters are integrated into four basic groups that are identified by numerical subscripts. They are:

- h_{11} = input impedance
- h_{12} = reverse voltage ratio
- h_{21} = forward current ratio
- h_{22} = output admittance

Each group represents a family of h parameters. For example, h_{fe} and h_{fb} both belong to the h_{21} family of forward-current-ratio measurements, as does h_{fc}, the forward current gain in the grounded-collector configuration. (The second letter in the subscript of an h parameter indicates the common element. For example, h_{fc} means the *collector* is common.)

A box elsewhere in this article shows the relationship between the various h parameters. The test circuits for h_{fe} and h_{fb} have already been discussed. Test circuits for other parameters are shown in Figs. 4 through 6.

For all of the circuits, the indicating meter M1, is identical to the one used in Fig. 1. The test frequency is 1 kHz, but 60 Hz should yield identical results in all but a few instances. By adjusting the the R1/R2 voltage divider's ratio to produce a calibration voltage of 10 millivolts, the h value can be read directly from the meter.

Bear in mind that the h parameters are DC dependent. In other words, expect a shift in values if the static current and voltage change.

Field-effect transistors

The field-effect transistor requires radically different test procedures because it more closely resembles a vacuum tube than it does a transistor. Consequently, many of the test parameters reflect vacuum-tube technology. For example, an FET's gain is specified in g_m, a term that is borrowed from vacuum-tube terminology. Gain is listed as y_{fs} on the FET's data sheet. It may also be listed as y_{21}, g_m, or even g_{fs}. (Notice the similarity to a transistor's h parameters.)

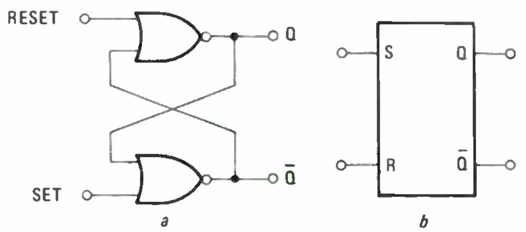
The quantity y_{fs}, which is often referred to as *transconductance* or *admittance*, is

continued on page 90

WORKING WITH FLIP-FLOPS

Flip-flops are the basis of all digital circuits. Learn about the different types and practical applications for them.

RAY MARSTON



S	R	Q	$\overline{Q}$
0	0	NO CHANGE	
0	1	0	1
1	0	1	0
1	1	DISALLOWED	

c

FIG.1—THE SET-RESET FLIP-FLOP is built from two NOR gates *a*. Its symbol is shown in *b*, and its truth table in *c*.

DIGITAL IC'S CAN BE CLASSIFIED INTO TWO basic types: gates and flip-flops. The latter are also known as bistable latches and memory elements. Many devices are based on flip-flops, including counters, dividers, shift registers, data latches, etc., as well as presettable up/down counters and dividers, and other devices.

In this article we will explain how several types of flip-flops work. Then we'll go on to discuss several versatile CMOS flip-flops. Last, we'll show many practical circuits that use flip-flops.

Basic principles

The simplest type of CMOS flip-flop is the cross-coupled bistable latch shown in Fig. 1-*a*. The circuit is built from two NOR gates; it has two inputs (usually tied low via pull-down resistors), and a pair of out-of-phase outputs. The circuit works like this: If the SET terminal is briefly taken high, the Q output immediately goes high, and the $\overline{Q}$ output goes low. The cross-coupling between the two gates causes the outputs to latch in that state, even when both inputs are pulled low again. The only way the output states can be changed is by applying a high to the RESET terminal, in which case the Q output immediately goes low, and the $\overline{Q}$ output goes high. Again, cross-coupling causes the outputs to latch into the new state even when both inputs are pulled low.

Because of the latching action, the basic Set-Reset (S-R) flip-flop acts as a simple memory element that "remembers" which of the two inputs last went high. Note, however, that the output state cannot be predicted if both inputs go high simultaneously, so that must not be allowed to occur. Fig. 1-*b* shows the symbol of the S-R flip-flop, and Fig. 1-*c* shows its truth table.

The versatility of the basic circuit can be enhanced greatly by wiring an AND gate in series with each input terminal as shown in Fig. 2. That way high input signals can reach the S-R flip-flop only when the clock (CLK) signal is also high. Therefore, when CLK is low, both inputs of the flip-flop are held low, irrespective of the states of the SET and RESET inputs, so the flip-flop functions as a "permanent" memory. However, when CLK is high, the circuit functions as a standard S-R flip-flop. Consequently, information is not automatically latched into the flip-flop, but must be "clocked" in; that's why the circuit is known as a clocked S-R flip-flop.

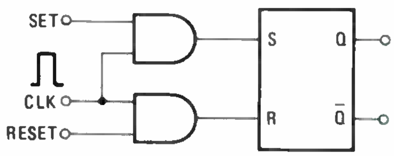


FIG. 2—THE CLOCKED S-R FLIP-FLOP is built from two AND gates, in addition to the S-R flip-flop.

Figure 3-*a* shows how to make the most important of all flip-flops, the clocked master-slave flip-flop. It's built from two clocked S-R flip-flops that are cascaded and clocked out of phase via an inverter in the clock line.

It works as follows. When the CLK input is low, the inputs to the master flip-flop are enabled via the inverter, so the SET-RESET data is accepted. However, the inputs to the slave flip-flop are disabled, so the data is not passed to the output terminals. Then, when the CLK input goes high, the inputs to the master flip-flop are disabled, so the input data is latched in the outputs; simultaneously, the input to the slave flip-flop is enabled, and the latched data is passed to the output terminals. The symbol of the clocked master-slave flip-flop is shown in Fig. 3-*b*.

The clocked master-slave flip-flop can be made to toggle (or divide by two) by cross-coupling the input and output terminals as shown in Fig. 4-*a*. By doing so, SET and Q (and RESET and $\overline{Q}$) are always at opposite logic levels. So when CLK goes

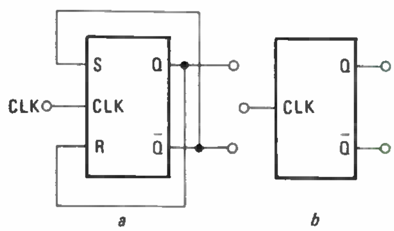


FIG. 4—THE TOGGLE OR TYPE-T FLIP-FLOP (*a*) is built from a clocked master-slave flip-flop. Its symbol is shown in *b*.

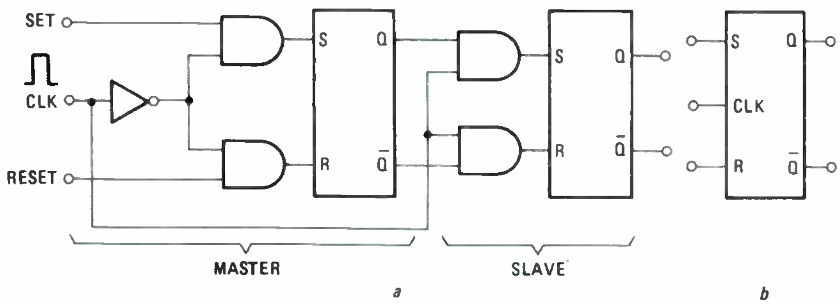


FIG. 3—THE CLOCKED MASTER-SLAVE FLIP-FLOP (*a*) is built from two S-R flip-flops driven by an out-of-phase clock. Its symbol is shown in *b*.

low, the master flip-flop changes state. When CLK goes high, the slave flip-flop changes state. Note that the output states change on the arrival of the leading edge of each new clock pulse.

It takes two clock pulses to change the output from one state to another and back again, so the frequency of the output is half the frequency of the clock. The circuit is known as a Toggle (or type-T) flip-flop; its symbol is shown in Fig. 4-*b*.

The D flip-flop

The type-T flip-flop is a special device that functions only as a counter/divider. A far more versatile device is the Data or type-D flip-flop, which is made by connecting the clocked master-slave flip-flop as shown in Fig. 5-*a*. In that circuit, an inverter is wired between the S and R terminals of the flip-flop, so those terminals are always out of phase, and the input is applied via a single pin. Fig. 5-*b* and Fig. 5-*c* show the symbol and the truth table of the type-D flip-flop, respectively.

A type-D flip-flop can be used as a data latch by connecting it as shown in Fig. 6-*a*, or as a binary counter/divider by connecting it as shown in Fig. 6-*b*.

The JK flip-flop

Figure 7-*a* shows the basic circuit of an even more versatile clocked flip-flop, which is universally known as the JK-type. It can function either as a data latch, a counter/divider, or as a do-nothing element by suitably connecting the J and K terminals. The symbol of the JK flip-flop is shown in Fig. 7-*b*, and its truth table is shown in Fig. 7-*c*.

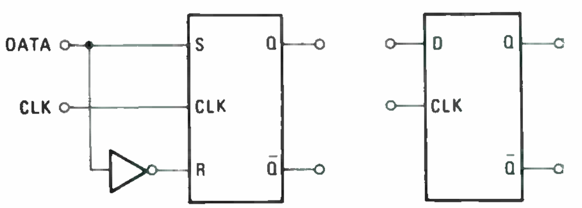
In essence, the JK flip-flop functions as a T-type when inputs are both high, and as a D-type when they're different. When they're both low, the outputs remain unchanged when a pulse arrives.

Real-world devices

The two best-known clocked CMOS flip-flops are the 4013 D-type and the 4027 JK-type. Each IC contains two independent flip-flops that share power and ground connections. Figure 8-*a* shows the functional diagram of the 4013; the truth table of its clocked inputs is shown in Fig. 8-*b*, and that of its direct inputs is shown in Fig. 8-*c*. Corresponding diagrams for the 4027 are shown in Fig. 9-*a*, Fig. 9-*b*, and Fig. 9-*c*.

Note that both the 4013 and the 4027 have SET and RESET inputs in addition to the normal clocked inputs. For both IC's those terminals are direct inputs that enable the clocked action of the flip-flop to be overridden, in which case the device functions as a simple unclocked S-R flip-flop. For normal clocked operation, the direct inputs must be grounded.

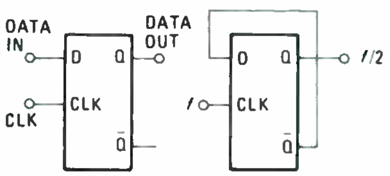
The 4013 and 4027 are fast-acting, so it is important that their clock signals be absolutely noise-free and bounceless, and that they have risetimes and falltimes of less than five μs. Both IC's clock on the positive transition of the clock signal.



D	CLK	Q	Q̄
0	↑	0	1
1	↑	1	0

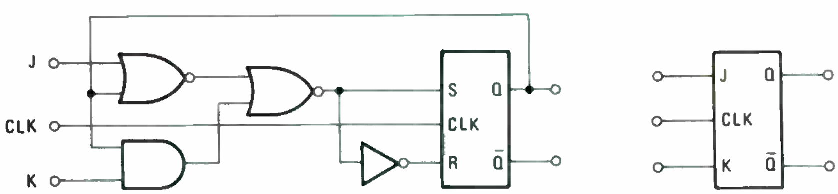
a b c

FIG. 5—THE DATA OR TYPE-D FLIP-FLOP *a* is built from a clocked master-slave flip-flop. Its symbol is shown in *b*, and its truth table in *c*.



a b

FIG. 6—THE D FLIP-FLOP can be used as a data latch (*a*) or as a divide-by-two counter (*c*).



a b

J	K	CLOCKING ACTION
0	0	DOES NOTHING (INHIBITS)
0	1	SETS Q OUTPUT LOW
1	0	SETS Q OUTPUT HIGH
1	1	CHANGES OUTPUT STATE

c

FIG. 7—THE JK FLIP-FLOP'S CIRCUIT is shown in *a*, along with its symbol (*b*) and action table (*c*.)

Ripple counters

The most popular application of the clocked flip-flop is as a binary counter. Fig. 10-*a* shows how to connect the 4013 as a divide-by-two counter; Fig. 10-*b* shows the corresponding connections for the 4027. When clocked by a fixed-frequency waveform, both circuits give a symmetrical square-wave output at half the clock frequency.

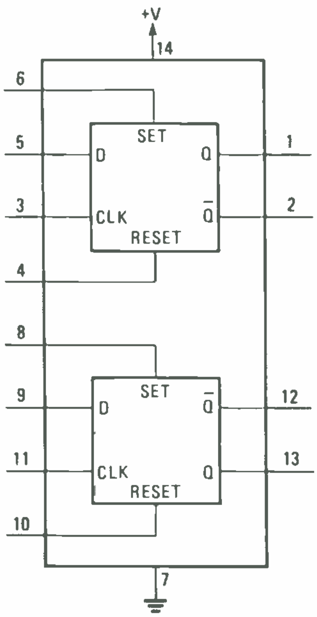
As shown in Fig. 11, you can cascade several ripple counters (so called because of the way that clock pulses appear to ripple from stage to stage) to provide division by successive powers of two. Figure 11-*a* shows how to cascade two D-type flip-flops, and Fig. 11-*b* shows how to cascade two JK-type flip-flops to provide a division ratio of 4 (2 × 2 or 2^2). In a like manner, Fig. 12-*a* and Fig. 12-*b* show how three stages can be cascaded to give a division ratio of eight (2^3). In fact, an arbitrary number of stages can be cascaded, as shown in Fig. 13, to provide a division ratio of 2^n, where *n* is the number of stages.

The circuits shown in Fig. 11–Fig. 13 are known as ripple counters, because each stage is clocked by the output of the preceding stage, rather than by a master clock signal. The effect, therefore, is that the clock signal seems to "ripple" through the counter chain. The problem is that the propagation delays of all the dividers add together and provide a delay that prevents the counter stages from clocking synchronously. Counters of that sort are in fact called asynchronous counters. If the outputs of the stages are decoded via gate networks, output glitches and inaccurate decoding can result.

Long ripple counters

Although 4013 and 4027 counters can be cascaded to give any desired number of stages, when more than four stages are needed, it's usually economical to use a special-purpose MSI ripple-carry binary counter/divider IC. Our next few figures show several examples.

The 4024, shown in Fig. 14, is a seven-stage ripple counter; all seven outputs are externally accessible. The IC provides a maximum division ratio of 128 (2^7). The



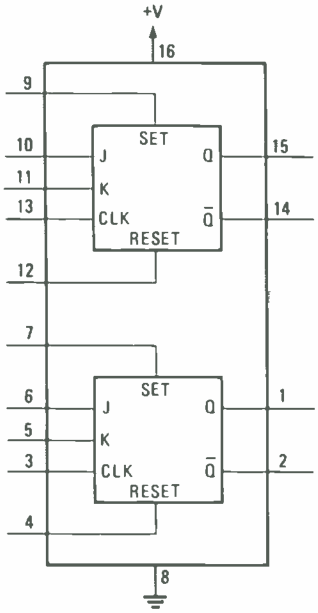
CLOCKED INPUTS			
D	CLK	Q	$\bar{Q}$
0	↑	0	1
1	↑	1	0
$\bar{Q}$	↑	CHANGES	

b

DIRECT INPUTS			
R	S	Q	$\bar{Q}$
0	0	CLOCKED OPERATION	
0	1	1	0
1	0	0	1
1	1	DISALLOWED	

c

FIG. 8—THE 4013 contains two type-d flip-flops (*a*). Truth tables for its clocked and direct inputs are shown in *b* and *c*, respectively.



CLOCKED INPUTS				
K	J	CLK	Q	$\bar{Q}$
0	0	↑	NO CHANGE	
0	1	↑	1	0
1	0	↑	0	1
1	1	↑	CHANGES	

b

DIRECT INPUTS			
R	S	Q	$\bar{Q}$
0	0	CLOCKED OPERATION	
0	1	1	0
1	0	0	1
1	1	DISALLOWED	

c

Fig. 9—THE 4027 contains two JK flip-flops (*a*). Truth tables for its clocked and direct inputs are shown in *b* and *c*, respectively.

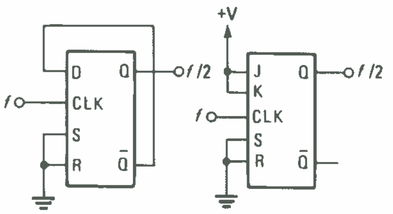


FIG. 10—TO DIVIDE FREQUENCY BY TWO, you can use a D (*a*) or a JK (*b*) flip-flop.

4040, shown in Fig. 15, is a 12-stage device, of which all outputs are accessible. It provides a maximum division ratio of 4096 (2^{12}). The 4020, shown in Fig. 16, is a 14-stage counter; all outputs except 2 and 3 are externally accessible. The 4020 provides a maximum division ratio of 16,384 (2^{14}).

Figure 17-*a* shows details of the 4060. It is another 14-stage device, but outputs 1, 2, 3, and 11 are not accessible. A special feature of the IC is that it incorporates a built-in oscillator circuit. As shown in Fig. 17-*b* and Fig. 17-*c*, the device can use either a crystal or an RC network to set the frequency of oscillation.

The 4020, 4024, 4040, and 4060 IC's all have Schmitt-trigger inputs that trigger on the negative transition of each input pulse. All of those counters can be set to zero by applying a high level to the RESET line.

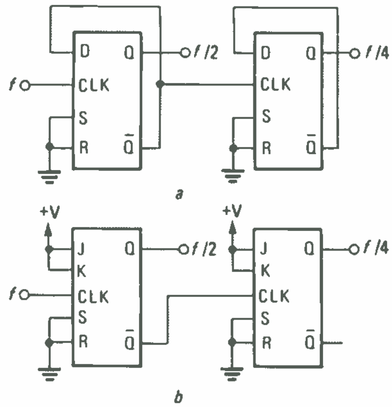


FIG. 11—TO DIVIDE FREQUENCY BY FOUR, you can use a pair of D (*a*) or JK (*b*) flip-flops.

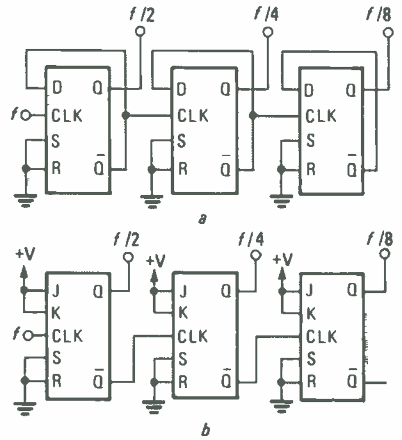


FIG. 12—TO DIVIDE FREQUENCY BY EIGHT, you can use three D (*a*) or JK (*b*) flip-flops.

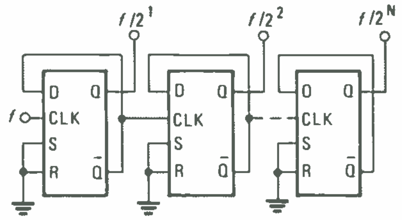


FIG. 13—TO DIVIDE FREQUENCY by an arbitrary factor 2^n, use *n* stages.

Glitches

A two-stage divide-by-four ripple counter, like that shown in Fig. 18-*a*, can have four possible output states, as shown in Fig. 18-*b*. Both outputs can be high, both can be low, one can be high and the other low, or the former low and the latter high. Before any clock pulses have been received, the Q2 and Q1 outputs are low. When the first pulse arrives, Q1 goes high. When the second pulse arrives, Q2 goes high and Q1 goes low. On the third pulse, Q2 and Q1 both go high. Last, on the fourth pulse, Q2 and Q1 both go low again.

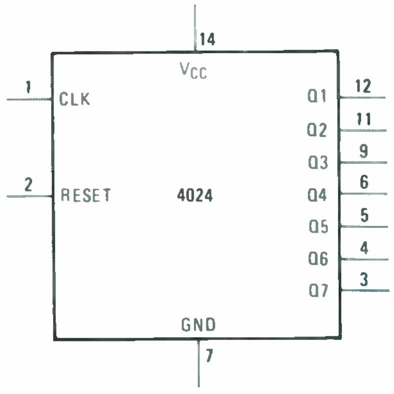


FIG. 14—PINOUT OF THE 4024 seven-stage ripple counter is shown here.

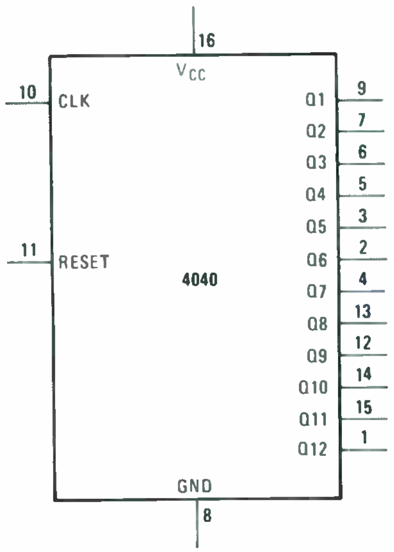


FIG. 15—PINOUT OF THE 4040 12-stage ripple counter is shown here.

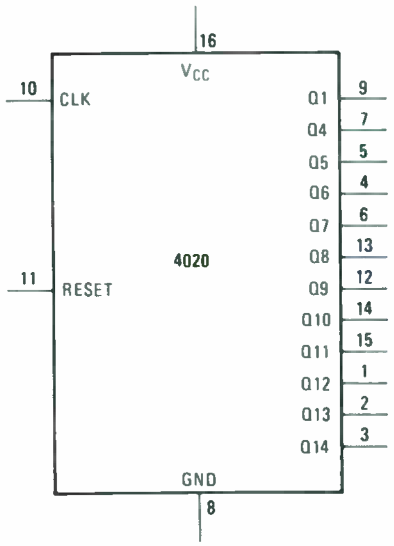


FIG. 16—PINOUT OF THE 4020 14-stage ripple counter is shown here.

Each of the four possible states can be decoded to provide four unique outputs by ANDing the outputs that are unique to each state, as shown in Fig. 18-*c*. Because the ripple counter is an asynchronous device, however, the propagation delay between the two flip-flops may cause glitches to appear in the decoded outputs, as shown in Fig. 18-*d*. Of course, those types of glitches are possible with any multi-stage ripple counter, and the greater the number of stages, the greater the total propagation delay becomes, and the greater the problem with glitches. The solution to the glitch problem is to use a clocked-logic device, which we'll discuss momentarily.

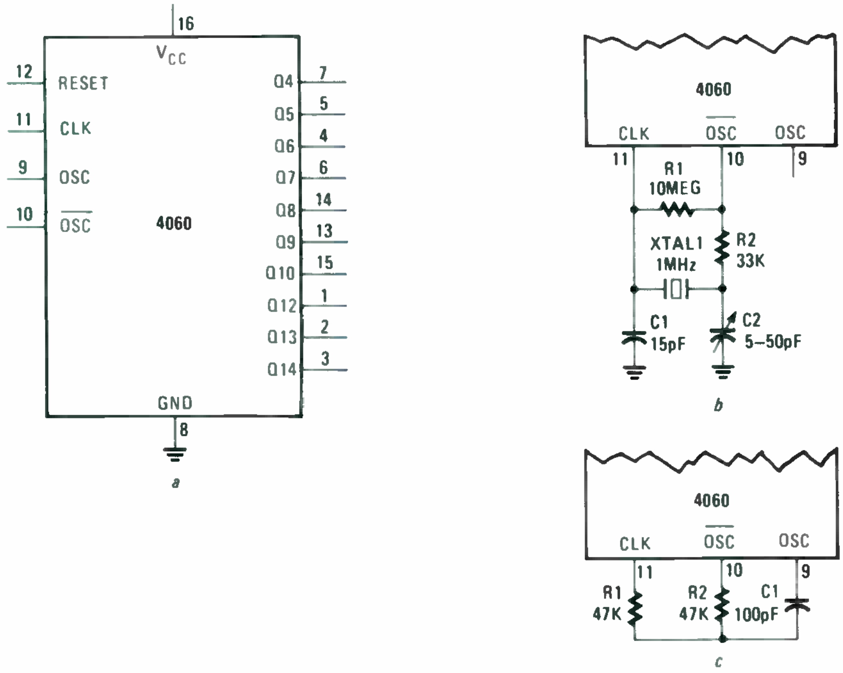
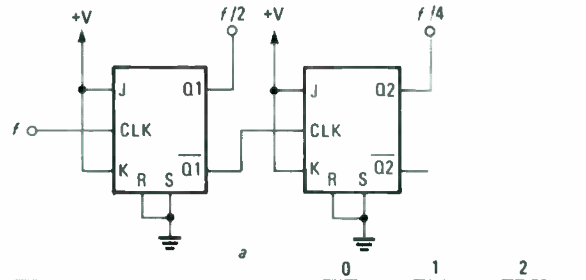


FIG. 17—THE 4060's PINOUT is shown in *a*; several oscillator connections are shown in *b* and *c*.



CLOCK CYCLE	Q2	Q1
0	0	0
1	0	1
2	1	0
3	1	1

b

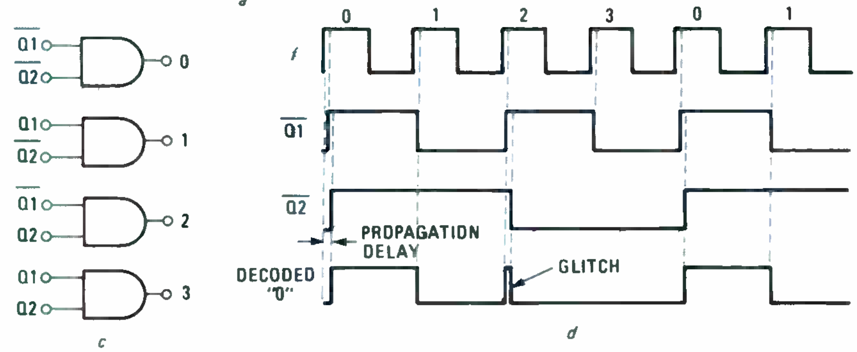


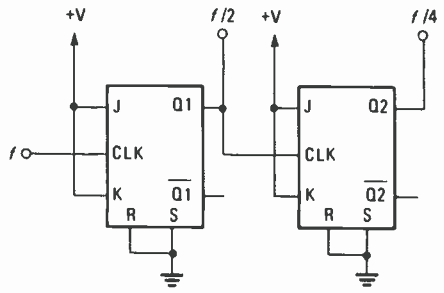
FIG. 18—GLITCHES may be generated when decoding a ripple counter like that shown in *a*. The Q1 and Q2 outputs respond to the input signal as shown in *b*. When they're combined as shown in *c*, a glitch may be generated, as shown in *d*.

Up and down counters.

A standard ripple counter counts up—the decoded outputs increase in value with each succeeding clock pulse. It is possible, however, to build a counter that works in the opposite direction. That type of counter is called a down (or a subtract) counter. The circuit is shown in Fig. 19-*a*; its truth table is shown in Fig. 19-*b*.

Walking-ring (Johnson) counters

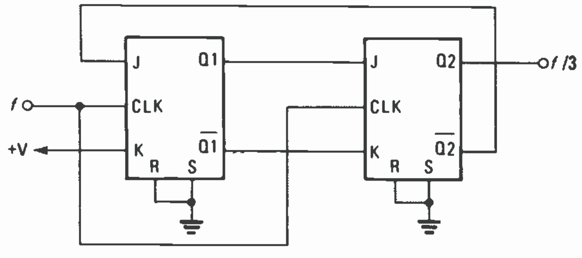
Ripple counters are useful where undecoded binary division is needed, but



CLOCK CYCLE	Q2	Q1
0	0	0
1	1	1
2	1	0
3	0	1

b

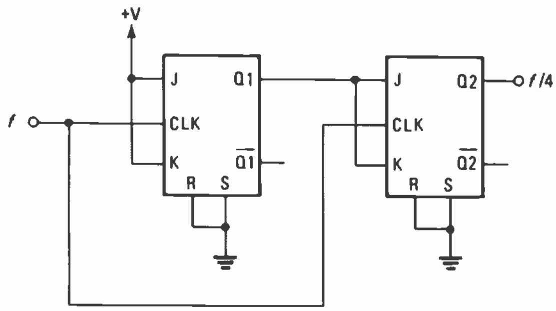
FIG. 19—A DOWN-COUNTING RIPPLE COUNTER is shown in *a*; the truth-table is shown in *b*.



CLK CYCLE	Q2	Q1	FF2 JK CODE	FF2 INSTRUCTION	FF1 JK CODE	FF1 INSTRUCTION
0	0	0	0 1	SET Q2 LOW	1 1	CHANGE STATE
1	0	1	1 0	SET Q2 HIGH	1 1	CHANGE STATE
2	1	0	0 1	SET Q2 LOW	0 1	SET Q1 LOW
0	0	0				

b

FIG. 20—THE SYNCHRONOUS COUNTER eliminates glitches; a divide-by-three circuit is shown in *a*, and its truth-table in *b*.



CLOCK CYCLE	Q2	Q1
0	0	0
1	0	1
2	1	0
3	1	1

b

FIG. 21—A SYNCHRONOUS DIVIDE-BY-FOUR CIRCUIT is shown in *a*; its truth table is shown in *b*.

(because of glitches) not where decoded outputs are required. Fortunately, an alternative circuit, which is suitable for generating decoded outputs, is available. It is known as the walking ring or Johnson counter. It relies on the "programmable" nature of the JK flip-flop, which enables it to act as a SET (or a RESET) latch, as a binary divider, or as a "do nothing" device. In a walking-ring counter, all flip-flops are clocked simultaneously, so it is also known as a synchronous counter.

Figure 20-*a* shows the circuit and Fig. 20-*b* the truth table of a synchronous divide-by-three counter. Note that the truth table shows the state of each flip-flop at each stage of the counting cycle. Remember that, when the clock is low, the "instruction" is loaded (via the J and K inputs) into the flip-flop; the instruction is carried out as the clock goes high.

So, at the start of the cycle, Q2 and Q1 are both low, and the "change state" instruction (JK code 11) is loaded into the first flip-flop. Then the instruction "set Q2 low" (JK code Ø1) is loaded into the first flip-flop. When the first clock pulse arrives, the instruction is carried out, Q1 goes high, and Q2 stays low.

When the clock goes low again, new program information is fed to the flip-flops. Flip-flop 1 is instructed to change state (JK code 11), and flip-flop 2 is instructed to set Q2 high (JK code 1Ø). Those instructions are executed on the positive transition of the second clock pulse, causing Q2 to go high and Q1 to go low. When the clock goes low again, new program information is again fed to each flip-flop from the output of its partner. The counting sequence then repeats *ad infinitum*.

So in the walking-ring or Johnson counter, all flip-flops are clocked in parallel, but are cross-coupled so that the response of one stage (to a clock pulse) depends on the states of the other stages.

Walking-ring counters can be configured to give any desired count ratio. For example, Fig. 21-*a* and Fig. 21-*b* show the circuit and truth table respectively of a divide-by-four counter. Figure 22-*a* and Fig. 22-*b* show the circuit and truth table respectively of a divide-by-five counter.

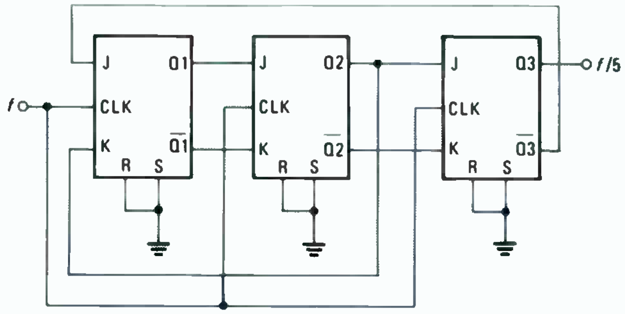
The 4018

When synchronous counts greater than four are needed, it is usually economical to use an MSI IC rather then several 4027's. A suitable device is a 4018, a presettable divide-by-N counter that can be made to divide any whole number between 2 and 10 by cross-coupling input and output terminals in various ways. That IC incorporates a five-stage Johnson counter, has a built-in Schmitt trigger in its clock line, and clocks on the positive transition of the input signal. The counter is said to be presettable because the outputs can be set to a desired state at any time by feeding the inverted binary code to the Jam inputs (J1–J5) and then loading the data by taking pin 10 high.

Figure 23 shows how to connect the 4018 to give any whole-number division ratio between 2 and 10. No additional components are needed to obtain an even division ratio, but a two-input AND gate (a 4081, for example) is required to obtain an odd division ratio.

Greater-than-ten division

Even division ratios greater than ten can usually be obtained simply by cascading suitably scaled counter stages, as shown in Fig. 24-*a*–Fig. 24-*d*. Non-standard and uneven division ratios can be



a

CLOCK CYCLE	Q3 Q2 Q1
0	0 0 0
1	0 0 1
2	0 1 1
3	1 1 0
4	1 0 0

b

FIG. 22—A SYNCHRONOUS DIVIDE-BY-FIVE CIRCUIT is shown in *a*; its truth table is shown in *b*.

DIVISION RATIO	FEEDBACK CONNECTIONS
2	$\overline{Q1}$ TO DATA
3	$\overline{Q1}$, $\overline{Q2}$ (AND) → TO DATA
4	$\overline{Q2}$ TO DATA
5	$\overline{Q2}$, $\overline{Q3}$ (AND) → TO DATA
6	$\overline{Q3}$ TO DATA
7	$\overline{Q3}$, $\overline{Q4}$ (AND) → TO DATA
8	$\overline{Q4}$ TO DATA
9	$\overline{Q4}$, $\overline{Q5}$ (AND) → TO DATA
10	$\overline{Q5}$ TO DATA

FIG. 23—TO OBTAIN AN ODD DIVISION RATIO with the 4018, an external AND gate must be used.

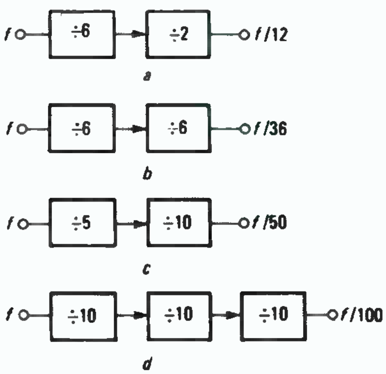


FIG. 24—A DIVISION RATIO OF arbitrarily large size may be obtained by cascading divider stages and multiplying the division factor. In *a* is a divide-by-12 *(2 × 6)* circuit, in *b* a divide-by-36 circuit *(6 × 6)*, in *c* a divide-by-50 *(5 × 10)*, and in *d* a divide-by-1000 *(10 × 10 × 10)* circuit.

obtained by using a standard synchronous counter (the 4018, for example) and decoding the outputs to generate suitable counter-reset pulses when the desired count is attained.

Latches and registers

Now let's move away from counters and take a brief look at three other applications of the clocked master-slave flip-flop.

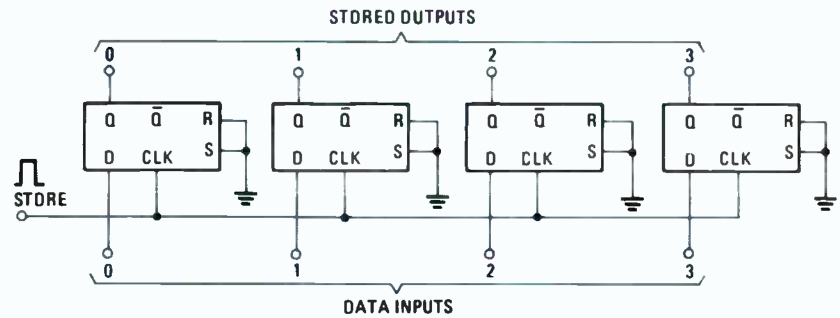


FIG. 25—TO STORE FOUR BITS OF DATA, all four inputs are clocked simultaneously.

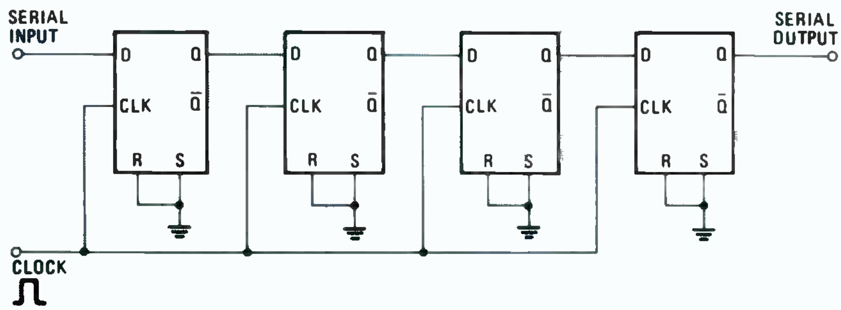


FIG. 26—FOUR TYPE-D FLIP-FLOPS are cascaded to create a four-bit SISO shift register.

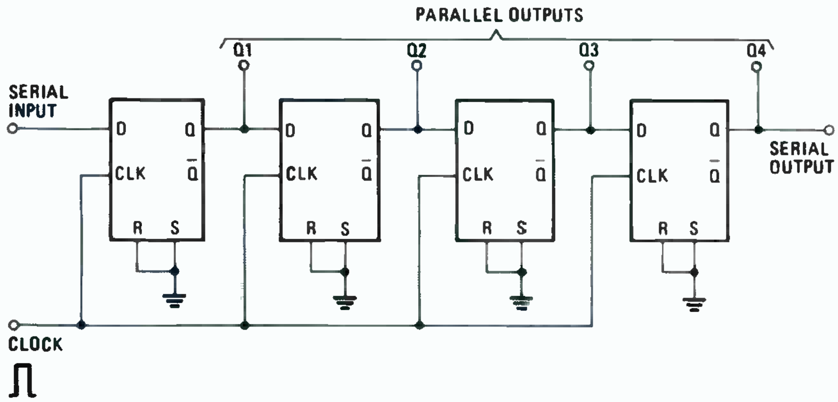


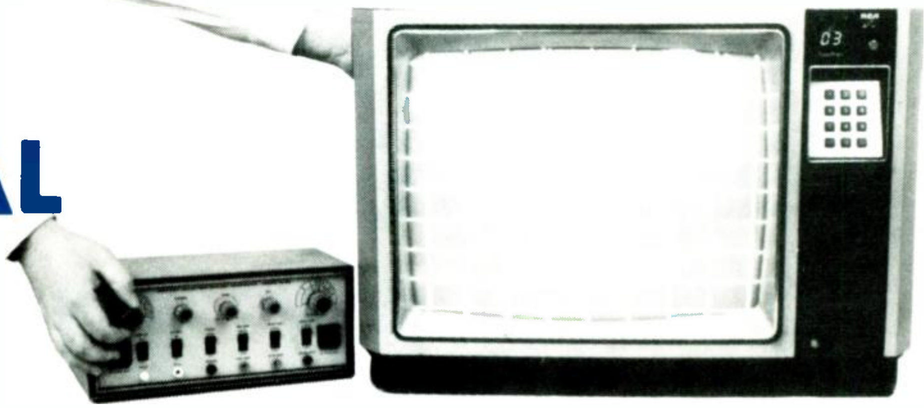
FIG. 27—FOUR TYPE-D FLIP-FLOPS are cascaded to create a four-bit SIPO shift register.

Figure 25 shows how to make a four-bit data latch from four D-type flip-flops. The data latch is useful for storing binary numbers or data. Input data is ignored until a positive-going STORE pulse is applied, at which point the latch stores the data and outputs it on the Q outputs.

Figure 26 shows how to make a four-bit *S*erial-*I*n/*S*erial-*O*ut (SISO) shift register. A bit of binary data applied to the input is passed to the output of the first flip-flop on the application of the first clock pulse, to the output of the second on the second pulse, to the output of the third on the third pulse, and to the fourth (and final) output on the fourth pulse. The circuit can hold four bits of data at any given moment. The SISO register is useful for delaying binary signals, or for storing bits of binary data and unloading them (in serial form) when required.

Figure 27 shows how the previous circuit can be converted to a *S*erial-*I*n/*P*arallel-*O*ut (SIPO) shift register simply by using the Q outputs of each flip-flop. The circuit might be useful, for example, in converting data transmitted from a remote location in serial form to the parallel form used by computers. **R-E**

TV Troubleshooter's Notebook: BLACK VERTICAL BARS



JAY SHANE

Here's a real "head-scratcher" from the files of a TV-service technician.

WE'VE BEEN SUBSTITUTING COMPONENTS in TV sets and radios since the first day we discovered it could be done. Though sometimes it's done to the detriment of good servicing, often a technician has no other choice. The following is an experience of that sort.

Flyback fireworks

A Wards color TV, model *GGY-12983A*, came in with symptoms of no picture or sound, and it smoked. A cursory inspection revealed that the horizontal transistor was okay and that the flyback didn't have any swollen places or cracks in its shell. However, when the set was fired up there were fireworks under the chassis in the area of the flyback.

The receiver was stood on end to expose the full circuit panel. We immediately could see that a carbon path was burnt between two traces. Not being acquainted with this particular chassis, it was necessary to dig out the Sams folder. However, we were in for a surprise: Though the model was almost five years old it was still not listed.

The set's owner was a loyal customer, so since it was a quiet day we decided to search our folder file to see if we had servicing information for anything that was close to that chassis. Luckily, a similar one was found in Sams Photofact folder 2165-2; it was for a Wards model *GNB-12914A,B*. The component layout and the schematic numbering for the two sets were almost identical.

Now we could see that the carbon path ran from pin-7 of the flyback to the far side of a two-amp fuse, FS-501, located in the 117-volt line to pin 3 of the flyback. See Fig. 1.

It the set, those traces ran parallel, about ⅛-inch apart, for about three inches. Pin 7 is the return of the internal rectifiers in the flyback going to the 23.8-volt leg of the low-voltage power supply. The arc-over meant that excessive reverse current was flowing from the tripler section of the transformer.

Replacing the flyback was the only solution. No American manufacturer was listed so the part had to be ordered from Montgomery-Ward at list. The customer was notified of the estimate for repairs and he gave the go-ahead.

When it was received, the replacement transformer turned out to be a substitute. The original was part 50 3015344-02, type B. Their data sheet showed the substitute to be a 361883-0003, type B. The two parts appeared to be identical in every respect.

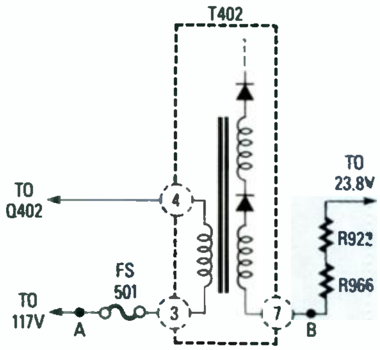


FIG. 1—ARCING BETWEEN POINTS A and B was caused by a defective flyback. Later we found that R966 was cracked, too.

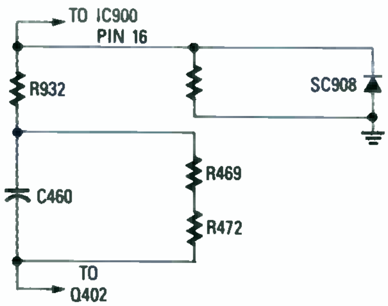


FIG. 2—THE BLACK BARS were caused by an abnormal horizontal pulse at the junction of R469, R932, and C460.

More problems

After the flyback was installed, excess solder and rosin were cleaned from the solder terminals with a wire brush. Each soldered terminal was then carefully checked for resistance to the nearest circuit component.

Satisfied that there were no circuitry leakages, the receiver was fired up. When it came on without any apparent further problems, it was placed on the cooking bench to run for several hours. That's when the new symptom developed: There were now four and a half black vertical bars at the left side of the screen. There was also a faint streaking in the picture and raster. What happened?

After some head scratching, we remembered that a similar symptom had shown up once in a totally different brand. The cause had something to do with pulse feed.

An analysis of the circuitry revealed an RC network between the horizontal-output transistor, Q-402, and pin 16 of the video/chroma processor, IC-900. That component is shown in Fig. 2.

Checking the horizontal pulse at the junction of R932, C460, and R469 with an oscilloscope showed that it was not normal; the pulse had excessive amplitude, and a sharp spike at its leading edge.

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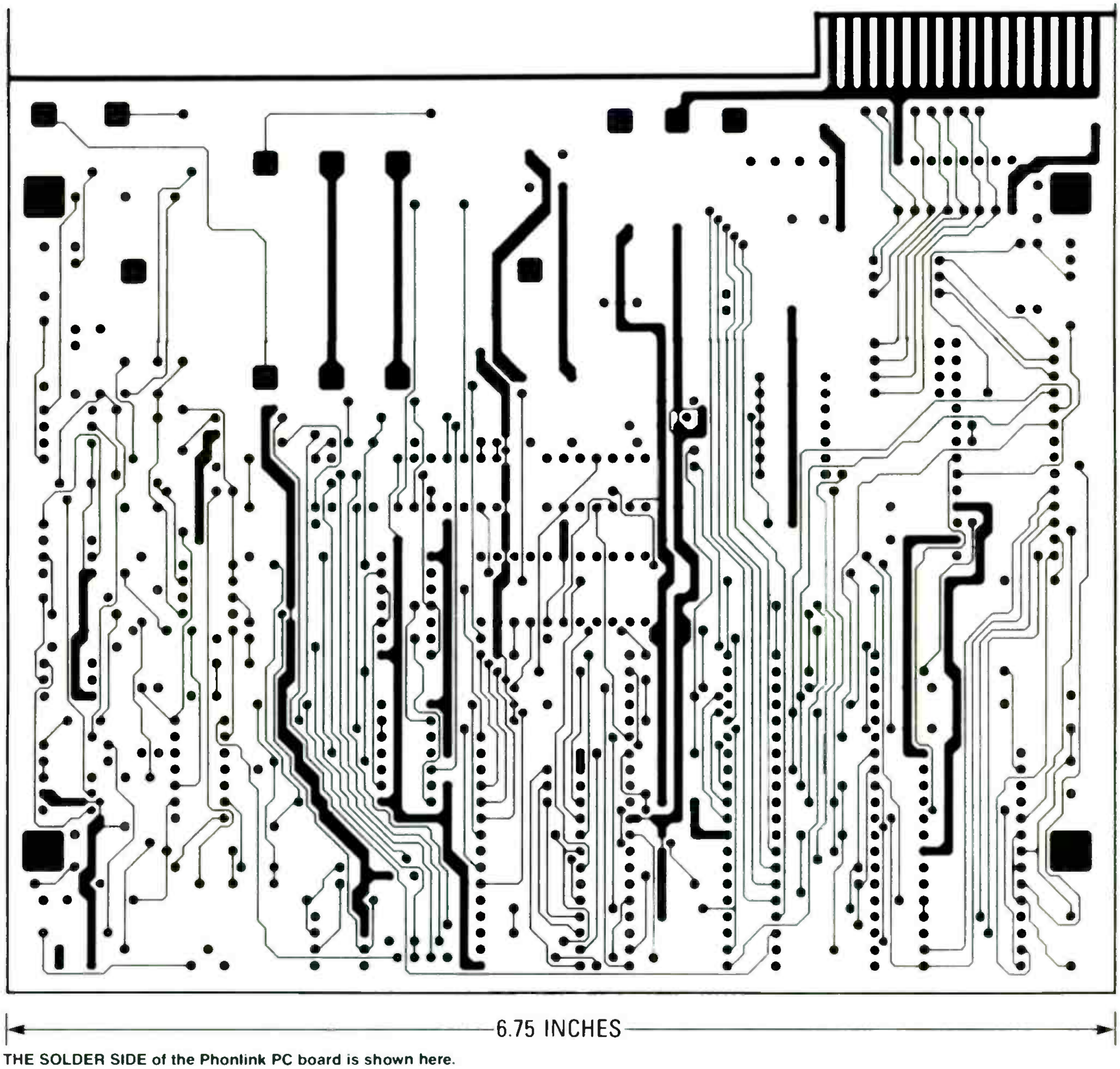
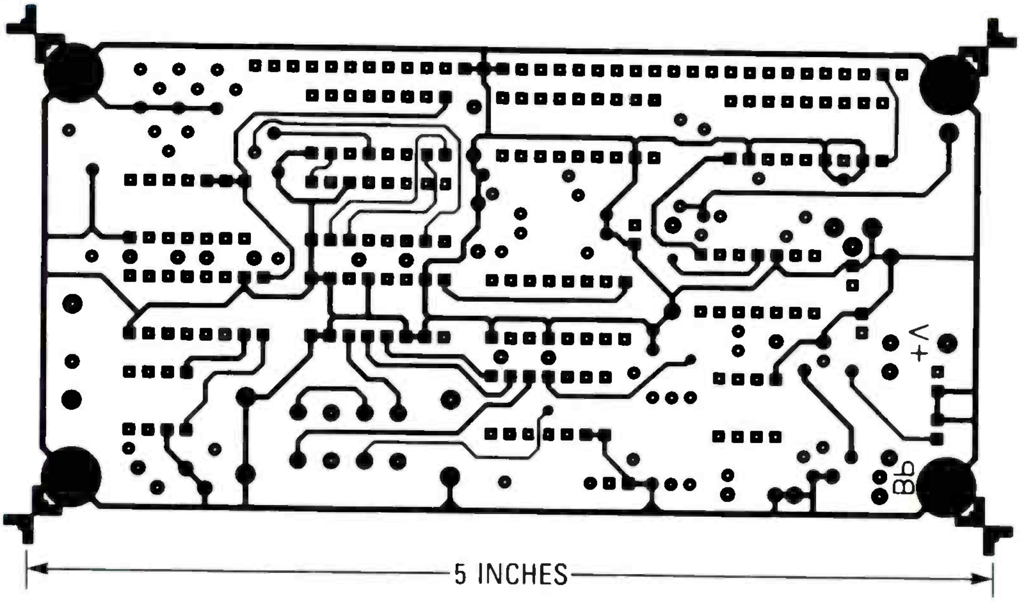
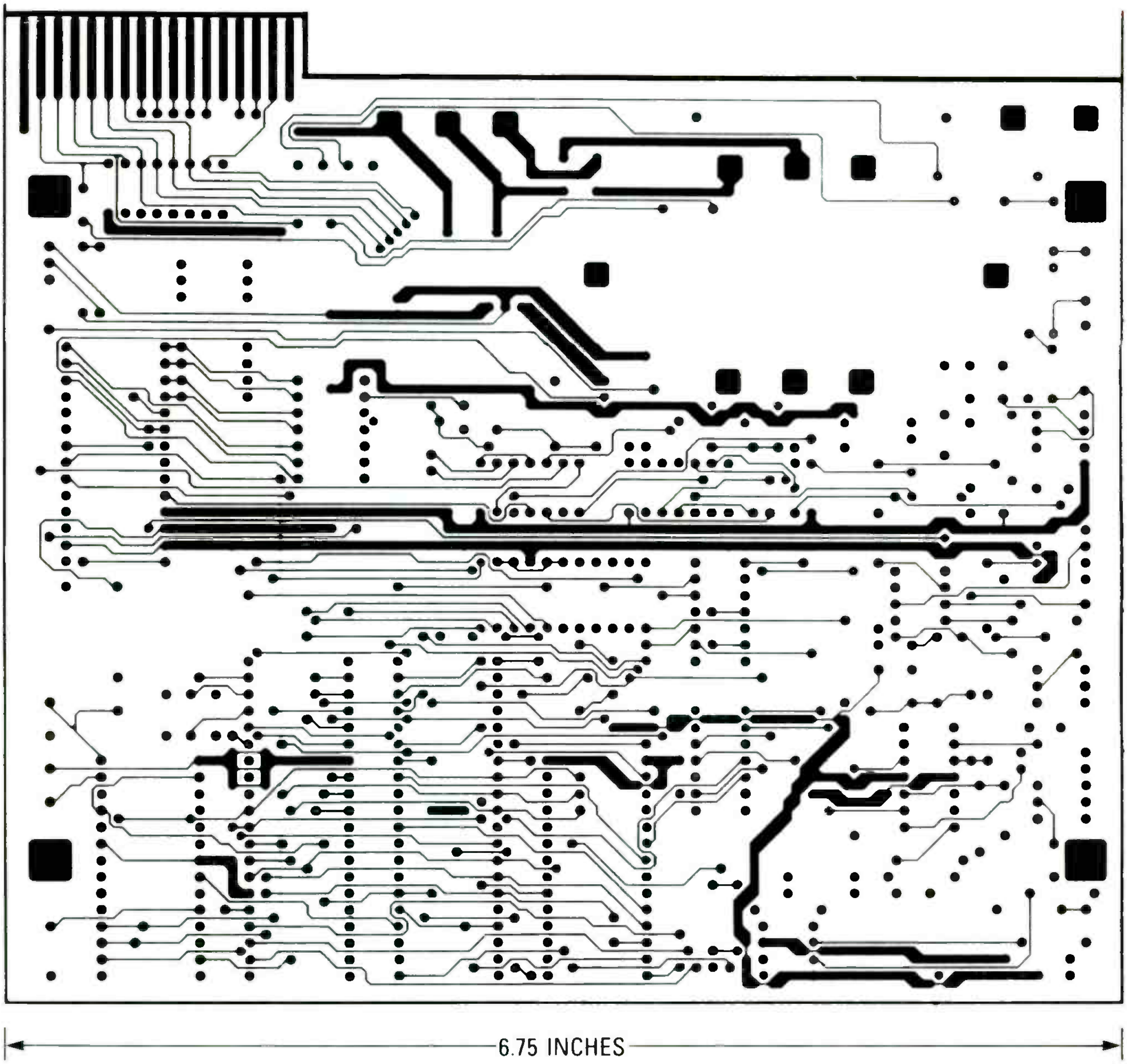


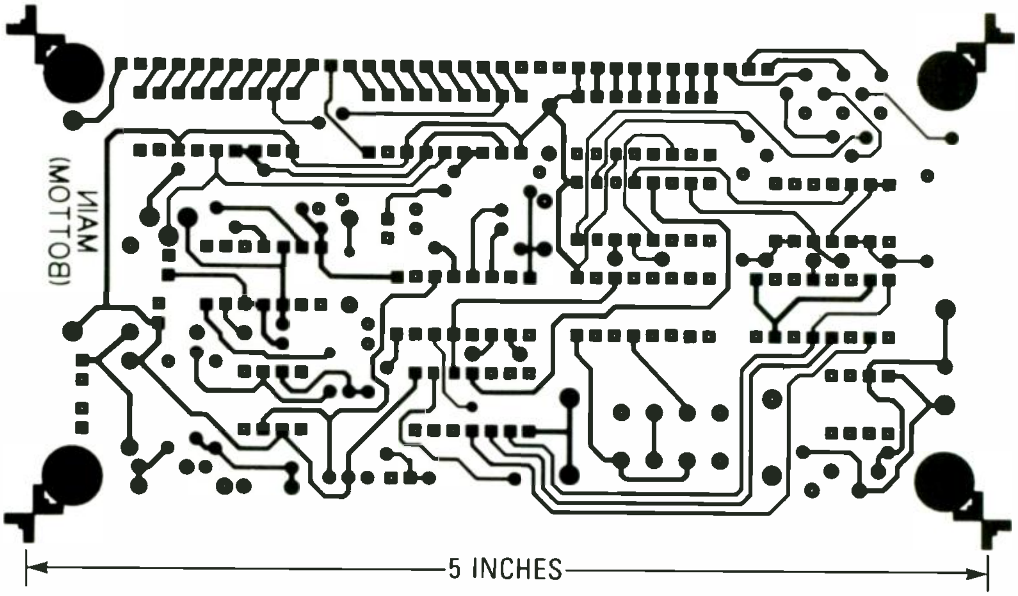
THE SOLDER SIDE of the Phonlink PC board is shown here.



THE COMPONENT SIDE of the digital tachometer.



THE COMPONENT SIDE of the double-sided Phonlink PC board.



THE SOLDER SIDE of the digital tachometer is shown here.

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

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

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

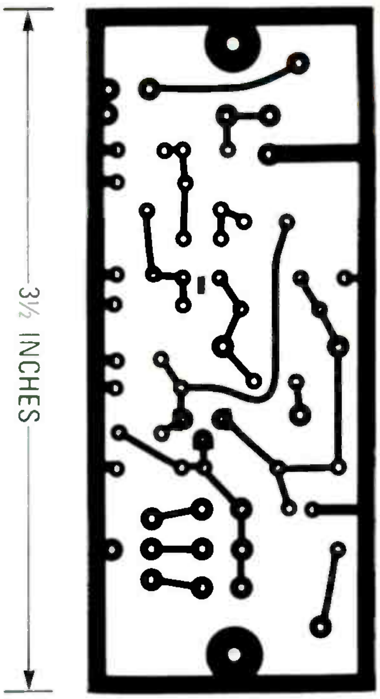
In order to produce a board directly from the magazine page, remove the page and carefully inspect it under a strong light and/or on a light table. Look for breaks in the traces, bridges between traces, and in general, all the kinds of things you look for in the final etched board. You can clean up the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

An optional step, once you're satisfied that the artwork is clean, is to take a little bit of mineral oil and carefully wipe it across the back of the artwork. That helps make the paper transluscent. Don't get any on the front side of the paper (the side with the pattern) because you'll contaminate the sensitized surface of the copper blank. After the oil has "dried" a bit—patting with a paper towel will help speed up the process—place the pattern front side down on the sensitized copper blank, and make the exposure. You'll probably have to use a longer exposure time than you are used to.

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

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

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



THIS SHORTWAVE CONVERTER PC board cannot be made using the direct-etch method.

SATELLITE TV

The ZITS fraud

BOB COOPER, JR.,
SATELLITE-TV EDITOR

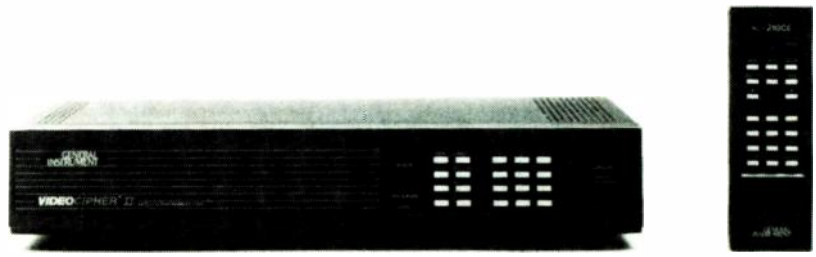


FIG. 1

IN OUR LAST REPORT WE RELATED THE unveiling of a *VideoCipher*-descrambling IC called the ZITS (*Z*ero *I*nformation *T*urn-on *S*ystem) or European Chip. We noted that it functions by snaring a *VC2000* authorization (ID) number from the satellite data stream and adopting that number as its own. In effect, the ZITS chip appeared to be outside the GI-controlled authorization system; and when it was installed in a descrambler, a home viewer could access scrambled transmissions without having to sign up and pay for any services.

It turns out that the ZITS chip is a fraud; the facts behind the apparently amazing chip are quite bizarre. And there's a lesson here for us all.

The European Chip was first introduced to the home-dish industry at a technical seminar held in mid-January, shortly after GI introduced the new consumer *VideoCipher* descrambler, the *2100E,* shown in Fig. 1. Anyway, the demonstration was impressive. A *VideoCipher* unit was unplugged from the AC power source, the internal lithium battery (which contains the unit's ID) was disconnected, and nearly 100 pins on various IC's inside the *VC2000* were purposely shorted to ground to ensure that the unit was "brain dead." Then the *VC2000* was reloaded with three IC's that not only restored operation, but the original factory ID as well.

The primary claim of the unit's designers was that it did not have a *real* unit-ID number at all, and that, as the GI authorization system transmitted valid addresses (via satellite), the device read the data stream and picked off an address to adopt as its own.

They further claimed that, if the adopted address later became inoperative, the European Chip would simply search out another available address ID and adopt it as the unit's new address.

Many who considered themselves acquainted with the inner workings of *VideoCipher* and the U7/U30 software were not satisfied with that explanation. They felt that if it worked at all, the unit had to have some other explanation.

Around the time of the first demonstration, a chip-scam originating on the West Coast began to surface. Someone had managed to extract an ID number from a *VC2000.* That number was then merged into a U30 EPROM using something the creator called a "loader chip." The sellers of that system made claims similar to those of the Europeans: No authorization was required because the IC was adopting data-stream-transmitted ID numbers as its own. The IC from the West Coast turned out to be a fraud; upon analysis a unit-ID number removed from an "innocent" unit was found buried inside the operational unit. In other words, the wonder-chip from the West Coast was not actually adopting any number at all; *it had its own number all along.*

The Europeans used similar tactics; using programming jumps, the unit-ID number was hidden from normal view in an obscure location in the EPROM's 16,384-byte address space. That was the end of the European Chip's claim to fame, but the mystery did not end there.

The unit-ID number discovered in the West Coast chips turned out to be the same unit-ID number found in the European Chip. In fact, as more and more chips were uncovered all over the U.S. and Canada, *they all had the same number* buried in various locations in the EPROM. It turned out that a single *VC2000,* belonging to a consumer in the midwest, was supporting thousands and thousands of clones!

Tracing the origin of the *VC2000* in question was not difficult. A consumer, sympathetic to the scrambling battles, had loaned his *VC2000* to a research group. After a month or so the unit was returned to that person, seemingly intact. What he did not know was that, while the unit was out of his possession, the key was extracted and stored. Later, the key would be sold and re-sold, traded and re-traded, to perhaps a dozen or more clone suppliers all over the United States, and perhaps the world. The consumer continued to use his *VC2000,* unaware that his subscriptions to Showtime *et al* were also supporting a lively nationwide business.

The truth is that a unit's factory-installed ID number can be extracted by anyone who has key-extraction hardware and software. Extraction could even happen at an authorized distributor or dealer, because it's done with clip-on devices that leave no trail. Therefore the key can easily become a clandestine commodity traded without the knowledge of the innocent owner.

European extras

The European Chip was really a combination of both clone and musketeer technology. It relied upon the unit-ID number of an innocent box to turn on; then it used musketeer software to authorize not only the services that the innocent box actually subscribed to, but the balance of the services as well. Even the cable-only WOR service, which is not available to home-TVRO owners, was included in the European Chip service menu, because someone had discovered a two-byte change in the software that enabled reception of WOR.

Exposure of the European Chip (and others operating under various names) as a fraud sent shock waves through the descrambling underground. That's because the capture of a single IC in a family would reveal the master ID number for the entire family, and that wou'd allow GI to disable many systems simultaneously.

The danger of such discovery has always been a problem with clone devices, so most clone-cells have been self-limited to 50 or fewer users per clone master. But claims made about the European Chip caused people to be less cautious about protecting clone-cell size.

Meanwhile GI has been tightening up on the flow of clone and musketeer IC's. Canadian musketeer suppliers have abandoned their system of shipping from Can-

continued on page 86

INTERESTED IN SCRAMBLING?

Bob Cooper's *CSD Magazine* maintains a 24 hour per day *Scramble-Fax-Hotline* telephone service (305/771-0575) which you may call to obtain a 3-minute recorded update on the latest happenings in the satellite scrambling world. *Scramble-Fax Newsletter* is also published to keep you abreast of the latest events in descrambling, including sources for descrambling chips and equipment. For information, write *Scramble Fax*, P.O. Box 100858, Ft. Lauderdale, FL. 33310 or telephone 305-771-0505.

If you have a dish of your own, tune in the Caribbean Super Station (Western 5, transponder 23) Tuesdays at 7 PM eastern for a special weekly Bob Cooper report. Also tune-in *Boresight* at 9 PM Thursday nights (Spacenet 1, transponder 9) for a weekly one-hour report on the activities in the home TVRO field.

AUDIO UPDATE

Unwanted sounds

LARRY KLEIN,
AUDIO EDITOR

YOU'VE JUST HELPED A FRIEND SET UP his new $5,000 audio system. For the first week or so he is extremely pleased; then the complaints start to come in. It's not that he's complaining to you, but that his neighbors are complaining to him. It seems that your friend's new speakers—which are renowned for their deep, strong bass—are achieving a different sort of fame throughout his condo. The problem is described in slightly hysterical terms by the lady in the apartment below: "All I hear all night is this boom-boom-boom!" Even allowing for some hyperbole, the neighbor's complaint is probably not unwarranted. Is there a solution?

Soundproofing.

Most people tend to confuse the techniques appropriate for soundproofing with those used for sound treatment. In general, the methods used for soundproofing (preventing noise originating inside a room from getting out—or noise from outside getting in) have little relevance to sound treatment (that is, adjusting the acoustic absorptive properties of a room). Soundproofing is by far the tougher problem.

Think of sound as vibrations of the air itself. Therefore, to keep sound out—or in—the first step is to make sure that insofar as is possible, all air transmission paths from one area to another are blocked. Those include seams around door edges, windows, ventilation ducts, etc. Most of the procedures used to prevent heat loss will also block sound. Measurements have shown that even the smallest air leakage path can defeat an otherwise effective sound-blocking approach.

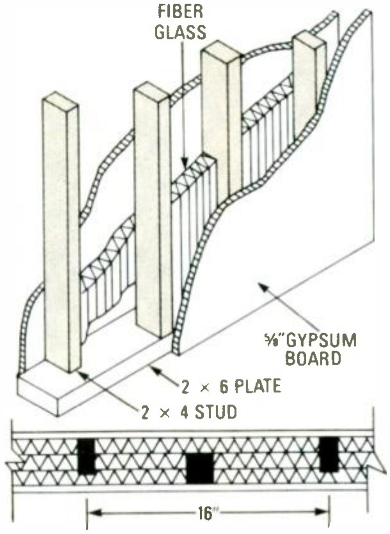


FIG. 1

Once the paths for airborne sound are located and eliminated—and that certainly isn't always easy—then you must minimize the vibrations in solids, which also serve to couple sound from one area to another. When acoustic vibrations (sound waves) impinge on a surface, they are likely to cause it to vibrate. In fact, sound waves vibrating your eardrums are essential to the hearing process. Sound gets through walls in two ways: vibratory transmission through a solid and/or diaphragmatic action.

A child's telephone consisting of two tin cans with a string stretched taut between them illustrates both principles in action. The acoustic energy from a voice causes the bottom of the can to act as a diaphragm that vibrates in response to the acoustic energy impinging on it. The mechanical vibration is transmitted by the taut string. At the receiving end, the vibrating string causes the receiving can-bottom diaphragm to vibrate the air and to recreate, more or less, the original sound. In much the same way, the walls of a room can act as a diaphragm to "pick up" sound and couple it to the next room either through the air spaces between the studs, or through the studs themselves.

Eliminating the diaphragm

To eliminate diaphragmatic transmission, you have to eliminate (or dampen) the diaphragm. One very effective technique is to increase the mass of the walls in the transmission path so that they no longer are able to vibrate freely. For example, you can use heavy wall panels instead of thin ones and/or you can brace the panels with 2 × 4 studs at 10- or 12-inch intervals instead of using the standard 16-inch spacing. Or instead of studs and panels between interior rooms, you can use brick, concrete, cinder blocks, etc.; all of which are excellent barriers to impinging airborne vibration. However, anyone who has ever used a string telephone—or communicated to a building superintendent in the basement by hammering on a radiator—knows that solids can also serve as excellent sound-transmission paths.

To minimize such transmission, one can build up a wall or door using sandwiched layers of different types of materials to take advantage of the fact that vibration tends to be attenuated when traveling through the interfaces of different materials. (The double-glass windows with internal spacing used in recording-studio control rooms function on that principle.) Tests have shown that even the screws or nails used to hold panels to studs can provide transmission paths. For that reason, cementing panels in place with the mastic material commonly used to mount ceiling tiles is a preferred technique when resistance to sound transmission is important.

An excellent sound-isolating wall-construction technique has been described by Owens-Corning Fiberglass Corporation. Shown in Fig. 1, it consists of staggered vertical 2 × 4's on a 4 × 6 sole plate arranged so that the two sides of ⅝-inch gypsum board partition wall are independently supported. Another 4 to 10 dB of sound attenuation can be achieved by filling the spaces between the walls with fiberglass insulation batting.

A one-inch layer of sand between closely spaced panels or beneath a false floor also forms an excellent inert high-mass sound barrier. For the same reason, sheet lead is used industrially as a popular sound-shielding material, either by itself or bonded to other materials.

Note that the lower frequencies, because of their greater energy content, are the ones that are most readily transmitted through walls and floors, and are therefore the most difficult to isolate or absorb. That's the reason why only the low "boom, boom, boom" (rather than the full audio range) was heard by the lady downstairs—and probably in other adjacent apartments. The higher frequencies, which are readily absorbed and blocked by acoustical tile and other absorbing materials, seldom get through to the neighbors unless there is a direct air-leakage path such as an air shaft. You can see how the the nature of the leaked sound provides a good clue as to the transmission path. If no highs are heard, air transmission is probably not at work.

Decoupling the speakers

At this point, it should be apparent that eliminating low-frequency transmission through walls or floors is no simple matter. For most people, and particularly apartment dwellers, the need for massive construction or reconstruction probably eliminates most of the available techniques right at the outset. For that reason, the very best place to cut down vibratory transmission is right at

continued on page 84

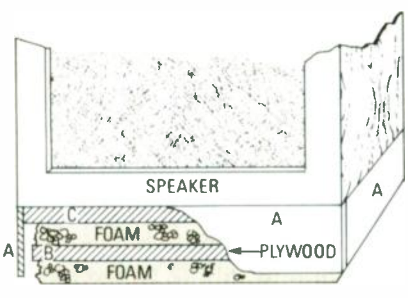


FIG. 2

ANTIQUE RADIOS

RICHARD D. FITCH

Restoring a classic

STARTING WITH THIS COLUMN, WE ARE going to change the focus of our discussions somewhat. In the past, we have primarily been interested in the history and evolution of radio, though we have also looked at topics ranging from cabinet styles to servicing. Now, we are going to look inside the radios themselves, including automotive radios, and study their circuitry. We'll also look at early Hi-Fi and FM circuitry, and early TV circuitry. Those whose interest is in restoring antique radios to operating condition will find these articles invaluable.

Radio of the month.

We'll start our look at early-radio electronics with the General Electric *A-53*. That model, which was produced in 1934, was very popular in its day. The one in my own collection is shown in Fig. 1. While I've had the set a long time, it has never worked. Also, I have never attempted to restore it. Now, we'll take an in-depth look at the radio's circuitry and then try and restore it together.

One reason that I've shied away from restoring that radio is that it is obviously not in its original condition. There is a hole in the cabinet front where the band switch should be, and another hole, midway up on the right-hand side of the cabinet, where nothing should be. Looking at the rear of the set, on the back apron of the chassis is a jack and a switch that clearly are not part of the original circuit. See Fig. 2. They likely are part of a phono-input circuit that was added by a previous owner.

FIG. 1

While we are concentrating on the electronics, we cannot ignore the cabinet. It too will need to be restored if the radio is to become something worthy of showing off. As far as the cabinet on our *A-53* goes, I've seen worse, but I've also seen better. It will take at least two days to make the veneer patches and refinish the entire cabinet. One of the patches will be used to cover up the added hole. Of course, the grill cloth will have to be replaced.

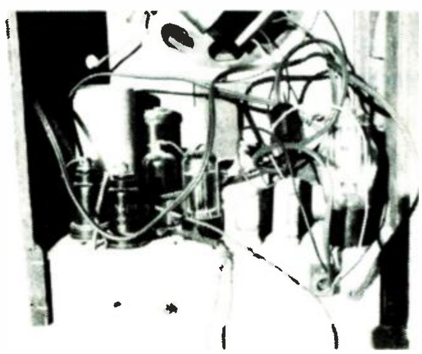


FIG. 2

Determining condition

One thing that you might be wondering about is how I determined that the radio does not work. Obviously, the answer is that I tried it!

The safest route to follow in determining whether or not a radio will work is to test every part, and to look for shorts and opens before plugging the unit in. Many readers have written me saying that they indeed do that each and every time. Unfortunately, human nature being what it is, I am sure many more of you do not. Even if I strongly urged you to follow that route, few of you would, as most are just too impatient to see if our new find works. I must confess, I too fit that description in many instances.

In lieu of testing, you should at the very least examine the radio carefully to uncover any obvious problems. I call that determining whether or not the radio is in "apparent safe operation condition." Among other things, see if all the tubes are present and in the right place. Check the integrity of the line cord. Look for bare wires, or ones that appear to be unconnected. Finally, check the chassis bolts. If several or all are missing, it is likely that someone once tried to fix the radio but did not complete the job. If you see the slightest sign of trouble, **do not plug the radio in** until you have completely examined and tested the radio. Otherwise you risk further damaging your prize at the very least, and possibly exposing yourself and others to dangerous electrical shocks.

Determining that your radio is in

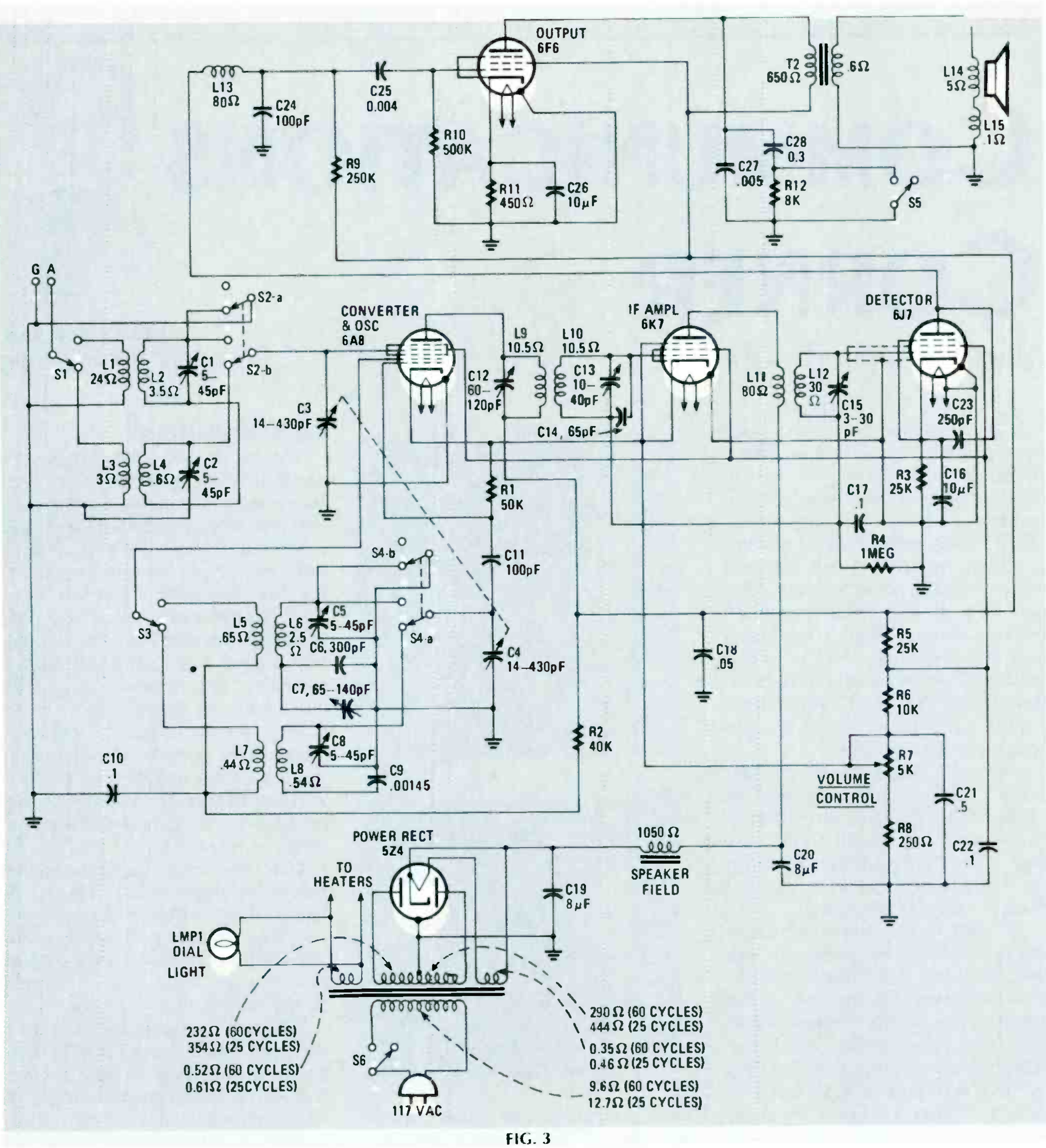


FIG. 3

"apparent safe operating condition" doesn't mean that other safeguards can be disregarded. When plugging in the radio, use an ***isolated, fused receptacle***. Also, while the set is plugged in, don't handle the cabinet or chassis, and don't "stick your face" into the back of the cabinet to see if the tubes are lit.

Getting to work

As we've said, one reason we did not previously restore our *A-53* was that it has been considerably altered, or mutilated, depending on the skills of whoever made the modifications we noted. Restoring 50-year old radios to their original condition offers enough problems without having to also figure out how someone else's circuits are supposed to work.

Nevertheless, the radio is still a good choice for restoration. For one thing, as you can see from the schematic in Fig. 3, its use of superheterodyne circuitry identifies the *A-53* as one of the better radios of its period. Further, despite its "man-made" defects, the cabinet is in relatively good shape.

Examining the circuit we see that it is a two-band unit. The missing band switch consists of S1–S4, and it is used to switch from the broadcast band to the 2.6–6.9-MHz shortwave band. The signal from

(Continued on page 84)

COMMUNICATIONS CORNER

Marconi lucked out.

HERB FRIEDMAN,
COMMUNICATIONS EDITOR

ONE OF THE OBSTACLES FACED BY EARLY radio pioneers was a lack of understanding about the ways radio signals propagate, and how outside factors, such as the ionosphere, affect that propagation. Had Marconi attempted to push a signal across "the big pond" earlier in the day, or a few days earlier or later, he would most likely have failed and the development of radio communications would have been delayed several years. The *Titanic* would have gone to the bottom with no one the wiser.

Marconi simply lucked out. "Skip" was unknown, as was its cause, its effect, and its relation to frequency. Let us all thank the gods that "the band" was open on the memorable day that Marconi tried to span the Atlantic.

Another factor that was misunderstood by early pioneers was the significance of antenna length. They believed that the longer the antenna the better the reception. (Of course, antennas work the same for transmitting as they do for receiving.) While long wires do provide higher gain than do short wires, to many users that gain works in mysterious ways, often causing a *weaker* signal to be received at a specific location.

Early broadcasters soon understood the vagaries of the long-wire antenna. Unfortunately, many hobbyists and shortwave listeners still do not; poor reception, solely due to using a too-long wire, often is the result.

The term *long wire* is really relative. Although an antenna must be at least ½ wavelength long at 3.5 MHz to be considered a long wire at any frequency, in modern times we consider anything greater than ½ wavelength at the desired frequency to be a long wire.

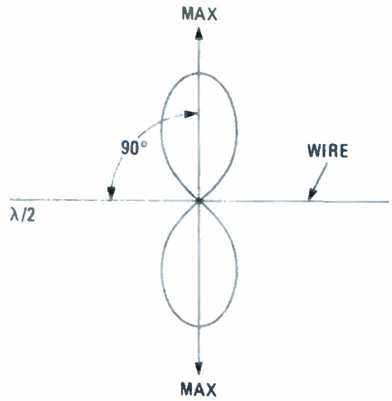


FIG. 1

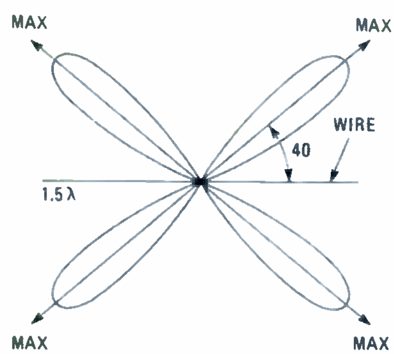


FIG. 2

Antennas longer than ½ wavelength have unusual sensitivity patterns. That's what causes high-gain TV antennas to poop out on signals arriving at a 90° angle, where gain should be greatest. The long-wire effect is also what causes multipath interference (TV ghosting) from water towers, tall buildings, and hills that are well off in the distance and to the side of the antenna.

Different directions

The problems with long-wires are that they have more than one major lobe (maximum sensitivity), and that the precise angle of the lobe is determined by the length of the wire. To keep things simple, for this discussion we will not get into "doughnut" sensitivity patterns nor vertical radiation/reception angles (vertical angle being the effect that beams your antenna's signal to Mars instead of to some place on Earth). We will concentrate on horizontal radiation—the sensitivity (radiation) pattern as it would appear if we were in the heavens looking down on the antenna in question.

Our reference antenna is the half-wavelength dipole shown in Fig. 1. That antenna, as you can see, has two lobes, yielding a sensitivity pattern whose maximum lies on a line that's at a right-angle to the wire itself.

Now let's assume that we want a stronger signal from the antenna, so we stretch a wire across several backyards for an overall length of 1½ wavelengths at the desired frequency, as shown in Fig. 2.

As you can see, we now have four lobes, each more sensitive than the lobes of a half-wavelength antenna. But there is no such thing as a free lunch. The antenna cannot create gain; it simply compresses the width of the lobe, taking energy from the sides of the lobe and concentrating it along the lobe's axis. Notice that the 1½-wavelength antenna in Fig. 2 is essentially dead to signals arriving directly into the antenna (at a 90° angle).

If a shortwave listener was interested in receiving signals arriving at a right angle, simply extending the wire "for more gain," would instead result in a weaker received signal. To achieve higher gain, the wire would have to be repositioned so that one of the lobes was aimed at the desired station.

But many users report superior reception at all times when they switch to a long-wire. How can that be?

Often, the improvement is not due to improved sensitivity but to *diversity reception*, and the listener simply perceives better performance. Diversity reception has nothing to do with antenna gain. Instead, it comes about because different regions of a long-wire antenna respond differently to different phase relationships; those relationships are constantly changing because of changing ionospheric conditions. The effect is called *selective fading*. As the received signal fades out because of phase changes on one part of the antenna, it increases on another. The overall effect is an apparent improvement over the half-wavelength antenna, which has its maximum sensitivity to only one phase relationship.

At even longer wavelengths the antenna creates major and minor lobes; Fig. 3 shows the sensitivity/radiation pattern for a two-wavelength antenna. Notice that we now have a total of eight lobes, with the major lobes getting closer to the wire's axis.

If you could make the wire sufficiently long, the major lobes would flatten to 20° from the wire's axis. Also, the lobes would be so narrow that at 33° from the axis the

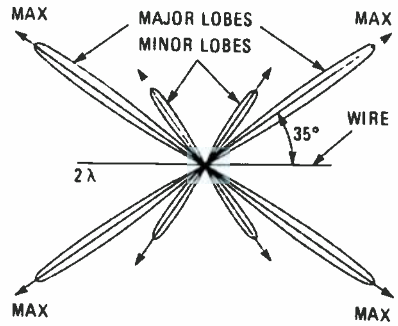


FIG. 3

antenna would have essentially no sensitivity.

Now, what does all that ancient theory on antennas have to do with modern technology? Simply go outside and look at your TV antenna. If it's the typical "all channel" moderate to deep-fringe model, many of the elements are long wires at the higher frequencies. Instead of having maximum forward at 90° to the elements,on some channels the maximum gain is out to the sides.

That is what explains unusual multipath ghosting. Imagine, if you will, that your city's master transmitting antenna is on a mountaintop due north of your receiving location, and that there is a water tower located to the northeast, some 10 miles away. As usual, you aim the receiving antenna directly at the transmitting antenna, and all channels are received with more than adequate signal strength. But one of the higher VHF channels has two distinct, widely separated images. Here's why: At that channel's frequency, the antenna is several wavelengths long. Because of that, a major lobe extends to the northeast, rather than due north (forward). Therefore, the reflected signal from the tower is actually being received with greater strength than the direct signal from the broadcasting antenna. To avoid such situations, better antenna installers adjust an antenna for best picture rather than by compass heading, even when they can literally see the transmitting antenna from the receiving site.

It's very difficult to change the rules of the game, no matter how ancient they are. At any frequency, a longer antenna is not necessarily a better one. **R-E**

AUDIO UPDATE

continued from page 79

the speaker system itself, by minimizing its physical coupling to the floor or wall. You can do that by "floating" the offending speakers on structures built up of plywood and foam glued together as shown in Fig. 2. Alternately, a single 4-inch foam slab can be used.

As mentioned earlier, vibration tends to get decoupled when traveling between different materials such as the wood and foam layers. This is in addition to the losses in the foam itself. Make sure that there's sufficient clearance so that the ¼-inch decorative plinth (A) does not touch panel (B) or the floor. The parts labeled (B) and (C) are ¼-inch plywood, and the foam should be fairly dense and at least an inch thick. Some trial and error will probably be necessary before everything fits together properly. Keep in mind that isolation will be lost if any part of the plinth or the speaker touches the floor.

Any audiophile readers who believe in the "advantages" of speakers or speaker stands that use floor spikes for improved bass, should keep in mind that mechanical coupling to the floor is likely to cause the floor structure itself to vibrate and contribute coloration to the sound of the system. Although some people apparently like the sound of resonating floorboards, I prefer that my speakers sound straight (as designed), thank you. Of course, spurious vibration should be avoided in both the stands or the speaker cabinets themselves, but that is a different matter that is best handled by the cabinet manufacturer's bracing and damping.

The bottom line is this: There really aren't any simple after-the-fact fixes you can apply to existing structures to minimize sound-coupling between rooms, apartments, or floors. But if you block the higher frequency sounds with thermal-insulation techniques and use speaker mountings that prevent bass coupling to the building structure, you certainly can help minimize problems—not to mention complaints. **R-E**

ANTIQUE RADIO

continued from page 81

the antenna is coupled to the control grid of the 6A8 converter and oscillator tube via the RF coil. (Note that the value of that coil, and the others in the schematic, are specified in ohms. That is not a misprint. In those days manufacturers often identified the coils in a schematic in that way to make servicing easier. By checking the resistance of the coil against the rating, a serviceman could spot open or shorted units.) The 6A8 serves two functions: local oscillator and mixer. Tuning is accomplished using a dual-ganged variable capacitor, which is designated C3 and C4 in the schematic. The rear part of the capacitor, C3, is used to tune the receiver to the desired frequency. The front part of the capacitor, C4, is used to tune the local oscillator so that, when mixed with the incoming signal in the 6A8, an IF of 465 kHz results.

The IF amplifier, which is built around a 6K7 tube, differs somewhat from more modern sets. The difference lies mainly in the design of the two IF transformers. The IF-input transformer has a tuned primary and a tuned secondary. The coils themselves sit within a shield located on the top of the chassis. However, their trimmer capacitors are located on the underside of the chassis. Turning to the IF-output transformer, only the secondary is tuned and the entire circuit is located on the underside of the chassis.

The output of the IF amp is coupled via the IF-output transformer to the detector stage, which is built around a 6J7. Volume is controlled in the radio by varying the IF gain using R7, which is a potentiometer, and R8, which is a fixed unit. Those resistors are located in the cathode circuit of the 6K7. Note the 1 megohm resistor (R4) in the grid circuit of the detector; that resistor is also connected to the grid return of the 6K7. Its purpose is to prevent overloading the 6J7 in the event that the volume control, R7, is turned up when a strong signal is received.

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TROUBLESHOOTING TV

continued from page 70

The excessive amplitude and the spike were was obviously upsetting something in the video processor.

Essentially, the RC network is there for amplitude reduction and wave shaping, so that seemed like a logical place to start. First, R472, a 150K, ½-watt unit, was removed and replaced with a 120-pF capacitor. Since, at that stage we were only doing some experimenting, and our whole approach could be wrong, the added component was just "tacked" in.

Since that little network physically lies just ahead of the flyback and very close to the focus lead emerging from the transformer it was important to make sure that the components were dressed well away from the focus lead. There was just about an inch of space for that. Making sure everything was clear and secure for a test run, the receiver was fired up.

At least we were in the ball park. The black bars were still present but in a sort of hazy way, with that half bar still present near the center of the screen. And the streaking was still there, with much less brightness. Instead of reducing the pulse, we had expanded it until over-blanking was taking place.

The next step was to reduce the value of the capacitor by about half to, say, 62 pF, and remove C460 completely from the circuit. That brought the brightness back to near normal and, for the most part, removed the black bars. But the half bar still was winking at us and the streaking still was present.

Next, R469, a 150K ½-watt resistor, was removed from the circuit and a 100K ½-watt unit was put in its place. That change completely removed and and all traces of the black bars. The modified circuit is shown in Fig. 3.

One last hurdle

Now to find the cause of the streaking: It looked like some sort of outside interference, but none of the other sets were being affected.

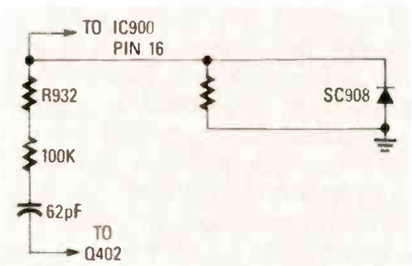
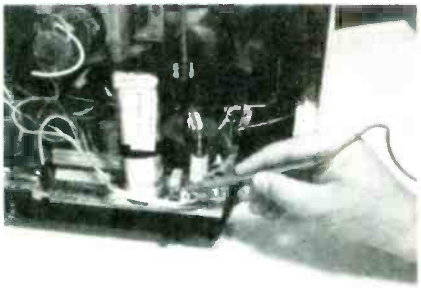


FIG. 3—DELETING C460, R469, and R472 and adding a 100K resistor and a 62-pF capacitor cured the black-bar problem. Modifying the circuit as described in the text cured the problem; the modified circuit is shown here.



PROBING THE SHADOWY AREAS near the flyback revealed a cracked resistor. It proved to be the cause of the mysterious steaking.

With a flashlight and magnifying glass the shadowy areas around the flyback were thoroughly investigated. Just when we were about to knock off for the day we noticed what appeared to be a crack in R966; see Fig. 1.

That resistor was removed and, sure enough, it was split, and it was open. The streaking was caused by the return of the internal rectifiers of the flyback arcing through that resistor back to the low-voltage supply. When the flyback failed, it probably took that resistor with it. Replacing R966 resolved the streaking problem and the set has worked fine ever since. **R-E**

SATELLITE TV

continued from page 77

ada because hundreds of IC's have been detained by U.S. Customs. The Canadian firms still operate from Canada, but they have begun shipping their wares from the U.S. side of the border.

Conclusions

There are several conclusions to be drawn from all of that. First, several descrambling IC's being marketed may not be what they are made out to be. Second, those dealing the IC's may have considerable liability above and beyond that incurred in violating Federal statutes if customers awaken one day to find their Chip-equipped descrambler shut down.

Third, a serious effort to shut down various descrambling operations has begun. In late February and early March, GI indiscriminately shut off thousands of descramblers, without apparent regard to their legal status. They also discontinued distributing their model *VC2000* units after finding that those could be breached with software modifications. The replacement *VC2100* featured epoxy coating over several key areas. Unfortunately for the manufacturer, chemicals that could dissolve the epoxy soon were found and a Bahamian firm has announced a musketeer IC that can be used without dissolving the epoxy coating.

Even those providing information about descrambling are under investigation. Among those parties are this author. *(For late breaking news regarding descrambling and the law, see "What's News," which can be found on page 6 in this issue—Editor.)*

Fourth, in spite of all claims to the contrary, there does not appear to be any *VideoCipher* defeat mechanism other than the much-publicized clone and musketeer systems. And GI seems to be extremely confident that it can deal with both techniques in both the long run and the short run. In retrospect, *VideoCipher* may be less broken than bent, and GI may actually end up with the upper hand in this engagement. **R-E**

STATE OF SOLID STATE

Instrumentation amplifiers

ROBERT F. SCOTT,
SEMICONDUCTOR EDITOR

INSTRUMENTATION AMPLIFIERS ARE high-performance, high-gain op-amps used in applications that require precise, low-level signal amplification with low noise, accurate, closed-loop gain, and very low drift. The AD625, from Analog Devices, is a new precision programmable-gain instrumentation amplifier designed especially for:

1. Circuits requiring non-standard gain values not easily obtained from earlier instrumentation amplifiers such as the AD524 that featured programmable gains of 1, 10, 100, and 1000; and the AD624, with gains of 1, 100, 200, 500, and 1000.

2) Circuits requiring low-cost, precision software-programmable gain, and especially where low noise, low drift, and a high Common-Mode Rejection Ratio (CMRR) are desired.

The AD625 is a cost-effective device that uses three external resistors to set gain to any value from 1 to 10,000. Performance limitations are due mainly to those external resistors. The gain error contributed by the device is less than 0.5% and the temperature error is less 5ppm/°C. The CMRR is independent of feedback resistor matching.

A software-programmable gain amplifier can be designed around the AD625 by using a switch network such as a CMOS multiplexer. The on resistance of the switching network is not in the signal path, so the AD625 can provide 12-bit precision and can be programmed for gains between 1 and 10,000 in user-selected steps.

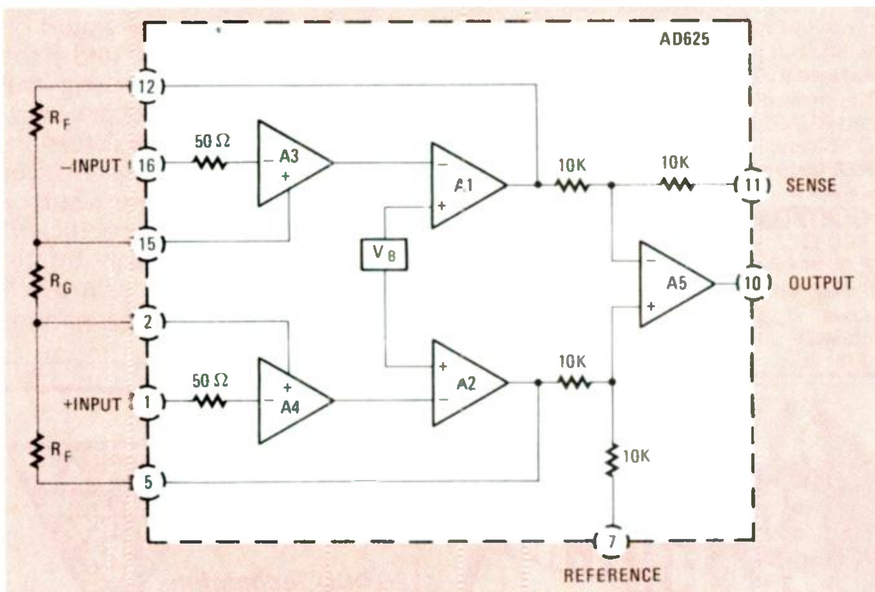


FIG. 1

The AD625 provides highest precision with input offset voltage drift below 0.25µV/°C, output offset voltage drift below 15 µV/°C, and maximum nonlinearity of 0.001% when gain is unity. All grades of the AD625 provide a 25-MHz gain-bandwidth product, 5V/µs slew rate, and 15 µs settling time.

The AD625 comes in three accuracy grades (A, B, and C) for industrial (–25°C to +85°C) temperature range, grades J and K for commercial (0 to +70°C) temperatures, and S grade for temperatures in the –55°C to +125°C range.

A block diagram of the AD625 is shown in Fig. 1. A differential voltage appears at the outputs of A1 and A2. That voltage, A_V, is the product of the differential portion of the input voltage times the gain, or as shown,

$$A_V = 2(R_F/R_G) + 1$$

Amplifier A5 is a unity-gain circuit that removes any common-mode signal from the output signal, which appears at pin 10.

The transconductance of the preamp input stage is determined by the value of R_G. Transconductance and gain increase as R_G decreases. That has three major advantages. 1) It makes very high open-loop gain possible; 2) The gain-bandwidth product increases with gain, thereby optimizing frequency response. 3) Input-voltage noise is reduced to a value that is determined by the collector current of the input transistors.

The REFERENCE terminal (pin 7) may be used to offset the output up to ±10 volts, for floating output loads or coupling to a circuit with an isolated ground.

The sense terminal (pin 11) is the

feedback point for the output op-amp. Usually it is connected directly to the output at pin 10. But, if heavy load currents are drawn through long leads, voltage drop in the lead resistance can cause errors. To eliminate those errors, the sense terminal can be connected directly to the load. Doing so places the lead's IR drop inside the feedback loop.

Typical IC instrumentation amplifiers can swing ±10 volts across a 2000-ohm load. However, when more current must be delivered to a heavier load, an output current-booster amplifier can be connected between the AD625 output and the load. In such a configuration the SENSE terminal would be connected to the "high" end of the load, thereby including the booster amp in the feedback loop.

Only three external resistors are needed to select any given gain from 1 to 10,000. The gain accuracy and gain temperature coefficient are determined primarily by the external resistors. The gain-sense current is insensitive to common-mode voltage, so the CMRR of the resistor-programmed AD625 is independent of the match of the two feedback resistors, R_F. A value of 20K is normally used for R_F. Values above 20K are not recommended because gain errors referred to the output increase with increased feedback resistance. Values below 10K can cause instability. See Table 1 for resistor values that can be used to set several gains with errors of only ±0.5%.

TABLE 1—RESISTOR VALUES

Gain	R_F	R_G
1	20K	∞
2	19.6K	39.2K
5	20K	10K
10	20K	4.42K
20	20K	2.1K
50	19.6K	806Ω
100	20K	402Ω
200	20.5K	205Ω
500	19.6K	78.7Ω
1000	19.6K	39.2Ω
4	20K	13.3K
8	19.6K	5.62K
16	20K	2.67K
32	19.6K	1.27K
64	20K	634Ω
128	20K	316Ω
256	19.6K	154Ω
512	19.6K	76.8Ω
1024	19.6K	38.3Ω

Further technical and applications data on the AD625 (including programming by microprocessor) are included in the New Products section of the Analog Devices *1986 Update and Selection Guide*. Write to **Analog Devices**, Two Technology Way, Norwood, MA 02062-9106.

Ku-band amplifier modules

The new MC5875A, MC5875B, and MC5876A, MC5876B are modules developed for mass-production of low-cost Ku-band satellite data-link receivers. Both are two-stage GaAs FET/hybrid-IC amplifiers designed to be cascaded to provide excellent noise (2.5 dB) and gain (33 dB) performance over the 11.7 to 12.2-GHz band. Both the low-noise module (A) and the gain module (B) come in hermetically sealed packages.

Both devices from NEC are available from the exclusive North American sales agent, California Eastern Labs. For data and other information write **California Eastern Laboratories**, 3260 Jay Street, Santa Clara, CA 95054. **R-E**

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CIRCLE 65 ON FREE INFORMATION CARD

R-E ROBOT

continued from page 60

or you can investigate the use of incremental shaft encoders.

With the quadrature system, two pulse trains, 90° out of phase, are produced. Motor-direction information can be obtained by examining the relationship of the two waveforms; that is, to see which one is leading and which one is lagging. With proper decoding, spurious counts that may occur when the robot stalls or the motor shaft vibrates will be rejected.

A non-quadrature optical-feedback system can be implemented simply by attaching a disk with holes drilled around its circumference to the motor's backshaft. A simple optical encoder can then be used to keep track of shaft rotation in the conventional way. Be sure that you drill as many holes as possible, for improved low-speed performance. You will have to condition the encoder's output signal to match TTL levels; that can be done with an LM393 comparator.

A quadrature encoder can be made from two optical sensors positioned so that the output waveforms are 90° out of phase. The sensors are properly positioned when the distance between the optical centers is such that when one hole is centered on one encoder, another hole is covering 50% of the other encoder. With a typical system using using 0.25-inch sensor spacing, the hole pattern consists of ⅛-inch holes on ¼-inch centers. That results in 12 holes on a 1.43-inch radius. That hole pattern is sufficient to give satisfactory feedback for operation at all but the lowest speeds.

Once again, the outputs of the two optical encoders should be conditioned with LM393 comparators. The circuit is then interfaced with the controller board and the output signals are decoded.

SOURCES

The following are available from Vesta Technology, 7100 W. 44th St., Wheatridge, CO 80033 (303-422-8088): Bare RE-Robot controller board, $41; assembled and tested RE-Robot controller board, $200; bare RPC board, $41; assembled and tested RPC, fully populatec for the robot function, $294. Add $8.0C shipping per board ordered. Colorado residents add appropriate sales tax. Mastercard and Visa accepted.

Optical endocers (100 counts/revolution, quadrature output) are available from EMC Corp., 373 Hillsboro Way, Goleta CA 93117 (805-968-3060) for $40 each California residents must add appropriate sales tax.

Terminal count

The progress of the motor is monitored using two counters of the 8253. One counter is clocked by the forward progress of the robot; the other counter is clocked by the reverse progress.

As mentioned, one of the features of the 8253 is that it is programmable. By loading the appropriate control word into the IC, the counters can be set to operate in one of six modes. For example, to generate the reference frequency we set up one of the 8253's counters to divide by a 16-bit number. That is the IC's mode 2. Here, we need to set up the remaining counters to operate in one of the IC's other modes, interrupt on terminal count (mode 0). In mode 0, the output goes high when the accumulated count has reached a value programmed into the counter. That output may be connected to a digital input for polled operation, but is connected to an interrupt input on the RPC for interrupt-driven operation. The counters can be interrogated by the RPC at any time during motor operations to ensure that the motor has not stalled or is not vibrating.

That's all for now. Next time we'll show you how to build and mount the board. We'll also look at some software considerations. **R-E**

SEMICONDUCTOR TESTING

continued from page 63

defined as the forward transfer ratio in the common-source mode. It is expressed as:

$$y_{fs} = \frac{\Delta I_D}{\Delta V_{GS}}$$

where I_D is the drain current and V_{GS} is the gate voltage for an FET in a common-source configuration. A basic test circuit for y_{fs} is shown in Fig. 7

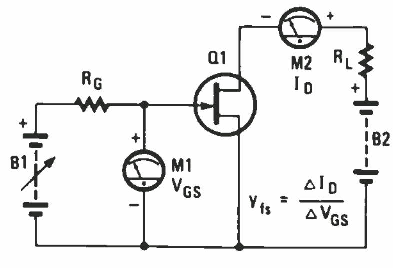


FIG. 7—A basic y_{fs} test configuration for FET's.

To measure y_{fs}, the gate is first DC-biased with a voltage and the resulting drain current (I_D) indicated by meter M2 is noted. Then, the input voltage is changed and the resulting change in the gate voltage (V_{GS}) measured by meter M1, and the change in drain current measured by M2 are used to calculate y_{fs}.

Again, we must emphasize the word *change*. The static conditions under which the measurements are made are not anywhere near as important as the values of any changes.

Bear in mind that y_{fs} is not a gain factor, per se. Rather, it describes the *maximum* possible gain. Generally, the larger the y_{fs} value the greater the gain. Junction FET's have a fairly high forward transconductance, typically ranging from 4,000 to 10,000 µmhos. MOSFET (*M*etal-*O*xide *S*ilicon *F*ield *E*ffect *T*ransistor) gains tend to run higher, and dual-gate MOSFET gains are higher yet, wherein values up to 20,000 µmhos are not uncommon.

Dual gates

Dual-gate MOSFET's can be tested in three different ways. In the first kind of test we apply a signal to one of the gates and connect the unused gate to the drain.

By alternating the signal gate (by reversing the gate connections) we create a second distinct test configuration. In some cases, a voltage may be applied to the unused gate during the test; if so, that information is listed on the data sheet.

The third test configuration ties the two gates together and treats them as one. That is the test most commonly used with dual-gate MOSFET's, and its result is shown on most data sheets. While the arrangement yields the highest y_{ss}, it also results in decreased bandwidth.

Variations in y_{fs}

Technically, y_{fs} represents a resistive value that is influenced by the biasing voltage on the gate, which in turn influences the drain current, I_D. In spite of the variations in y_{fs}, the device's manufacturer arrives at a representative y_{fs} value by not applying a DC bias voltage to the transistor and by maintaining the input signal at 100 mV or less, a configuration that yields the highest y_{fs} value. Practically, however, that configuration serves little purpose, because with no DC bias on the gate the output signal may be severely distorted.

The effect of temperature on variations in gain should not be overlooked. As the ambient temperature increases, the leakage component through the semiconductor also increases, which affects I_D, which, in turn, affects y_{fs}. In all cases, the tests are made at 25°C. When tests are performed at elevated temperatures the results are listed separately in the data sheet.

Next month we'll look into the fascinating world of operational amplifiers. **R-E**

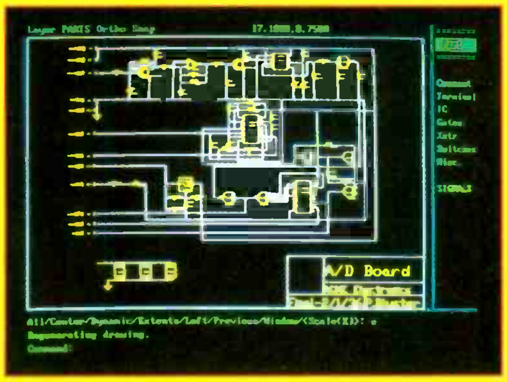
VOL. 5 NO. 6 JUNE 1987

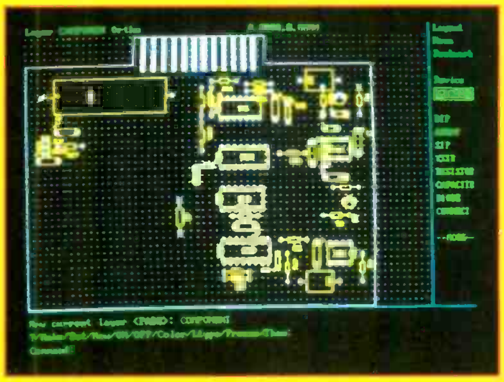
COMPUTER DIGEST

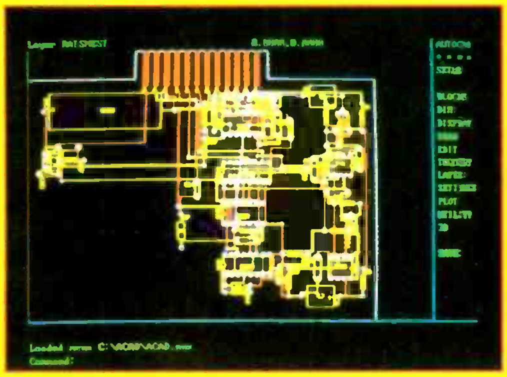
A NEW KIND OF MAGAZINE FOR ELECTRONICS PROFESSIONALS

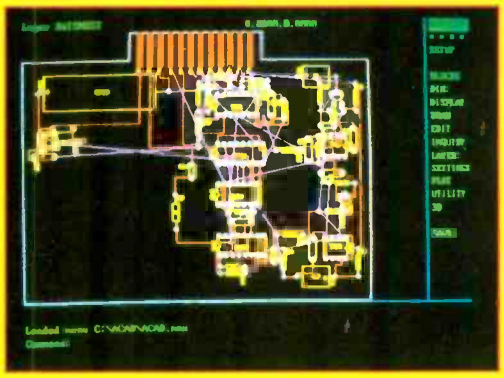
DESIGNING PC BOARDS ON YOUR PC

New programs make it easy









THE KEPROM

Sinking the software pirate

A GERNSBACK PUBLICATION

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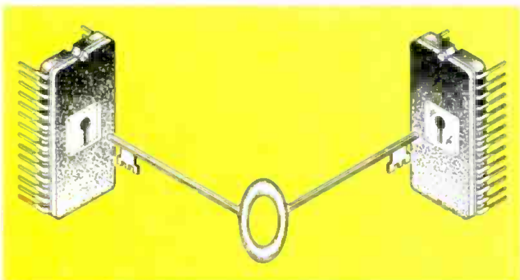

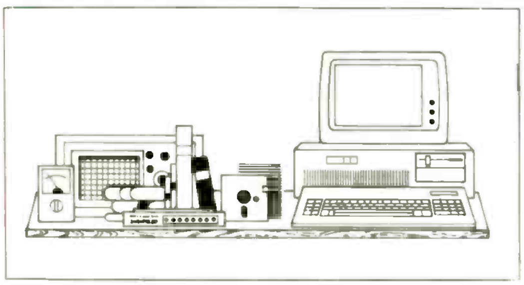

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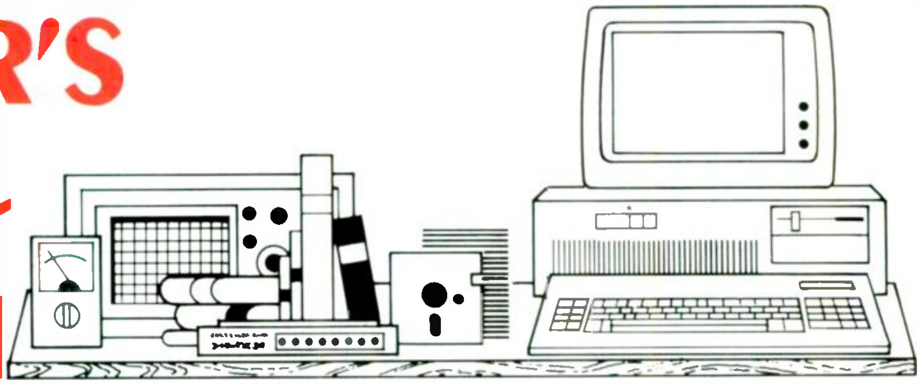


We've got reviews of several exciting products this month, including a well-done 8088/assembly-language tutorial and a disk-conversion package that allows you to read Apple disks on an IBM (or compatible) machine, along with brief spots on new releases of several industry standards. However, before getting to our reviews, we'd like to take time out to examine the chaotic state of IBM operating systems.

IBM'S NEW OPERATING SYSTEM(S): THE M & M'S

From the user's standpoint, there are two kinds of operating systems: command-line based and icon based. Apple's Macintosh, based to a great extent on work done by a research subsidiary of the XEROX Corporation, is an icon-based system; the IBM-PC is a command-line based system.

Much ink has been spilled arguing the merits of one system over the other, but few would argue that icon-based systems are more appropriate for beginning and occasional users, and that command-line-based systems are more appropriate for medium and advanced users who are willing to forego the ease of use of the icon system for the speed of the command-line system.

The IBM-PC (and its close relatives) to date have used an operating system that is command-line based. However, it seems likely that the next generation of IBM/Microsoft operating systems will be oriented toward a Mac-style interface. The problem with that type of interface is simple: the 8088 microprocessor used in the IBM-PC, the IBM-PC XT, and millions of clones is too slow to handle a full graphics interface like Microsoft Windows.

However, the IBM-PC AT has a higher-powered microprocessor (the 80286) that allows Windows to run at acceptable speed. And the latest member of the 80xxx family, the 80386, is even more powerful than the '286, so raw performance of Windows can theoretically improve by a factor of ten or so.

There's another problem. The '286 and '386 IC's can run standard MS-DOS applications as-is, but a large part of the inherent power of those microprocessors is thereby left untapped. On the other hand, the current generation of MS-DOS applications programs simply can't use the advanced features of the new IC's. What kinds of features? The M & M's: Memory and Multitasking. How much memory? Megabytes, gigabytes, terabytes (literally!) of memory. Multi-tasking? Why? So that you can run several programs simultaneously, and so that programmers can run several parts of the *same* program simultaneously.

Why would you want your computer to do more than one thing at a time? If all you use the machine for is to write letters to Aunt Sally and balance your checkbook, you don't need the M & M's. But if you do CAD, or manage large spreadsheets or databases, or do circuit design and analysis, then M & M's will become not optional but necessary as the next generation of software learns how to use the new hardware.

Why? Because, for example, the typical CAD program on an unenhanced PC runs slow. Speed may be acceptable on a '286 machine, but even then you don't get the snap out of it that you can get with, say, a well-designed wordprocessor on an '88 machine.

But speed isn't valuable in and of itself, it's a means to an end. And the kinds of things a fast microprocessor can be used for may surprise you. For example, how would you like to use a CAD program that had separate background processes that kept various views of the screen up to date? No more thirty-second screen redraws, switching views would happen instantaneously.

Or how would you like to use a circuit design/analysis program that allowed you to enter components graphically, and in the background kept track of voltages and currents at all nodes? So if you needed to bias a transistor to a certain point, given the output of the preceding stage, the circuit would calcuate resistor values instantaneously, and, based on that information, start calculating values for the next stage.

How about a wordprocessor that did real-time spelling checking, disk saves (in the background, of course) every five minutes or 2000 keystrokes? And (everybody's favorite) how about running a spreadsheet, a database manager, a communications program, and a wordprocessor simultaneously?

You can't do any of those things in an acceptable manner on the present generation of PC's (IBM or otherwise). The hardware is here (sort of), but the software isn't. Computers (UNIX-based systems and engineering workstations, for example) have been around for some time that can do multitasking, but the hardware is high-priced, and the software (especially the user interface) is in many ways less functional than what is available for PC's.

So where does all of that leave IBM and Microsoft? They're supposed to release new hardware and software by the time you read this. The new hardware probably will include a low-priced PC that will compete with foreign clones and with the PC compatibles released by Commodore and Atari. The new hardware will probably also include a '386 machine; indeed, IBM would be foolish not to get something to market quickly, because it has been reported that Compaq is selling 10,000 '386 machines per month! Last, there may be something in between, perhaps another '286 machine.

New DOS

The new hardware is going to be nothing more than a high-priced bookend without software to take advantage of it. And, fortunately, Microsoft is slightly more open about internal development than IBM; there has been some indication that DOS as we know it may split into three different operating systems

At the lowest level we'll see some sort of extension of DOS 3 Speed may be enhanced, and some sort of graphics-based (not necessarily a full icon-based) user interface with more-comprehensible error messages and a built-in help system will be added Both IBM and Microsoft have emphasized that the new DOS 3 will be much friendlier than (and compatible with) past versions, but hopefully the command-line interface will be retained In any case, the new DOS 3 will be unable to take advantage of the M & M's, so don't expect to be able to run bigger spreadsheets or do multitasking Power users will probably shun the new DOS because the graphics and help systems will eat up valuable system RAM and slow overall operations down

At the next level we'll see an operating system for the '286 (which is used in the AT and in many accelerator cards), one that will allow specially-written programs to take advantage of the M & M's. However, 286-DOS (also unofficially called A-DOS, Advanced-DOS, DOS 5.0, and other names) will not allow traditional applications (those that can use only 640K of memory and those that write directly to video RAM) to use more memory or to do multitasking Only new or adapted programs will be able to take advantage of the M & M's.

The '386 IC has a special mode that allows it to run multiple traditional applications simultaneously. The new '386 operating system (control program) will exploit the multitasking capability, but, like 286 DOS, will not allow traditional applications to access more than 640K of contiguous RAM. However, each traditional application will think it has a complete 640K machine at its disposal. But no particular application will be able to take advantage of extended resources (the M & M's) by itself In addition, 386-DOS will be able to run other operating systems simultaneously, so it should be possible to build a UNIX-based engineering workstation that could run DOS applications in a UNIX window.

Apple and IBM

Meanwhile, Apple has introduced two new Macintosh computers, one of which (the Macintosh II, shown in Fig. 1) uses a CPU (the 68020) that can compete directly with the '386. More significant is the fact that Apple has finally realized two things: (1) IBM is a force to be reckoned with, and (2) an open-architecture machine with expansion slots and good technical documentation (like the IBM-PC and like the original Apple II) is good for business in that it encourages third-party innovation

The new Macintosh II is an open-architecture machine that will run IBM software (with the addition of a plug-in card containing an '88 or compatible microprocessor). In addition, Apple has ported UNIX to run on the machine, and there have already been good reports about the machine from the academic community (UNIX's traditional stronghold) It's likely, at least in the high end of the market, that Apple will finally be able to compete with IBM (i e, with the forthcoming '386 machine)

Similarly, Commodore's recently announced A2000 has a keyboard that looks remarkably like the new IBM keyboard, and a plug-in co-processor card that runs IBM software. Inside, the A2000 has four slots that accept IBM-compatible expansion cards.

FIG. 1

Conclusions

The point is that IBM is slowly moving toward the ease-of-use features that Apple brought to the PC world, and Apple (as well as Commodore) is moving simultaneously toward IBM compatibility and the large base of quality software and hardware that exists to serve the IBM market. Perhaps the Hatfields and McCoys can make up after all.

For users, these are all good signs. We'll get software that is more powerful, more kinds of hardware to run it on, and, as different system designs converge, we'll have less trouble moving from system to system. And just as the M & M's will bring increased power to advanced users, that additional power will also be useful in creating "friendly" graphics-oriented systems for beginners and occasional users. So don't let anyone tell you that the average user doesn't need a '386 (or a 68020); he may need it more than the power user!

IBM has been hurt by the invasion of the Clones, but IBM (like few other companies) has the resources to develop the next generation of hardware and (with a little help from its friends) systems software. Whatever IBM does, it always takes the Clone makers six months to a year to catch up—and by then IBM is working on something new. So, even if it has lost some market share, IBM is still calling the shots. R-E

MICROSOLUTIONS' MATCHPOINT-PC

Except by means of an expensive hardware emulator, it has not been possible to interchange disk files between Apple II- and IBM-compatible computers directly. (For the remainder of this review we'll use the term IBM to cover both IBM-made machines and clones.) Small businessmen with years of data generated on an Apple discovered that those files had to be recreated if the computer system was upgraded to an IBM. Similarly, the educational system, which has an enormous installed base of Apples, discovered that teachers could not prepare work at home on an IBM because even simple BASIC programs and text files could not be read by the school computers, and vice versa.

Although software that can convert virtually any CP/M or TRSDOS file to the MS-DOS format (and vice versa) has been available for several years, it wasn't available for the Apple II. Of the more than 100 brands of computers that are commonly used for education and business, only the Apple was foreclosed from the MS-DOS world.

But Apple/IBM incompatibility has finally been resolved by a device called the MatchPoint-PC, made by MicroSolutions (132 West Lincoln Highway, DeKalb, IL 60015.) It's a hardware/software package specifically designed for reading and writing, on an IBM, disk files written in AppleDOS and ProDOS, Apple Softcard CP/M, and just about any other CP/M format.

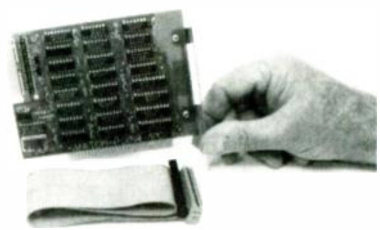


FIG. 2

The hardware part is a half-length controller board (Fig. 2) that you install in an otherwise unused slot. It connects between the IBM's floppy-disk controller and its floppy-disk drives. A cable (which is supplied) that will match either card-edge or header-type controller terminals connects the MatchPoint-PC to the existing controller. The computer's original cable is moved from the controller to the MatchPoint-PC, thereby placing the MatchPoint-PC between the disk controller and the disk drives.

The supplied software, which consists of a program called MPOINT and a special version of Uniform—a "universal" CP/M disk format/read/write program that can handle more than 100 different disk formats—sets up the operating conditions for foreign (non MS-DOS) disk formats.

Running the MPOINT program allows the interface to recognize Apple II disk formats, and temporarily adds five new commands to MS-DOS. They are: ACOPY, ADEL, ADIR, AINIT (which formats a disk), and ATYPE. All commands function just like their MS-DOS equivalents (COPY, DEL, DIR, FORMAT, and TYPE).

How to use it

In normal operation, the MatchPoint-PC is totally transparent; the computer functions exactly as it always did. In fact, placing an AppleDOS or ProDOS disk in a drive will result in a read error message.

However, MPOINT allows the computer to recognize a single physical drive as two logical drives. For example, assume that MPOINT is configured so that drive B: will be the Apple-compatible drive. When the command DIR B: is entered the computer will recognize only MS-DOS disks in drive B. But if the command ADIR B: is entered, the MatchPoint-PC hardware automatically treats drive B: as an Apple drive and reads in the Apple disk's directory. In short, the mode in which drive B: operates is automatically determined by the command you use. Figure 3 shows the ADIR screen display of an Apple disk on an IBM computer.

```
E:\APPLE>ADIR B:
MatchPoint-PC by Micro Solutions

Directory of Apple DOS diskette
Volume 254 in drive B:

*A 004 HELLO
*I 008 APPLESOFT
*B 050 FPBASIC
*B 063 FILER
*B 018 FAST COPY
*A 018 DISK TEST
*A 009 DISK SPEED
*B 010 OBJ.QUADCOPY
79K bytes (316 sectors) available.

E:\APPLE>
```

FIG. 3

Here's another example. The command ACOPY B:WORK.TXT A: will copy the Apple file WORK TXT from drive B: to an MS-DOS disk in drive A:. You could, of course, do it the other way around—MS-DOS (A:) to Apple (B:)

Uniform

By using the Uniform program, drive B can function as a CP/M drive (Apple or otherwise) using the next higher drive designator. If your computer has two physical drives (A: and B:), drive B: will double as CP/M drive C:. If your computer already has a drive C: (a hard disk, perhaps), the created CP/M drive will be drive D:.

If that's confusing, perhaps a few examples will straighten things out. Assume the computer has two disk drives, A and B:. If the selected Uniform mode is CP/M, the command COPY C:WORK.TEXT A: will copy the Apple Softcard CP/M file WORK.TXT from drive C (physical drive B:) to MS-DOS drive A:. And even though drive B: functions as CP/M drive C:, it also functions as MS-DOS drive B:.

Although an IBM computer can read Apple disk files, it cannot run binary programs. BASIC programs might be convertible, depending on how many machine-specific statements are used. Graphics programs, for example, will be particularly difficult to translate. Only ASCII text and data files are truly interchangeable between Apple and IBM machines. For example, SuperCalc files in an Apple CP/M format could be converted and then used on an IBM version of the program.

UniDOS

There is one exception to the rule of binary-file incompatibility, and that is when MatchPoint-PC is used with Uniform and an additional program called UniDOS (also sold by MicroSolutions), which is a Z80 emulator for IBM machines. It allows an IBM to run Z80 and 8080 CP/M programs. The catch is that the CP/M program runs much slower on the IBM than it would on a true Z80 machine because UniDOS is only an emulator. So, for example, if you're upgrading from a CP/M to an IBM machine, you can continue to run your old CP/M software on the IBM.

Half-tracking

Although MatchPoint-PC works extremely well and with little trouble, its Apple/IBM compatibility is limited by something known as "half-tracking," which refers to disk data written between tracks on the disk. Basically, it's as if the disk drive's read/write head, instead of stepping from track to track, stepped between tracks first. Half-tracking is used by some copy-protected Apple II software, which locates data or special encoding between the conventional tracks—in the half-tracks. IBM-type drives cannot step to the half-track location, hence, they cannot read nor write a half-track diskette. So, if you have Apple disks that are half-tracked, they will not be read by the MatchPoint-PC system. That's the only limitation we've found in MatchPoint-PC.

The MatchPoint-PC package, which includes the hardware interface, MPOINT, and UNIFORM retails for $195. For orders or further information write directly to Microsolutions.

SOFTWARE MASTERS' VISIBLE COMPUTER: 8088

I bought my first personal computer, a single-board 6502 machine, in 1979. After hooking the board up to a power supply, with shaking hands I turned it on. Not much happened—no smoke, anyway. The six-digit seven-segment LED display showed a row of zeros. After staring at those zeros a while I realized I was in trouble—big trouble. I had just purchased the most expensive gadget (about $250) I had ever seen—and I didn't know the first thing about how to use it. It had no BASIC in ROM (one would be forthcoming), nor even an assembler, so programs had to be assembled by hand. And that was a difficult proposition for someone who had never even *heard* of hexadecimal numbering! It took me months just to learn how to add two numbers together!

Times have changed since 1979. Now anyone who wants to learn about microprocessors and machine- and assembly-language programming can do so without going gray in the process. How? With *The Visible Computer: 8088,* a disk-based self-teaching guide by Software Masters, P.O. Box 3638, Bryan, TX 77805.

The Visible Computer comes with a single floppy disk and a 350-page book. The disk contains more than 50 demonstration programs and a special program, called TVC, that functions as a combination assembler, debugger, and 8088 simulator. You can use TVC to run the demonstration programs, programs you write yourself, and commercial MS-DOS programs.

A beginner won't use TVC right away; he'll start off reading the book. The book contains 34 chapters and several appendices that cover numbering systems, basic logic (AND, OR, etc.), machine language, the stack, looping, arrays, the 8087 math coprocessor, interrupts, and more.

The book is well-written and well-illustrated; new topics are introduced at a rate that should be acceptable to most aspiring assembly-language programmers. The author (who is not named) has an irreverent style that will make you chuckle more than once. For example, Chapter 2 ("Alternate Numbering Systems") starts off like this: "If you bought The Visible Computer with the hope that it would somehow save you the effort of climbing Mount Hexadecimal, picking you up magically and dropping you softly into the Valley of 8088 Machine Language on the other side, sorry, no can do." Later he offers an explanation for why we (normally) use decimal numbers. ". . . because people have 10 fingers, and for millions of years, fingers were all we had for representing numbers. On a planet where beings have two hands of four fingers each we can reasonably predict that their positional numbering system is based on the number 8."

That's not to say that the book's lighthearted approach prevents it from digging into some heavyweight material. In the chapter on interrupts there is a section entitled "An 8088 Goof." In it the author discusses a design error of the 8088 that was not caught until after the IC had been in production for some time. The error can cause memory locations to be overwritten at random, depending on when an interrupt occurs. Later versions of the 8088 have a fix, but a special programming technique is necessary to avoid trashing memory when using earlier models of the IC. The point is that the author is familiar with many of the subtle quirks (bugs) of the 8088 that can drive novice programmers crazy.

Simulating the 8088

TVC is an 8088 simulator written mainly in Pascal. It comes up on-screen with several windows (starting in the upper left corner and working clockwise): the control window, the flags window, the status window, the disassembly window, and the processor window. See Fig. 4. Beneath the windows is the monitor area. Normally you enter commands in the monitor area; the results of those commands are displayed in the various windows.

The commands used to control TVC are similar to the corresponding commands in the MS-DOS DEBUG program, so if you already know DEBUG you'll have no trouble using TVC. On the other hand, if you don't know DEBUG, you can use TVC to learn it, and doing so is valuable, because most MS-DOS debuggers are based on DEBUG's command set.

Of course, TVC has a number of unique commands that allow you to step through programs step by step, examine and alter memory, assemble and disassemble programs, etc. The feature we like best is the simulator. You can set it up to display the machine state at one of several levels. The most detailed level (4) allows you to see what's happening inside the 8088 machine cycle by machine cycle. Or you can set it to stop between each instruction, or not at all.

You can also generate "interrupts" during simulation by pressing keys at the keyboard. A special command allows you to set the interrupt number that is generated. For example, to simulate an interrupt 9, you would issue the command INTR 9. Then, when you pressed a key during simulation, a pseudo-interrupt 9 would be generated.

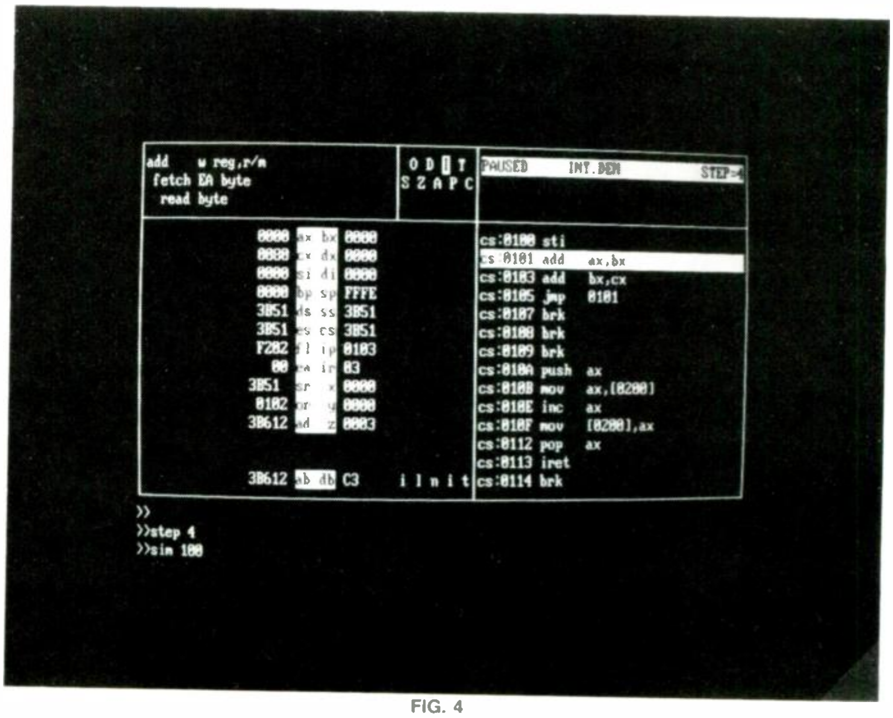


FIG. 4

To protect the beginner from himself, TVC has a privilege mode that must be entered via a special command. In non-privileged mode, the user is prevented from writing to system memory, output ports, etc.

Other commands allow you to load and save files, activate a calculator (that allows addition, subtraction, multiplication, and addition, and conversion between hex, decimal, and binary numbers), etc.

All in all, *The Visible Computer: 8088* provides a remarkably painless introduction to the 8088 microprocessor and assembly-language programming. So we heartily recommend it, a bargain at $79.95.

Software Masters also publishes versions of the package that teach the 6502 microprocessor. Contact them for details.

MICROPRO INTERNATIONAL, WORDSTAR PROFESSIONAL 4.0

It's been a long time in coming, but MicroPro (P. O. Box 7079, San Rafael, CA 94901-0079) has finally released an updated version of WordStar. The new version is much improved over version 3.31, and has features including what is probably the best spelling checker on the market, a built-in macro processor, extensive on-screen formatting, built-in table-of-contents and index generators, automatic indent (when editing program files), a very well done disk-based tutorial, and many more. The program is somewhat slow and doesn't make use of graphics modes, but for a mid-priced ($495) package, you'll find it hard to beat. Let's just hope MicroPro doesn't wait four more years to release another version—and how about a built-in outliner!

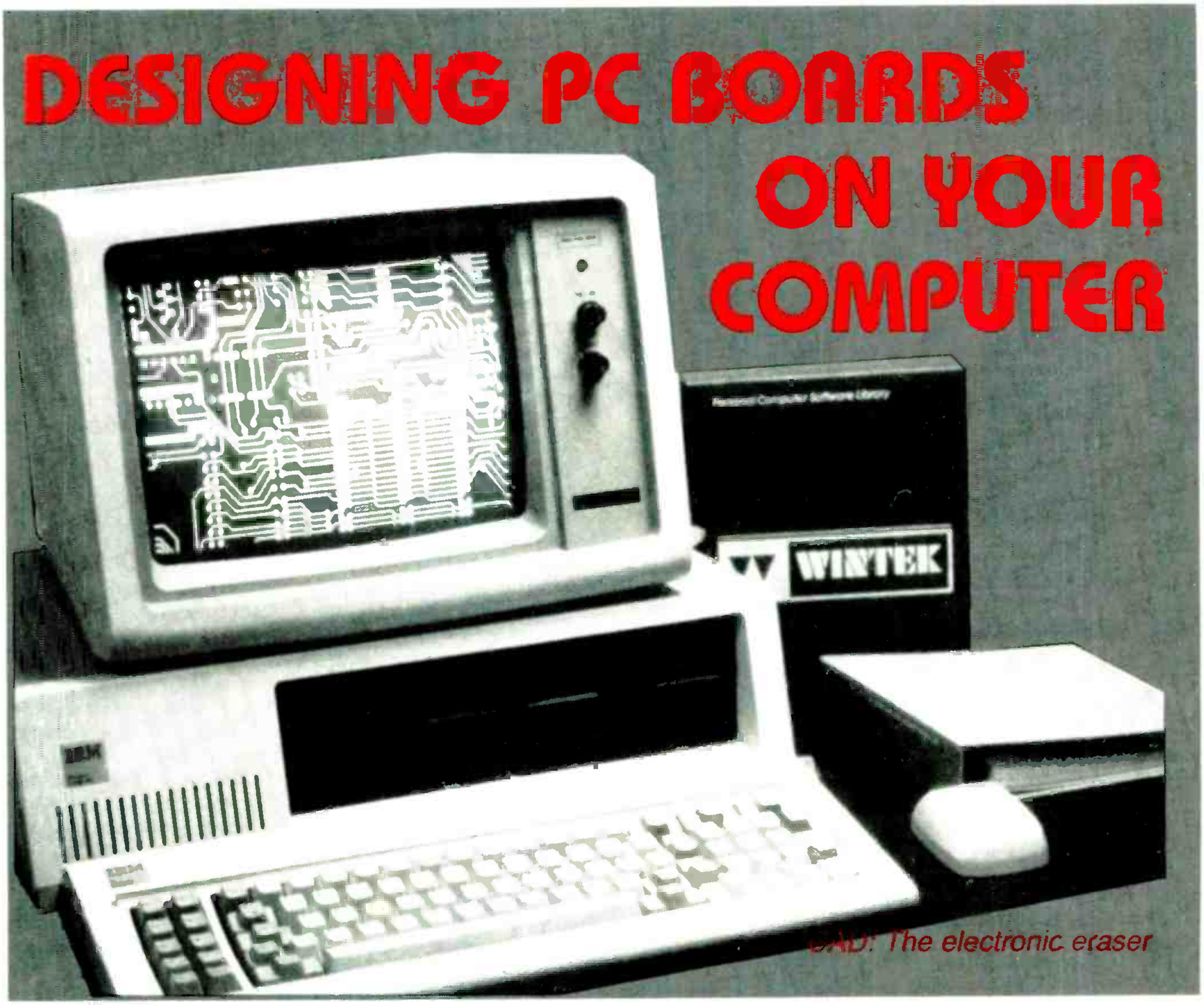
ASHTON-TATE, DBASE III PLUS

The last Ashton-Tate product we had occasion to use (some four years ago) was dBASE II on a CP/M machine. The program has evolved a great deal in those four years; dBASE III Plus (which runs only on IBM and compatible machines) is much polished and much enhanced over the previous version. For example, there are many many new programming commands and network support, but the more significant changes have occurred in the user interface.

dBASE III Plus has five user support systems: a disk-based tutorial; a program that helps you build a simple database automatically; another program that gives dBASE III Plus a menu-driven front end; extensive on-line help; and two thick manuals. The manuals constitute the weak link in the support system because it's hard to locate desired information quickly.

dBASE III Plus is a *de facto* standard in the microcomputer world. It's a powerful product with many features, so it's a serious contender for any moderate to complex database management job. The program lists for $695 from Ashton-Tate (20101 Hamilton Ave., Torrance, CA 90502).

DESIGNING PC BOARDS ON YOUR COMPUTER



CAD: The electronic eraser

ROBERT GROSSBLATT

It hasn't been long since the most sophisticated thing you could do on a home computer was save the Earth from an alien invasion. More practical (and more mundane) jobs like word processing, database management, and CAD were the exclusive property of mainframes and work stations. Why? Because they need lots of memory to work, and enough speed to provide a solution before the problem becomes obsolete.

However, the last several years have seen such a tremendous increase in computer technology that the difference between micro and mainframe machines is becoming more one of semantics than anything else. LSI and VLSI IC's have advanced microprocessors to the point where today's home computers are orders of magnitude more powerful than the mainframes used ten years ago. The bus width, instruction set, speed, and register structure of a modern CPU provides the perfect hardware environment for a new generation of sophisticated software.

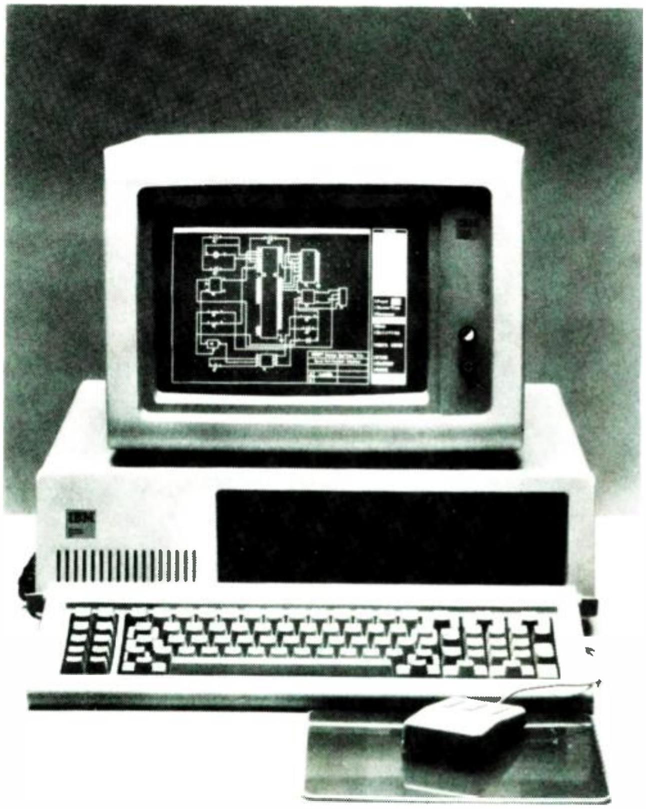
One of the beneficiaries of this advance in computer power is the printed-circuit board designer. Anyone who has laid a board out by hand knows that routing traces is really a matter of repetitive trial and error. After the circuit design is finalized and the size and shape of the board have been defined, connecting all the components properly entails doing a great deal of experimenting. There are many standard guidelines to follow, and every designer has his own bag of tricks, but there's no getting around the fact that the whole job is tedious, time consuming, and often incredibly boring.

The good news is that now there are several commercial printed-circuit board layout programs available for the home computer. But before you rush out to buy one, keep in mind the fact that there are vast differences in price and performance among them. How can you decide which is right for you? Keep reading. In this two-part article we are going to examine the features of several popular programs in detail. But before getting into specific features of specific programs, we're going to discuss the basics of PC-board design. That way, if you're new to CAD (Computer-Aided Design), you can get a feel for what it's all about. We'll talk about specific programs (those shown in Table 1) next time.

The basics of CAD

Laying out a PC board (by hand or by computer) is not a random process; you must have definite information at hand, and you must follow rational procedures.

1. The circuit design must be finalized. You must know how the components are supposed to be connected, which signals are going off-board, sizes and shapes of on-board connectors, etc.



THE SCREEN DISPLAY OF A Project: PCB layout is an accurate representation of the hardcopy that will appear.

2. The board itself must be defined. You have to decide on its shape, edge connector and header positions, the number of layers, and so forth.

3. Next the parts have to be placed. Components that need shielding should be physically close; power, ground, and bus lines must be allowed for, and so on.

4. Trace width must be decided. A circuit that draws a great deal of current will need wider traces than an all-CMOS design.

5. The method of fabrication must also be known. The layout may vary depending on whether you're taping the board, doing it photochemically, having it commercially made, etc.

Some of those considerations may never have crossed your mind, but, if you examine the steps you follow in laying out a board by hand, you'll see that (perhaps unconsciously) you decide every one of those issues before sitting down to do the layout. The point is that, in order for a computer to design a PC board, it must know (i. e., you have to tell it), all the things we just listed.

The routing program

The heart of any PC-board software is its routing package, the program that figures out how the traces should be laid out on the board. The routing program reads a file (that's created by another program) to get information on circuit connections and design rules, and then it goes ahead to solve all the topological problems for routing the board. The algorithms used to make connections vary from program to program, but they all do basically the same thing you would do if you were laying the board out by hand. A trace is started from one pin and keeps going until it finds an obstacle It then moves to one side a bit and tries again. The process is repeated until it gets to the final destination. Sounds familiar, doesn't it?

Different routers have different success rates with a given set of parameters on the same board. It all depends on how sophisticated the software is: how thin a trace it can draw, the minimum distance it can set between traces, what kind of corners it can turn, and, most important of all, how well the routing program was written to begin with.

The basic router is the "point-to-point" variety. When you use one, you indicate, for example, which two pins you want to connect, and the program tries to connect them. The interactive approach lets you control the order of traces, and it does all the tedious trial-and-error work for you. You can certainly lay out a board that way, but you'll have to be involved in every single step.

In a sense, the point-to-point router is a technician's version of "computer art" software. Using a computer art program, you would indicate two points on the screen and then connect them by entering the appropriate coordinates on a keyboard, by moving the cursor with the keyboard's directional (arrow) keys, by moving a mouse or joystick, or by drawing a line on a graphics tablet. Depending on the device or method used to create the line, the points would be connected by a straight line or by one having irregularities. The interactive basic router doesn't work much different, it just insures the connecting lines won't be irregular. Also, keep in mind that the more complex the board, the more difficult the job will be.

Remember that there's much more to laying out a board than just making connections. For example, let's say that you start at one corner of the layout and begin laying down traces. As the board fills up, it gets harder and harder to find paths to connect the pins. At some point you realize that you can simplify the routing of many traces by redoing much of the work you've already finished. So if you were doing everything by hand, you'd turn your pencil upside down and start erasing traces. That's exactly what you have to do with software that does point-to-point routing.

In fact, that's the biggest limitation of a point-to-point router. It doesn't know how or when to make the judgement that it's better off re-doing some work than sticking with a design and trying to work around it. That type of software only knows how to tie two points together—it can't optimize trace routing of the entire board. To do that, you need software that's several orders of magnitude smarter: what's called an auto-router.

Automatic trace routing

An auto-router knows when it makes sense to throw away earlier parts of the layout. You can sit down and tell it how you'd like to tie particular pins together (that's called pre-routing), or you can let it handle the whole job by itself. It takes both connection and placement information from files (called *netlists*) and sets about doing the entire layout from start to finish. All you have to do is give the auto-router the name of the job and start it up.

The success rate of an auto-router depends, among other things, on how flexible it is. A versatile program will provide you with many options so you can tell it what the layout parameters are, how much time to spend on an individual trace, how convoluted the path of any one trace can be, at what point it should consider redoing work it's already done, etc., etc. The bottom line is that, the more control you have over the rules the auto-router follows, the more chance there is that it will route your board in a satisfactory manner.

Feeding the router

No matter how sophisticated the router is, it's only one part of a complete PC-board layout package. You need some way to give it the information it must have to do the job. That information includes the following:

1. The components you're using.
2. How they're connected together.
3. The board's physical characteristics.
4. Where the parts are placed on the board.
5. The type of hardcopy output you want.

The way a PC-board layout program collects all that information is critical, because the data-gathering part of the package is usually the one the user spends the most time with.

The simplest approach is to provide a way to enter data in symbolic form via the keyboard. The data file thus created lists which pins are connected together. The shape of the board and its

TABLE 1—PROGRAMS DISCUSSED

smARTWORKS	The Wintek Corporation 1801 South Street Lafayette, Indiana 47904-2993 $895.00 Copy Protected
Project: PCB	DASOFT Designs Systems, Inc. P.O. Box 8088 Berkeley, California 94707-8088 $950.00 Hardware Locked
The Autoboard System	The Great Softwestern Company, Inc. 207 W. Hickory St. Suite 309 Denton, Texas 76201 $2500.00 Requires AutoCAD
AutoCAD	Autodesk, Inc. 2320 Marinship Way Sausalito, California 94965 $2850.00 (Version 2.5 or above)
smARTCAD	Creative Electronics 925 Fairwin Ave. Nashville, Tennessee 37216 $395

component layout can be handled in the same way You have to establish some sort of coordinate system and use it to indicate both the edges of the board and the location of each component. That data could be entered from the keyboard just as the circuit data was The problem with this method is that it's slow, non-intuitive, and prone to hard-to-detect errors

Graphics editor

Using a database manager or word processor to build the files needed by the router is one way to solve the problem, but a much slicker (and friendlier) way to get the job done is to use a graphics editor as the router's front end It's much easier to draw the schematic and the board than it is to describe them After all, everybody knows that one picture is worth a thousand words—to say nothing of hours and hours of work, as well

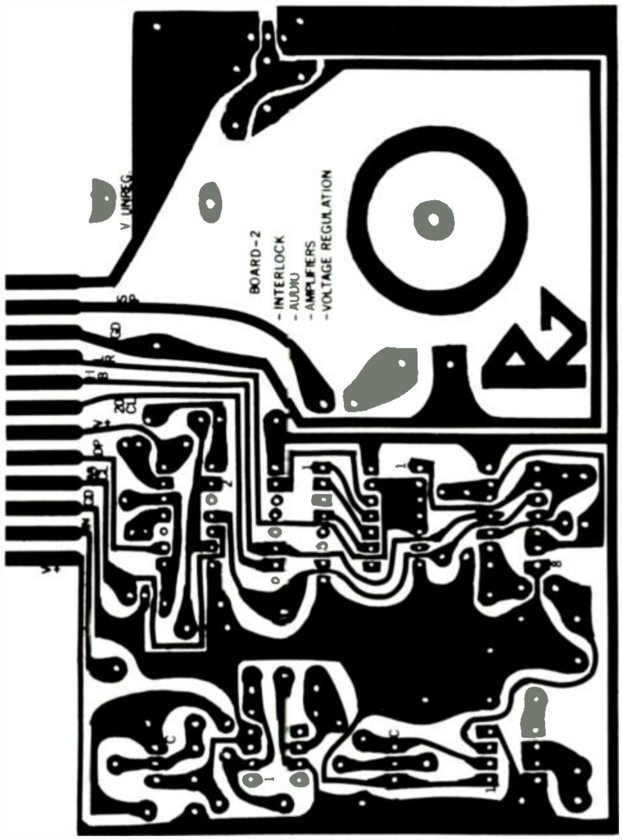
The idea is to use software that knows how to translate graphic images (drawn by you) into the tabular data needed by the router. The approach is terrific from the user's point of view, but it's an enormous problem for programmers, because designing a graphics system is not something you whip out between breakfast and lunch

Among other things, you have to contend with graphic display standards (or lack thereof), digitizers, printers, plotters, and the rest of the I/O can of worms It's one thing to manipulate graphic data in memory, but getting that data out in a useful form is difficult, because there are almost as many I O standards as there are peripherals on the market And even after the I O problems are solved, the software designer still faces the job of translating graphic data into files that can be read by the router

The router

Most commercial PC-board software allows you to enter data via a graphics editor, and most gives you some provision for editing the netlists that are produced If you pay attention to what you're doing, you can be reasonably sure that the router will work on exactly the circuit and layout you have in mind What the router will produce, however, is something else altogether

When you route a board by hand, the job is over when you put the last trace on the board But with a router, the job's finished when it's completed as many traces as it can The difference is more than merely semantic Even if you're using the world's most sophisticated software, there's a good chance that the router won't be 100% successful You'll still have to route a few traces by hand, and



EVEN THOUGH IT'S A GOOD JOB, this layout was obviously hand-drawn. Next month we'll do the layout by computer.

when you reach that point, a good graphics editor becomes extremely important.

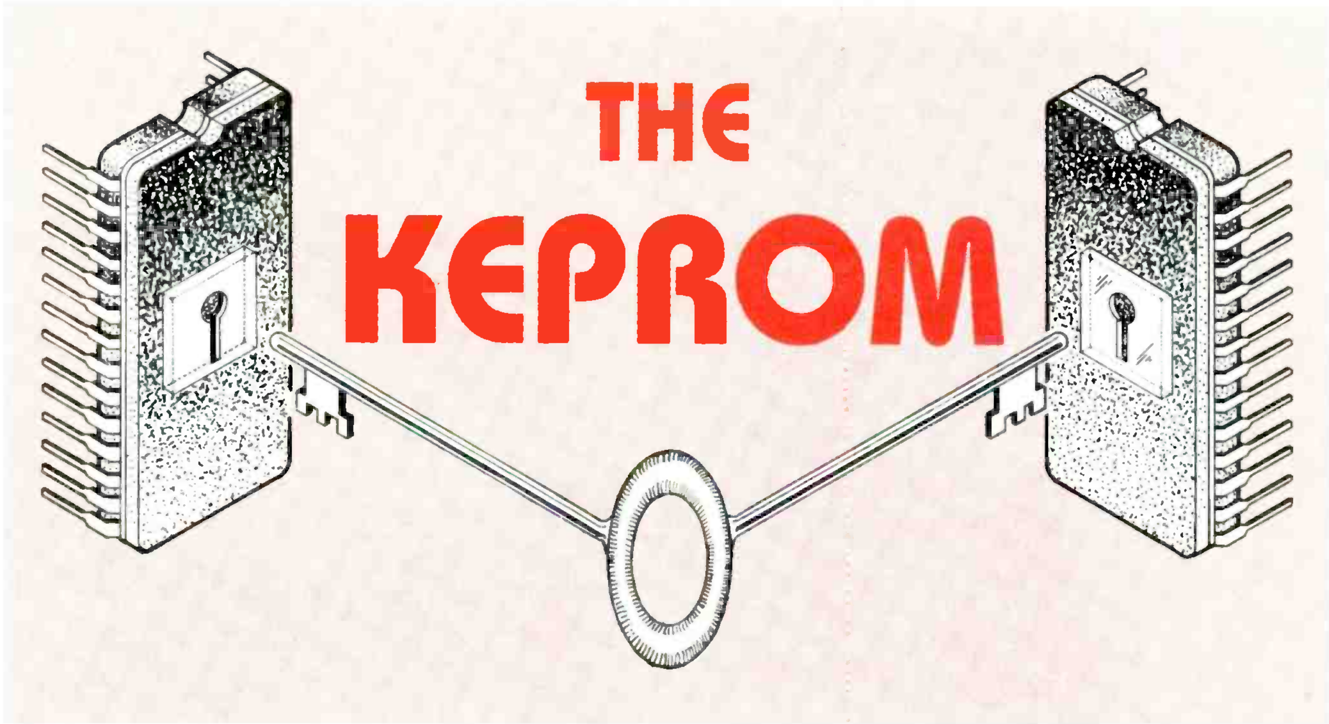
By the time the router finishes doing what it can, most of the traces will have been laid out, so adding the missing ones can turn out to be a tough job In fact, if the graphics editor isn't very powerful, it can be an impossible job You'll have to move and stretch many existing traces to be able to fit in the missing ones And more than likely you'll want to re-route some of the work done by the router, because some of the paths it made may have overlooked more obvious routes The reason for this is that the router doesn't think the way you do; *obvious* is a relative term

Getting hardcopy

However the software goes about collecting and processing the data, eventually the layout must be put down on paper It's all well and good to be able to take your circuit and generate a file that contains a description of the routed board, but the whole point of using a computer is lost if you can't get the answers out in a format you can use

Just as you can enter data in several ways, you can get hardcopy output in several ways You can send the image to a printer or a plotter and produce drawings for photochemical board production Or you might want it in a data coordinate format to use with a numerical-control drilling machine There are other options too, including files that can be processed further by other programs And you must know before you start what you want by the time you're finished So if you're considering a particular program, make sure it can provide the kind of output you want

Next time we'll look at the capabilities of several programs



THE KEPROM

Sinking The Software Pirates

JEFF HOLTZMAN, TECHNICAL EDITOR

Millions of dollars are lost every year because software pirates copy, use, and sometimes distribute popular computer programs. Until recently the usual method of protecting software from unauthorized distribution has been to provide that software on floppy disks that are copy-protected, or on special "key" disks that must be present whenever the program is running.

However, copy protection has not proven to be an effective means of halting the unauthorized usage and distribution of computer programs. Legitimate users find key disks inconvenient, but even more important, a number of companies sell programs that can copy so-called copy-protected disks with ease.

Intel Corporation (3065 Bowers Ave., Santa Clara, CA 95051) has come up with a hardware solution to the problem of copy protection. The solution involves use of two or more 27916 Keyed-access EPROM's (or KEPROM's for short). A factory-fresh 27916 functions just like a 27128 EPROM; the 27916 comes in a 28-pin package that is identical to that of a 27128. The 27916's pinout is shown in Fig. 1.

Inside, the 27916 contains 16,384 eight-bit bytes that may be programmed and erased using standard equipment and procedures. In addition, however, as shown in Fig. 2, the 27916 contains special circuitry that locks the KEPROM—that prevents all but a 528-byte boot area from being accessed until a special authentication sequence has been carried out. The authentication sequence involves the two-way transfer of an internally generated, 32-bit random number that is encrypted according to a designer-defined 64-bit key. If, after the transfer, the originating and receiving KEPROM's have not decrypted the same number, their memory arrays remain locked and unusable. Otherwise each functions just like a standard 27128 EPROM until the next power-down, or until a special reset code is received.

There are a number of ways of using the KEPROM's security features. Probably the most useful is to store the system's boot code in a KEPROM. Then, if the proper handshake sequence is not performed, the system will not come up. A limited number of users might have plug-in cartridges (computer game cartridges, for example), each of which would contain a KEPROM with the correct key. When a user inserted his cartridge, he would be able to boot the system. To perform that type of boot, both KEPROM's must have access to the data and address buses, as shown in Fig. 3.

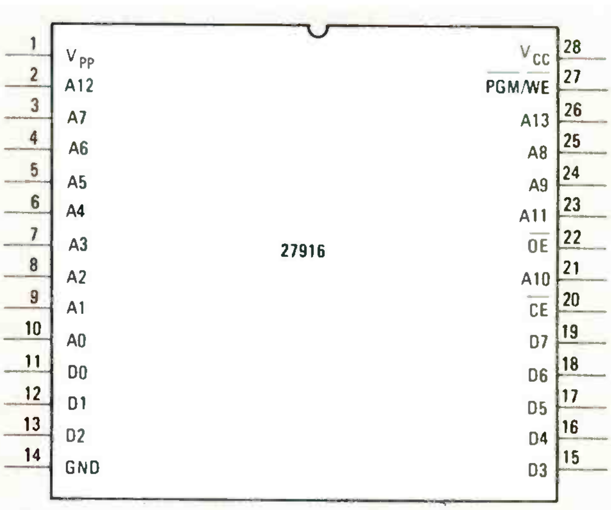


FIG. 3—THE PINOUT OF THE 27916 is functionally identical to that of the 27128.

A software publisher (like Microsoft) would find it difficult to use a KEPROM security system with present-day machines and a BASIC language program, for example. It takes two KEPROM's to perform the authentication handshake, so the BASIC cartridge should contain one KEPROM, and the other should be mounted on the system board. However, no present-day personal computers contain their boot software in KEPROM form. Retro fitting might be possible, but, to be most useful, a KEPROM-based security system must be designed in from the beginning.

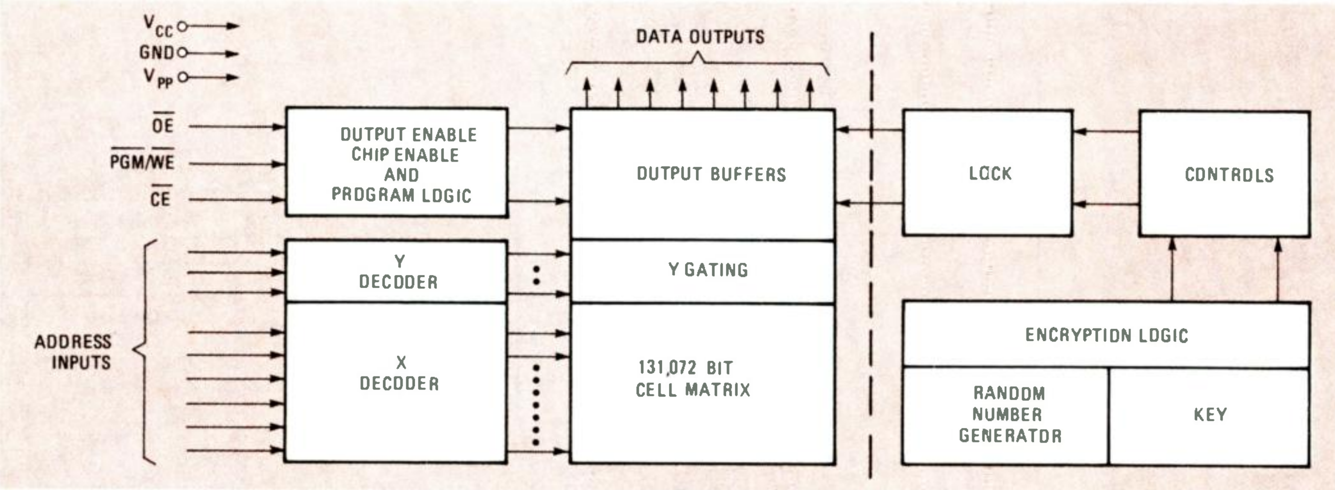


FIG. 2—BLOCK DIAGRAM OF THE 27916 reveals that half of the IC (shown to the left of the dashed line) is very similar to a standard EPROM. The other half (shown to the right of the dashed line) contains the extra logic, control, and memory cells.

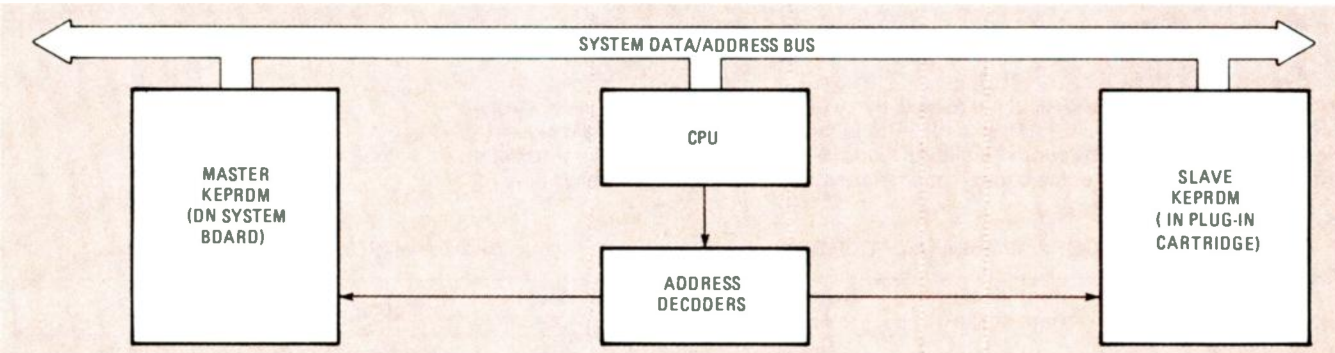


FIG. 3—A KEPROM-BASED SYSTEM requires normal access to the data anc address buses.

Configurations and states

A 27916 may be configured to operate in one of three different ways: as a 27128 EPROM, as a 27916 KEPROM, and as a 27916 Key Manager. As a 27128, no authentication process need be executed at power-up But as a KEPROM or a Key Manager, the authentication process must be executed at power-up. As a Key Manager, the device can control as many as 1024 KEPROM's In that configuration, the device holds 1024 eight-byte keys, so half of the 16,384-byte address space is unavailable for system and application software. Two programmable bits (that are not located in the regular 16,384-byte address space) determine the device's configuration.

When a 27916 is configured as a KEPROM or as a Key Manager, it can be in one of three different states originator, recipient, or memory. It can enter the memory state only after the authentication process has been completed successfully. The other two states are used during authentication, which we'll discuss more fully below.

Memory map

As shown in Fig. 4, the 27916 has a number of overlapping memory locations. As shown in Fig. 4-a, when a 27916 is in the memory state, and pin 24 is at a TTL high or low, the entire 16K of memory address space is available for normal read-only use. However, location 401 (all addresses are specified in hexadecimal notation) also contains a command register that controls the 27916's state. The possible states are listed in Table 1

When a 27916 is in Originator or Recipient states, several other registers become accessible Location 400 is an input/output register that is used to transfer the encrypted keys between two KEPROM's bit by bit Locations 402 and 403 contain an optional key number that is used as an index, in a Key Manager system, to the proper key (of 1024 possible keys) Location 404 contains a Ready register that is used to synchronize key-bit transfers

TABLE 1—COMMAND REGISTER CODES

Hex Value	Command
04	Enter Memory State
09	Enter Recipient State
31	Enter Originator State
29	Reset Default Recipient
31	Reset Default Originator
0B	Enter Recipient (Key-Manager Test)
33	Enter Originator (Key-Manager Test)
2B	Reset Default RE (Key-Manager Test)
33	Reset Default OR (Key-Manager Test)

Several additional registers become available when pin 24 (address line 9) is raised to 12 volts, as shown in Fig. 4-c. These locations need only be accessed during the manufacturing cycle, so you don't have to worry about 12-volt signals on your 5-volt system bus! Location 00 contains a manufacturer's code, and location 01 contains a device code. That information can be used by automatic programming machinery to select the proper programming voltages and algorithms.

Further, with pin 24 at 12 volts, a command mask register (location 401) and a programmable delay count register (location 405) can be written to. The delay count register determines the speed at which the authentication handshake occurs; legal values and corresponding handshake times are listed in Table 2. Slowing down the handshake process makes it more difficult for a would-be pirate to decode the sequence of operations

The Command Mask Register controls the 27916's configuration

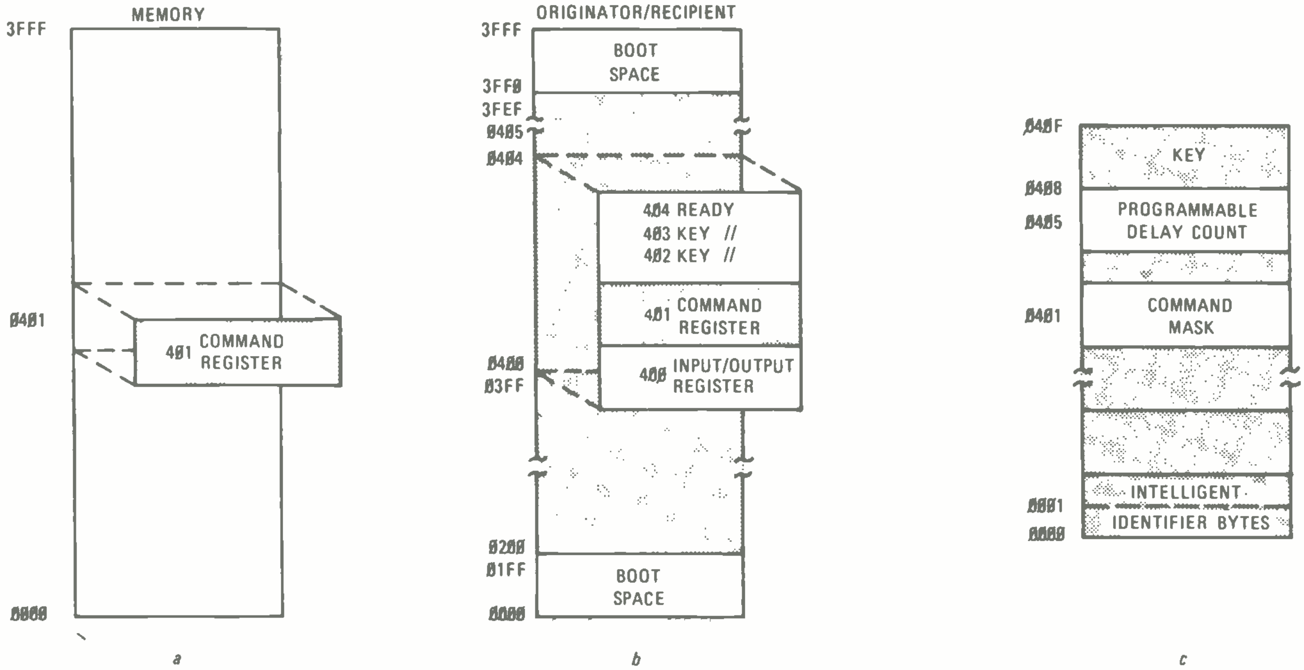


FIG. 4—MEMORY MAP OF THE 27916 reveals that when the device is in the memory state (a), all 16K of memory is available as usual. But in the originator and recipient states (b), only the boot areas and the control registers are accessible. In either state, by connecting pin 24 to · 12 volts, the delay count, command mask, and ID bytes are accessible (c).

TABLE 2—PROGRAMMABLE DELAY CODES

Hex Value	Approximate Handshake	Handshake Speed
1F	10 sec.	Slowest
3F	6-8 sec.	Slower
7F	3-5 sec.	Slow
FF	0.15 sec.	Fast

TABLE 3—COMMAND MASK CODING

Hex Code	Configuration and Default State
E0	Locked Key-Manager—Default Recipient
E1	Not Locked Key-Manager—Default Recipient
E2	Locked KEPROM—Default Recipient
E3	Not Locked KEPROM—Default Recipient
E4	Locked Key-Manager—Default Originator
E5	Not Locked Key-Manager—Default Originator
E6	Locked KEPROM—Default Originator
E7	Not Locked KEPROM—Default Originator

(KEPROM, 27128, or Key Manager) It, by the way, is the third register that can be accessed at location 401, the normal memory cell and the command register are the other two Legal values and corresponding configurations are shown in Table 3 Bit 0 of the Command Mask Register is the lock bit, bit 1 is the manager bit If either bit is programmed with a value of 0, the 27916 cannot be read without first executing an authentication sequence If the manager bit is programmed with a value of 0, the 27916 enters the Key Manager configuration The lock bit is erasable, but the manager bit is not Hence the Key Manager configuration is permanent

The authentication handshake

The overall system boot-up process is outlined in Fig 5 First the two 27916's must be reset by writing the appropriate reset code (as shown in Table 1) to the command register One 27916 goes into the originator state, and the other goes into the recipient state, according to the contents of their command masks (as shown in Table 3) The originator then generates a 32-bit random number and places a 00 in its ready register The CPU reads a byte from the I O register, polls the recipient's ready register, and transfers the byte to the recipient when it is ready Although an entire eight-bit byte is transferred, only one bit is significant, so 32 separate transfers must take place to transfer the entire key

The recipient encrypts the number according to its key, and then sends that number to the originator, using the same type of polling sequence The originator then encrypts the original number and compares the two encrypted numbers If they are equal, which they will be if the originator's and the recipient's keys are identical, the recipient can be placed in the memory state Then the two devices swap roles and the process repeats If the numbers match, the new recipient can be placed in the memory state

The key

The key used to encrypt the random number is 64 bits long, hence there are about 10^{19} possible keys That fact alone makes it difficult for the would-be pirate to attempt to determine the key The eight key bytes are programmed into memory locations 408–40F After the 27916 is configured as a KEPROM or a Key Manager, the key bytes are completely inaccessible to the outside world

Usage considerations

First the 27916's normal memory space should be programmed, keeping in mind that the first 512 bytes must be used to perform the authentication sequence The upper bytes of the 27916 (3FF0–3FFF) are also reserved for use with microprocessors like the 6502 whose reset and interrupt sequences use vectors in that area

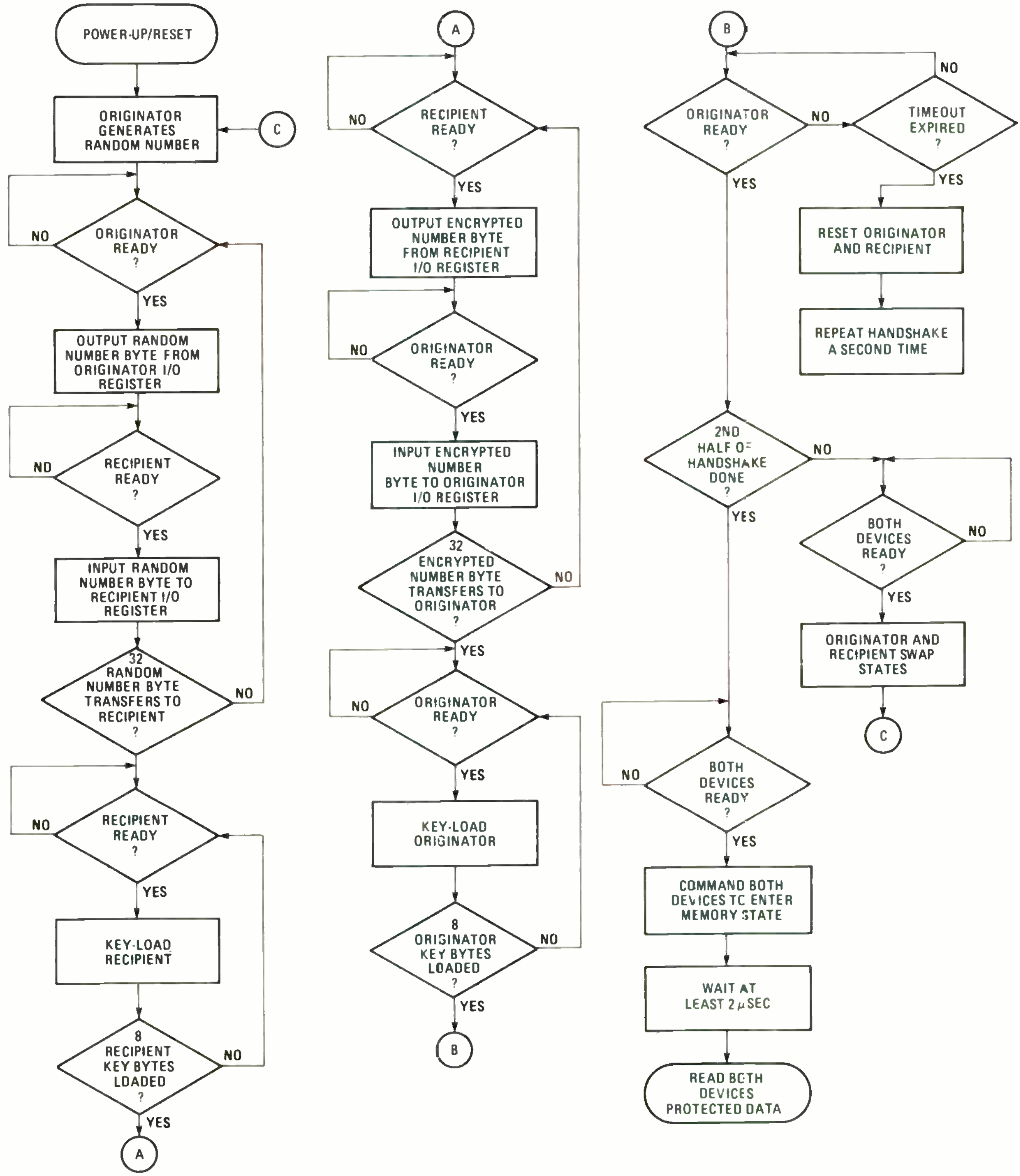


FIG. 5—FLOW CHART illustrates the proper boot-up sequence to enable the originator and recipient KEPROM's.

Then the Programmable delay counter should be programmed, if desired, and verified. The key (and the key number, if used) are programmed and verified next. Only then should the command mask be programmed. After that, the device will be locked, and access to its contents can only be gained after an authentication handshake. The Delay Counter, the Key bytes, the Key number and the command mask are programmed more or less the same as normal, but pin 24 (A9) is connected to a 12 volt source.

As for hardware considerations, Intel recommends connecting a 0.1-μF capacitor between V_{CC} and ground near each 27916, and one 4.7 μF tantalum capacitor for every eight 27916's to compensate for voltage droop due to PC-trace inductance. The 27916 has a 250 ns access time, so it should be fully compatible with standard EPROM circuits and layouts.

Intel recommends that the 27916 in which the boot code is located should be soldered, and perhaps glued, to the PC board for maximum protection. The "slave" 27916 can also be board-mounted, or it can be mounted in a plug-in cartridge. For use in 16-bit systems, the two KEPROM's can be connected in parallel; the authentication handshake would take place between the upper and the lower halves of the data bus.

How safe is a KEPROM?

It might be possible, using a scanning electron microscope and other highly sophisticated equipment, to take a 27916 apart and duplicate the code it contained. Few people have access to that sort of equipment, but for military and other security-sensitive uses, the possibility that a KEPROM could be disassembled must be taken into account.

Another way of cracking a KEPROM involves using a logic analyzer. One could be attached to the system bus of a target computer and used to record the contents of the various memory devices in a system as they were accessed. But even if the complete contents of a locked memory system were obtained, they would not be useful without knowledge of the key, and the key is never present on the output pins after the lock bit has been cleared.

To understand why, suppose someone were able to duplicate the contents of a plug-in KEPROM cartridge. If those contents were duplicated in a 27128 EPROM and plugged in the cartridge port, the authentication handshake would fail, because the 27128 would not echo the encrypted random number.

You might think that the recovered contents could be transferred to a blank KEPROM, and the key somehow discerned. But how? It would take (literal y!) centuries to try all possible 10^{19} keys one by one. Other methods using statistical analyses could be tried, or the key might be arrived at by cracking the encryption algorithm, but both are highly unlikely to yield results.

It's ironic that, just at the time when major software publishers like Microsoft and Ashton-Tate are dropping floppy-disk copy protection, Intel has developed the 27916. Whether those publishers will adopt hardware protection remains to be seen. It's highly unlikely that users will be happy with using plug-in cartridges. R-E

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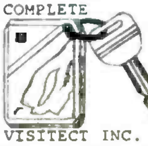

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LM339	50	711CH	60	LM3900	45
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LF351	45	741CV	29	4136	85
LF353	55	747	50	SD5000	1.75
LF355	85	LM798CT	60	N5534	75
LF356	85	DAC0800	2.95	N5596A	1.50
LM358	45	LM1310	1.40	SD6000	1.00
LM370	1.60	MC1355	70	8038	3.95
LM380	85	MC1391	1.00	8700CJ	5.95
LM384	1.60			LM13080	95

C/MOS

74C00	25	[illegible]	1.10	4027	35	4072	[illegible]
74C02	25	[illegible]	3.50	4028	65	4076	55
74C04	25	4001	19	4029	65	4077	28
74C08	25	4002	20	4030	35	4081	[illegible]
74C10	25	4006	65	4034	1.40	4082	[illegible]
74C14	55	4007	20	4035	65	4093	45
74C20	25	4008	85	4040	65	4099	1.40
74C32	35	4009	35	4041	75	4501	95
74C42	1.10	4010	35	4042	55	4503	45
74C74	55	4011	19	4043	85	4506	75
74C76	60	4012	25	4044	65	4510	65
74C83	1.20	4013	35	4045	85	4511	65
74C85	1.25	4014	65	4046	55	4512	75
74C86	35	4015	28	4047	65	4514	95
74C93	1.00	4016	28	4049	28	4515	1.60
74C154	3.00	4017	45	4050	28	4516	75
74C157	95	4018	65	4051	65	4518	85
74C161	95	4019	35	4052	65	4520	75
74C174	95	4020	55	4053	65	4528	75
74C175	95	4021	65	4060	65	4529	1.40
74C245	1.75	4022	65	4066	28	4538	95
74C901	35	4023	25	4068	35	4539	1.50
74C902	[illegible]	4024	48	4069	19	4541B	1.20
74C903	[illegible]	4025	25	4070	28	4553	1.75
74C907	[illegible]	4026	1.25	4071	20	4581	90
						4585	75

PLEASE CALL FOR QUANTITY PRICING

74S SERIES

74S00	25	74S85	90	74S165	1.50
74S02	29	74S86	35	74S174	75
74S03	29	74S89	2.00	74S175	75
74S04	29	74S112	50	74S181	3.00
74S05	29	74S113	50	74S182	2.00
74S08	35	74S124	2.20	74S189	1.60
74S09	40	74S133	45	74S194	1.30
74S10	29	74S135	85	74S195	1.30
74S11	35	74S138	75	74S240	1.40
74S15	35	74S139	75	74S241	1.40
74S20	29	74S140	50	74S244	1.25
74S30	29	74S151	75	74S251	75
74S32	35	74S153	75	74S257	90
74S40	29	74S157	75	74S260	75
74S42	85	74S158	90	74S373	1.65
74S51	35	74S161	1.25	74S374	1.65
74S74	45	74S163	1.25		

74LS SERIES

74LS00	[illegible]	74LS112	29	74LS240	65
74LS01	17	74LS113	33	74LS241	[illegible]
74LS02	[illegible]	74LS114	[illegible]	74LS242	[illegible]
74LS03	17	74LS123	45	74LS243	65
74LS04	17	74LS125	35	74LS244	65
74LS05	[illegible]	74LS126	35	74LS245	75
74LS08	17	74LS132	39	74LS246	1.40
74LS09	17	74LS136	35	74LS247	75
74LS10	17	74LS137	90	74LS248	65
74LS11	20	74LS138	39	74LS251	45
74LS12	27	74LS139	39	74LS253	45
74LS13	25	74LS145	70	74LS257	39
74LS14	36	74LS147	1.00	74LS258	45
74LS15	25	74LS148	90	74LS259	1.20
74LS20	17	74LS151	39	74LS260	45
74LS21	22	74LS153	39	74LS266	55
74LS22	22	74LS154	1.50	74LS273	75
74LS26	23	74LS155	55	74LS279	39
74LS27	23	74LS156	45	74LS280	1.70
74LS28	26	74LS157	35	74LS283	55
74LS31	17	74LS158	20	74LS290	80
74LS32	[illegible]	74LS160	29	74LS293	80
74LS37	26	74LS161	49	74LS298	65
74LS38	26	74LS162	49	74LS320	2.00
74LS40	17	74LS163	49	74LS322	3.00
74LS42	35	74LS164	45	74LS323	2.40
74LS48	65	74LS165	65	74LS365	39
74LS51	17	74LS166	95	74LS366	39
74LS54	22	74LS169	90	74LS367	39
74LS73	25	74LS170	80	74LS368	39
74LS74	24	74LS173	49	74LS373	75
74LS75	29	74LS174	39	74LS374	75
74LS76	29	74LS175	39	74LS377	75
74LS83	45	74LS181	1.40	74LS386	45
74LS85	45	74LS190	49	74LS390	1.10
74LS86	22	74LS191	49	74LS393	75
74LS90	39	74LS192	65	74LS398	2.50
74LS92	45	74LS193	65	74LS446	2.00
74LS93	45	74LS194	65	74LS541	1.40
74LS95	48	74LS195	65	74LS625	1.75
74LS96	49	74LS196	55	74LS645	95
74LS107	35	74LS197	55	74LS668	1.45
74LS109	35	74LS221	55	74LS670	95
				81LS98	1.40

RCA HC 2500 60 WATTS
SOLID STATE HYBRID LINEAR AND AUDIO AMP $34.95
BAND WIDTH 30 KHz at 60 WATTS 7 AMP OUTPUT

TANTULUM CAPACITORS

22UF 35V	5/$1.00	15UF 16V	3/$1.00
47UF 35V	5/$1.00	22UF 10V	$ .30
68UF 35V	[illegible] $1.00	30UF 6V	5/$1.00
1UF 20V	[illegible] $1.00	33UF 15V	$ .50
2.2UF 20V	5/$1.00	47UF 20V	$ .85
3.3UF 20V	4/$1.00	[illegible] 20V	$1[illegible]
4.7UF 20V	[illegible] $1.00	150UF 16V	$1.30
6.8UF 20V	[illegible]	200UF 20V	$1.75
10UF 20V	[illegible]	[illegible] 10V	$1.75

DISC CAPACITORS

.1UF 16V 10/$[illegible]
.01UF 35V 16/$1.[illegible]

1N4148 (1N914) 15/1.00

REGULATORS

[illegible]	$5.[illegible]	12V 1LA1405I	$2.95
78L05 or 12	$ .30	LM317	$2.75
78M05 12 or 15	$ .40	LM338K	$3.75
LM305	$ .75	3401 5 6 8.9 12 15 18 or 24V	$ .45
309K	$1.25		
LM317T	$ .90	723	$ .45
320T 5 12 15 or 24	$ .55		

L14I1 IR Detector	3/$1.00
FP 100 Photo Trans	$ .50
Red LED's 2"	10/$1.00
Yellow, Green or Amber Lg LED's 2"	8/$1.00
Red Green Bipolar LED	$ .90
Red Yellow Bipolar LED	$ .90
MLED92 IR LED	$ .40
MRD148 Photo Darlington	$ .60
IL 5 Opto Isolator	$ .60
4N45 Opto Coupler	$ [illegible]

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5V SPST	.75
5V DPST	.95
12V DPST	.95

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4" x 6" DOUBLE SIDED EPOXY BOARDED 1/16" THICK $.60 ea. 5/$2.60

20KV DIODES $1.95 250 ma

FULL WAVE BRIDGE

PRV	2A	6A	25A
100			1.40
200	80	1.30	2.20
400	1.00	1.65	2.30
600	1.[illegible]	1.90	4.40

DIP SWITCHES

CTS 206	4	4 Position	75
CTS 206	7	7 Position	95
CTS 206	8	8 Position	95
CTS 206	10	10 Position	1.25

SILICON POWER RECTIFIERS

PRV	1A	3A	12A	50A	125A	240A
100	05	14	35	90	6.00	
200	06	17	50	1.[illegible]0		[illegible]
400	09	25	65	1.50	10.00	12.00
600	11	30	80	2.00	12.00	15.00
800	13	35	1.00	2.50	16.00	18.00
1000	20	45	1.25	3.00	20.00	26.00

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CIRCLE 74 ON FREE INFORMATION CARD

ANTIQUE RADIO

continued from page 84

Finally, the output of the detector is capacitively coupled to the 6F6 power-amplifier pentode. The output from that pentode's plate circuit is coupled to the loudspeakers voice coil by T2.

Note the R-C network consisting of R12, C28, and C27, along with its associated switch, S5. That is a two-position tone control used to tailor the sound to the owner's preference. Such controls were not always included in radios of the period (or modern radios for that matter). As a result, the circuitry was often added by the owner. Details for doing that were available in Gernsback's **Radio Craft** and other electronics magazines of the day. One hint relating to that control: One of the things you should be sure to do once you've removed the chassis from the cabinet is to clean S5. Dirt on that switch can cause scratchy sound.

Next time we will get to work on restoring our radio. R-E

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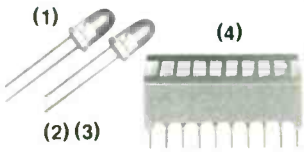
Unusual LEDs



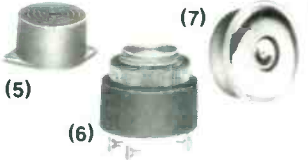
(1) Super-Bright Red. Outputs 300 mcd. #276-066 . . . . 99¢

(2) Blinking Red. MOS driver and a red LED combo. Can drive several LEDs in series. #276-036 . . . . 1.19

(3) Blinking Green. #276-030, 1.19

(4) Bar Graph Display. Ten bright red segments. #276-081 . . . . 2.99

Sound Wars!



(5) Tri-Sound Siren. Wiring options create three different 80 db outputs. 3 VDC. #273-072 . . . 5.95

(6) Pulsing or Continuous Piezo Buzzer. Screwdriver terminals. 4 to 28 VDC. #273-068 . . . . 6.95

(7) Electromechanical Buzzer. Extra loud! 12 VDC. #273-051 . . 1.89

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Save Postage! Our warehouse sends your order directly to the Radio Shack near you. We pay the shipping cost.

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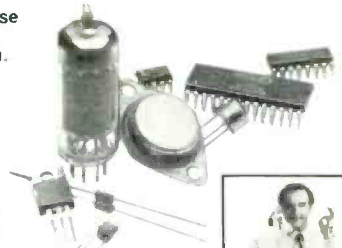

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Resistor Kits

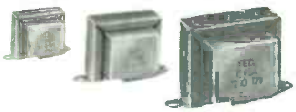
(8) 1/8-Watt 5% Carbon Film. Set of 100, 13 values, 10 ohms to one meg. #271-311 . . . . Set 1.98

(9) 1/4-Watt 1% Metal Film. Set of 50, 12 popular values from 10 ohms to one meg. #271-309 . . . Set 2.49

(10) 1/4-Watt 5% Carbon Film. Big 500-piece set! 54 values, 10 ohms to 10 megohms. #271-312 . . Set 7.95

12V Transformers

Mini Std. H-D



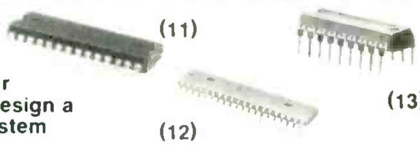
120 VAC primaries.

Type	Volts	Current	Cat No	Each
Miniature	12 6 CT	450 mA	273-1365	3 59
Standard	12 6 CT	1 2 A	273-1352	4 99
Heavy-Duty	12 6 CT	3 0 A	273-15 1	6 99

Experimenters! Put These LSI Chips to Work

Circuit Data Included

Add Speech to Your Computer and/or Design a Remote-Control System



(11) SPO256-AL2 Speech Synthesizer. This preprogrammed MOS device is easy to interface with most microprocessors. Includes detailed data and circuit interface examples. Requires 3.12 MHz crystal (available via our special-order "hotline," above). #276-1784 . . . . 12.95

(12) CTS256-AL2 Text-to-Speech. Translates ASCII from computer into control data for the synthesizer, above. With programming and circuit data. Requires 10 MHz crystal (special-order). #276-1786 . . . . 16.95

(13) SSI 202 Touch-Tone Decoder. Complete DTMF receiver on a chip. Heart of a remote control system! With data. #276-1303 . . . . 12.95

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(14) 6-Outlet. #61-2619 . . . . 19.95

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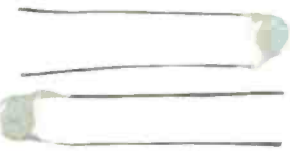
1 3/8" long. Includes 5 red, 5 black. #270-374. Set 1.19

Fuse Holder

Panel-Mount. For 1 1/4 x 1/4" fuses. UL recognized. #270-364 . . . 79¢

Ceramic Capacitors



Low As **39¢** Pkg. of 2

Pkg. of 2, Only 39¢

pF	WVDC	Cat No
4 7	50	272-120
47	50	272-121
100	50	272-123
220	50	272-124
470	50	272-125

Pkg. of 2, Only 49¢

µF	WVDC	Cat No
.001	500	272-126
0047	500	272-130
01	500	272-131
047	50	272-134
1	50	272-135

Tantalum Caps

Low As **49¢** Each

IC pin spacing. 20% tolerance.

µF	WVDC	Cat. No.	Each
0.1	35	272-1432	.49
0.47	35	272-1433	.49
1.0	35	272-1434	.49
2.2	35	272-1435	.59
10	16	272-1436	.69
22	16	272-1437	.89

Tool Set

You get all this: UL listed soldering iron, stand, solder, solder tool, pliers, cutter, 3 screwdrivers, heat sink. #64-2801, 14.95

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12 VDC Coil. #275-241 1.69

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DPDT. Center off position. 6 amps at 250 VAC. #275-653 . . 2.49

On/Off Labeling Plates. #275-320, 5/69¢

Hacker's Corner

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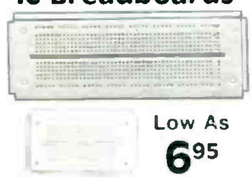
Sound/Color-Video RF Modulator. Top quality, originally for TI 99/4 computer. Built-in TV/computer switch. 12 VDC. #277-1015 . . . 4.95

Plug-In 9 VDC Adapter. What a deal! Efficient supply provides 9 VDC at up to 1 amp—or 13 VDC, no load. Prewired cord, barrel-type DC plug. UL listed. #277-1026 . . . 4.95

IC Breadboards



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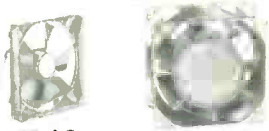
Cooling Fans



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7400

Part No.	1-9	10+	Part No.	1-9	10+
7400	.29	.19	7485	.65	.55
7402	.29	.19	7486	.45	.35
7404	.35	.25	7489	2.05	1.95
7405	.39	.29	7490	.49	.39
7406	.39	.29	7493	.45	.35
7407	.39	.29	74121	.45	.35
7408	.35	.25	74123	.59	.49
7410	.35	.25	74125	.55	.45
7414	.49	.39	74126	.75	.65
7416	.45	.35	74143	4.05	3.95
7417	.45	.35	74150	1.35	1.25
7420	.35	.25	74154	1.35	1.25
7430	.35	.25	74158	1.59	1.49
7432	.39	.29	74173	.85	.75
7438	.39	.29	74174	.65	.55
7442	.55	.45	74175	.65	.55
7445	.79	.69	74176	.99	.89
7446	.89	.79	74181	1.95	1.85
7447	.89	.79	74189	2.05	1.95
7448	2.05	1.95	74193	.79	.69
7472	.75	.65	74198	1.85	1.75
7473	.45	.35	74221	.99	.89
7474	.45	.35	74273	2.05	1.95
7475	.49	.39	74365	.69	.59
7476	.45	.35	74367	.69	.59

74LS

Part No.	1-9	10+	Part No.	1-9	10+
74LS00	.29	.19	74LS165	.75	.65
74LS02	.29	.19	74LS166	.99	.89
74LS04	.35	.25	74LS173	.59	.49
74LS05	.35	.25	74LS174	.49	.39
74LS06	1.09	.99	74LS175	.49	.39
74LS07	1.09	.99	74LS189	4.59	4.49
74LS08	.29	.19	74LS191	.59	.49
74LS10	.29	.19	74LS193	.79	.69
74LS14	.49	.39	74LS221	.69	.59
74LS27	.35	.25	74LS240	.79	.69
74LS30	.29	.19	74LS243	.79	.69
74LS32	.35	.25	74LS244	.79	.69
74LS42	.49	.39	74LS245	.89	.79
74LS47	.99	.89	74LS259	.99	.89
74LS73	.39	.29	74LS273	.89	.79
74LS74	.35	.25	74LS279	.49	.39
74LS75	.39	.29	74LS322	4.05	3.95
74LS76	.55	.45	74LS365	.49	.39
74LS85	.59	.49	74LS366	.49	.39
74LS86	.35	.25	74LS367	.49	.39
74LS90	.49	.39	74LS368	.49	.39
74LS93	.49	.39	74LS373	.79	.69
74LS123	.59	.49	74LS374	.79	.69
74LS125	.49	.39	74LS393	.89	.79
74LS138	.49	.39	74LS590	6.05	5.95
74LS139	.49	.39	74LS624	2.05	1.95
74LS154	1.09	.99	74LS629	2.29	2.19
74LS157	.45	.35	74LS640	1.09	.99
74LS158	.45	.35	74LS645	1.09	.99
74LS163	.59	.49	74LS670	1.09	.99
74LS164	.59	.49	74LS688	2.05	1.95

74S/PROMS*

74S00	.29	74S188*	1.29
74S04	.35	74S189	1.69
74S08	.35	74S196	2.49
74S10	.29	74S240	1.49
74S32	.35	74S244	1.49
74S74	.45	74S253	.79
74S85	1.79	74S287*	1.49
74S86	.35	74S288*	1.49
74S124	2.95	74S373	1.49
74S174	.79	74S374	1.49
74S175	.79	74S472*	2.95

74F

74F00	.39	74F139	.89
74F04	.39	74F157	.95
74F08	.39	74F193	3.95
74F10	.39	74F240	1.39
74F32	.39	74F244	1.39
74F74	.49	74F253	.99
74F86	.59	74F373	1.39
74F138	.89	74F374	1.39

CD—CMOS

CD4001	.19	CD4076	.65
CD4008	.89	CD4081	.25
CD4011	.19	CD4082	.25
CD4013	.29	CD4093	.35
CD4016	.29	CD4094	.89
CD4017	.55	CD40103	2.49
CD4018	.59	CD40107	.69
CD4020	.59	CD40109	1.49
CD4024	.49	CD4510	.69
CD4027	.35	CD4511	.69
CD4030	.29	CD4520	.75
CD4040	.65	CD4522	.79
CD4049	.29	CD4538	.79
CD4050	.29	CD4541	.69
CD4051	.59	CD4543	.79
CD4052	.59	CD4553	4.95
CD4053	.59	CD4555	.79
CD4059	3.95	CD4566	2.49
CD4063	1.95	CD4572 (MC14572)	.39
CD4066	.29	CD4583	.89
CD4069	.25	CD4584	.39
CD4070	.25	CD4585	.89
CD4071	.25	MC14411P	8.95
CD4072	.25	MC14490P	4.49

COMMODORE CHIPS

Part No.	Price	Part No.	Price	Part No.	Price
WD1770 Disk Cont.	19.95	6551 ACIA	3.29	8722 MMU	9.95
SI-3052P 5V Positive Voltage Reg. 2A	5.95	6560 VIC-I	10.95	*251104-04 Kernal ROM	10.95
6502 MPU w/int. Clock	2.25	6567 VIC II	14.95	318018-03 Basic ROM C128	15.95
6504A CPU	1.95	6569 VIC PAL	14.95	318019-03 Basic ROM C128	15.95
6507 CPU	4.95	6572 VIC PAL-N	14.95	318020-04 Kernal ROM C128	15.95
6510 CPU	9.95	6581 SID	14.95	325302-01 64K ROM for 1540/1541 Drive	15.95
6520 PIA	1.75	8360 Text Editing	10.95	*325572-01 Logic Array	24.95
6522 VIA	2.95	8501 MPU	10.95	*82S100PLA (906114-01)**	13.95
6525 TPI	7.95	8502 MPU	7.95	901225-01 Char. ROM	11.95
6526 CIA	14.95	8563 CRT Contr.	15.95	901226-01 BASIC ROM	11.95
6529 SPI	4.95	8564 VIC	15.95	901227-03 Kernal ROM	11.95
6532 128x8 RAM I/O Tim Ar	6.49	8566 VIC PAL	29.95	901229-05 Upgrade ROM (For 1541 Disk Drive)	15.95
6545-1 CRTC	2.49	8701 Clock Chip	9.95		
		*8721 PLA	14.95		

*No specs available
**Note 82S100PLA = U17 (C-64)

MICROPROCESSOR COMPONENTS

MISCELLANEOUS CHIPS

Part No.	Price
D765AC	4.49
WD1770	19.95
2661-3	5.95
WD9216	9.95

Z80, Z80A, Z80B SERIES

Part No.	Price
Z80	1.25
Z80-CTC	1.79
Z80-DART	4.95
Z80-PIO	1.79
Z80A	1.35
Z80A-CTC	1.49
Z80A-DART	4.95
Z80A-PIO	1.49
Z80A-SIO/0	4.95
Z80B	2.95
Z80B-CTC	3.49
Z80B-PIO	4.29

6500/6800/68000 SER.

Part No.	Price
6502	2.25
65C02 (CMOS)	8.95
6520	1.75
6522	2.95
6532	6.49
6551	3.29
6800	1.75
6802	3.49
6810	1.25
6821	1.29

6500/6800/68000 Cont.

Part No.	Price
6840	3.95
6843	2.95
6845	2.95
6850	1.49
6852	3.95
6875	8.95
MC68000L8	11.95
MC68000L10	19.95

8000 SERIES

Part No.	Price
8031	2.95
80C31BH	14.95
8035	1.49
8073	29.95
8080A	2.49
8085A	2.29
8086	6.95
8086-2	8.95
8087(5MHz)	125.00
8087-2(8MHz)	159.95
8088	6.49
8088-2	8.95
8116	4.95
8155	1.95
8155-2	2.49
8156	2.49
8202	9.95
8203	14.95
8212	1.49
8224	2.25

8000 SERIES Cont.

Part No.	Price
8228	2.49
8237-5	4.95
8243	2.25
8250A	5.49
8250B (For IBM)	6.95
8251A	1.75
8253-5	1.95
8254	2.95
8255A-5	1.69
8257-5	2.49
8259-5	1.95
8272	4.49
8279-5	2.95
8741	10.95
8748	7.95
8749	9.95
8751	39.95
8755	14.95

DATA ACQUISITION

Part No.	Price
ADC0804LCN	3.19
ADC0808CCN	5.95
ADC0809CCN	3.95
ADC0816CCN	14.95
ADC0817CCN	8.95
DAC0808LCN	1.95
DAC1008LCN	6.49
AY-3-1015D	4.95
AY-5-1013A	3.95

DYNAMIC RAMS

Part No.	Function		Price
4116-15	16,384 x 1	(150ns)	.89
4128-20 (Piggyback)	131,072 x 1	(200ns)	4.49
4164-120	65,536 x 1	(120ns)	1.75
4164-150	65,536 x 1	(150ns)	1.15
4164-200	65,536 x 1	(200ns)	.95
TMS4416-12	16,384 x 4	(120ns)	4.25
8118	16,384 x 1	(120ns)	.69
41256-120	262,144 x 1	(120ns)	3.95
41256-150	262,144 x 1	(150ns)	2.75
50464-15	65,536 x 4	(150ns) (4464) (41464)	4.95
511000P-10	1,048,576 x 1	(100ns) 1 Meg.	39.95
514256P-10	262,144 x 4	(100ns) 1 Meg	44.95

STATIC RAMS

Part No.	Function		Price
2016-12	2048 x 8	(120ns)	1.69
2102-2L	1024 x 1	(250ns) Low Power (91L02)	1.95
2114N	1024 x 4	(450ns)	.99
2114N-2	1024 x 4	(200ns)	1.05
2114N-2L	1024 x 4	(200ns) Low Power	1.49
21C14	1024 x 4	(200ns) (CMOS)	.49
2149	1024 x 4	(45ns)	4.95
5101	256 x 4	(450ns) CMOS	1.95
6116LP-2	2048 x 8	(120ns) Low Power CMOS	2.95
6116P-3	2048 x 8	(150ns) CMOS	1.89
6116LP-3	2048 x 8	(150ns) Low Power	1.95
6264LP-12	8192 x 8	(120ns) Low Power CMOS	4.25
6264P-15	8192 x 8	(150ns) CMOS	3.59
6264LP-15	8192 x 8	(150ns) Low Power CMOS	3.75
6514	1024 x 4	(350ns) CMOS (UPD444C)	4.49
43256-15L	32,768 x 8	(150ns) Low Power	24.95

PROMS/EPROMS

Part No.	Function		Price
1702A	256 x 8	(1µs)	6.95
TMS2516	2048 x 8	(450ns) 25V	4.95
TMS2532	4096 x 8	(450ns) 25V	5.95
TMS2564	8192 x 8	(450ns) 25V	8.95
2708	1024 x 8	(450ns)	4.95
TMS2716	2048 x 8	(450ns) 3 voltage	9.95
2716	2048 x 8	(450ns)	3.75
2716-1	2048 x 8	(350ns) 25V	4.95
27C16	2048 x 8	(450ns) 25V (CMOS)	6.49
2732	4096 x 8	(450ns)	3.95
2732A-20	4096 x 8	(200ns) 21V	4.25
2732A-25	4096 x 8	(250ns) 21V	3.95
2732A-45	4096 x 8	(450ns) 21V	3.75
27C32	4096 x 8	(450ns) 25V (CMOS)	6.49
2764-20	8192 x 8	(200ns) 21V	4.25
2764-25	8192 x 8	(250ns) 21V	3.75
2764A-25	8192 x 8	(250ns) 12.5V	4.25
2764-45	8192 x 8	(450ns) 21V	3.49
27C64	8192 x 8	(450ns) 21V (CMOS)	5.49
27C64-15	8192 x 8	(150ns) 21V (CMOS)	6.49
27128-20	16,384 x 8	(200ns) 128K 21V	4.95
27128-25	16,384 x 8	(250ns) 128K 21V	4.25
27128A-25	16,384 x 8	(250ns) 12.5V	4.95
27C128-25	16,384 x 8	(250ns) 21V (CMOS)	5.95
27256-20	32,768 x 8	(200ns) 256K (12.5V)	6.95
27256-25	32,768 x 8	(250ns) 256K (12.5V)	5.95
27C256-25	32,768 x 8	(250ns) 256K (CMOS) (12.5V)	8.95
27512-25	65,536 x 8	(250ns) 512K (12.5V)	19.95
68764	8192 x 8	(450ns) 25V	15.95
68766	8192 x 8	(350ns) 25V	16.95
74S387	256 x 4	PROM O.C.	1.29
74S471	256 x 8	PROM T.S.	4.95
N82S123	32 x 8	PROM T.S.	2.49

SATELLITE TV DESCRAMBLER CHIP

The MM5321 is a TV camera sync generator designed to supply the basic sync functions for either color or monochrome 525 line/60Hz interlaced and camera video recorder applications. COLOR BURST GATE & SYNC ALLOW STABLE COLOR OPERATION

MM5321N. $11.95

INTERSIL Also Available!

74HC HI-SPEED CMOS

Part No.	Price	Part No.	Price
74HC00	.25	74HC175	.69
74HC02	.25	74HC221	.99
74HC04	.29	74HC240	.79
74HC08	.29	74HC244	.79
74HC10	.29	74HC245	.89
74HC14	.49	74HC253	.59
74HC30	.29	74HC259	.65
74HC32	.29	74HC273	.79
74HC74	.39	74HC373	.79
74HC75	.39	74HC374	.79
74HC76	.45	74HC393	.75
74HC85	.79	74HC595	1.19
74HC86	.39	74HC688	.79
74HC123	.89	74HC4040	.89
74HC125	.49	74HC4049	.59
74HC132	.49	74HC4050	.59
74HC138	.49	74HC4060	1.09
74HC139	.49	74HC4511	1.29
74HC154	1.19	74HC4514	1.19
74HC163	.65	74HC4538	.89
74HC174	.69	74HC4543	1.19

74HCT — CMOS TTL

74HCT00	.29	74HCT139	.59
74HCT02	.29	74HCT157	.69
74HCT04	.29	74HCT174	.69
74HCT08	.29	74HCT175	.69
74HCT10	.29	74HCT240	.99
74HCT32	.29	74HCT244	.99
74HCT74	.49	74HCT245	1.19
74HCT86	.49	74HCT373	1.19
74HCT138	.59	74HCT374	1.19

74C — CMOS

74C00	.29	74C174	.79
74C02	.29	74C175	.79
74C04	.29	74C221	1.49
74C08	.35	74C240	1.29
74C10	.35	74C244	1.29
74C14	.49	74C373	1.49
74C32	.35	74C374	1.49
74C74	.59	74C912	7.95
74C85	1.39	74C915	1.39
74C86	.35	74C920	9.95
74C89	5.19	74C921	9.95
74C90	.99	74C922	3.95
74C154	2.95	74C923	3.95
74C173	1.05	74C925	5.95

LINEAR

DS0026CN	1.95	LM1458N	.39
TL074CN	.89	LM1488N	.49
TL084CN	.99	DS14C88N (CMOS)	1.19
AF100-1CN	8.95	LM1489N	.49
LM307N	.45	DS14C89N (CMOS)	1.19
LM309K	1.25	LM1496N	.85
LM311N	.45	MC1648P	4.95
LM317T	.79	LM1871N	2.95
LM318N	.99	LM1872N	2.95
LM319N	.99	LM1896N-1	1.59
LM323K	3.95	ULN2003A	.99
LM324N	.39	XR2206	3.95
LM338K	4.95	XR2211	2.95
LM339N	.39	XR2243	1.95
LF347N	1.79	DS26LS29CN	4.49
LM348N	.69	DS26LS31CN	1.19
LM350T	2.95	DS26LS32CN	1.19
LF351N	.39	DS26LS33CN	1.95
LF353N	.49	LM2901N	.49
LF355N	.79	LM2907N	2.49
LF356N	.79	LM2917N (8 pin)	1.55
LF357N	1.09	MC3419CL	9.95
LM358N	.49	MC3446N	2.95
LM360N	2.19	MC3450P	2.95
LM361N	1.79	MC3470P	1.95
LM380N-8	.99	MC3471P	4.95
LM386N-3	.99	MC3479P	4.79
LM387N	.99	MC3486P	1.69
LM393N	.39	MC3487P	1.69
LM399H	2.95	LM3900N	.49
LF411CN	.79	LM3905N	1.19
TL497ACN	2.69	LM3909N	.99
NE540H (C540H)	2.95	LM3914N	1.95
NE555V	.29	LM3916N	1.95
XR-L555	.75	NE5532	.89
LM556N	.49	NE5534	.69
NE558N	.89	7805K (LM340K-5)	1.29
LM565N	.99	7812K (LM340K-12)	1.29
LM567V	.69	7815K (LM340K-15)	1.29
NE592N	.89	7805T (LM340T-5)	.49
LM741CN	.29	7812T (LM340T-12)	.49
LM747CN	.59	7815T (LM340T-15)	.49
MC1350	1.49	7905K (LM320K-5)	1.35
MC1372P	2.49	7905T (LM320T-5)	.59
MC1377P	3.19	75472	.99
MC1398P	8.95	75477	1.29
LM1414N	1.29	76477	5.95
		MC145406P	2.95

IC SOCKETS

Low Profile		Wire Wrap (Gold) Level #3	
8 pin LP	.11	8 pin WW	.59
14 pin LP	.12	14 pin WW	.65
16 pin LP	.13	16 pin WW	.69
24 pin LP	.25	24 pin WW	1.19
28 pin LP	.27	28 pin WW	1.39
40 pin LP	.29	40 pin WW	1.89

Soldertail Standard (Gold & Tin) & Header Plug Sockets Also Available

PARTIAL LISTING • OVER 4000 COMPONENTS AND ACCESSORIES IN STOCK! • CALL FOR QUANTITY DISCOUNTS

CIRCLE 114 ON FREE INFORMATION CARD

What's New at
AMERICAN DESIGN COMPONENTS . . . ?

We warehouse 60,000 items at American Design Components — expensive, often hard-to-find components for sale at a fraction of their original cost!

You'll find every part you need — either brand new, or removed from equipment (RFE) in excellent condition. But quantities are limited. Order from this ad, or visit our retail showroom and find exactly what you need from the thousands of items on display.

Open Mon. – Sat., 9–5

THERE'S NO RISK.
With our full 90-day warranty, any purchase can be returned for any reason for full credit or refund.

3½", 10Mb HARD DISK DRIVE (IBM® Compatible)

Fits standard 5¼" spacing. Shock mounted. High speed, low power. Mfr — MMI #MM212
Item #9217 **$179.00** New
Controller Card for above
Item #9984 **$99.00**

5¼", 1.2 Mb. AT HALF HT. DISK DRIVE

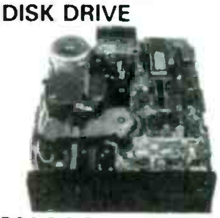
48/96 TPI (IBM® Compatible)
Double sided, single/double density; 80 track.
Mfr — Panasonic #JU-475
Item #10005 **$129.00** New

5¼" FULL HT. DISK DRIVES

48 TPI (IBM® Compat.)
Double sided/double density, full height drive. 48 T.P.I., 80 tracks.
Mfr — MPI-52S
Item #7928 **$79.95**
2 for **$150.00**

96 TPI, DS/Quad Density
Mfr — CDC #9409T
Item #1893 **$99.00**

5¼" 1/2 HT. DISK DRIVE



DOS 3.2 Compatible
96 TPI, DS/QUAD DENSITY
Tandon TM55–4 DS/Quad
Item #1904 **$79.00**
2 for **$150.00**

115 CFM MUFFIN® FAN

SPECIAL!
115 VAC/60 Hz., 21W., 28A., 3100 RPM; 5-blade model, aluminum housing. Can be mounted for blowing or exhaust.
Dim.: 4$^{11}/_{16}$" sq. x 1½" deep.
Item #5345 **$5.95** RFE

JOYSTICK CONTROLLERS

Fits Atari, Apple, Commodore, and our #10336 PC8300 Computer. Has 4-ft. cord with plug.
Dim.: 3½" sq. x1½" H.
Item #12143 **$5.95** New

EMI FILTER

6 Amp., 120/240 Volt

Provides the most effective attenuation of 'line-to-ground' and 'line-to-line' noise across the frequency range.
Dim.: 2.62" x 1.98" x .81".
Mfr — SAE (equiv. to Corcom type 6ECI)
Item #10959 **$4.95**
2 for **$9.00**

RECORDING TAPE

7½" Reel, 2400 ft.

Bulk erased. Major mfrs.: Ampex, Scotch, etc.
Item #6711 — ¼ Mil.
79¢ ea.; 3 for **$2.00**

Insides of the COMMODORE COMPUTER

Commodore VIC 20 CPU board & mechanical keyboard. Guaranteed not to work. (For parts only.)
Item #12144 **$14.95** RFE

MECHANICAL KEYBOARDS . . .

48-KEY — Timex Z81/1000
Item #6712 **$5.95** New
66-KEY — Commodore C-16
Item #9394 **$5.95** New
75-KEY — Timex or Adam
For computer upgrade . . .
Item #7429 **$5.95** New

115 VAC 27 CFM MINI FANS

50/60Hz.; 12W. Low noise level fans, can be mounted for blowing or exhaust.
1" Thin: contains 9 plastic blades
Dim.: 3⅛" sq. x 1" deep
Mfr — Tobishi #U9201B
Item #10960 **$7.95** New
1½" Standard: contains 7 metal blades.
Mfr — Rotron #SU2A1
Item #5970 **$7.95** New

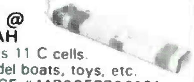
12/24 VDC MUFFIN-TYPE FANS

55/100 CFM

8 W. Can be mounted for blowing or exhaust. Aluminum housing, brushless, ball-bearing type.
1" Thin: 5 plastic blades with feathered edges.
Mfr — Centaur #CUDC24K4-601
Item #8541 **$19.95** New
1½" Standard: 5 plastic blades
Mfr — Centaur #CNDC24K4-601
Item #12109 **$14.95** RFE

Rechargeable NICAD BATTERY BACKUPS

12V @ 450 ma
Contains 10 AA cells. Recharge rate: 45 ma. 16–18 hours. Case with tab output connections.
Dim.: 2$^{1}/_{16}$"H x 1¼"W x 2$^{15}/_{16}$"L
Mfr — GE 123233 or equiv.
Item #5443 **$5.95** New



13.2V @ 1.65 AH
Contains 11 C cells.
For model boats, toys, etc.
Mfr — GE #41B035BB00101
Item #5444 **$15.95** New

Composite Video Monitors . . .

12" Monitor (Controls front panel mounted)
12", green phosphor, high resolution (12 lines center) and bandwidth from 10Hz to 30 Hz ± 3dB. Op. volt.: 120/240VAC, 50/60Hz., 65VA max. Controls front panel mtd.
Mfr — Motorola — Alpha Series
Item #10043 **$29.95** New

15" Monitor
15" screen. Same specs as above.
Item #10044 **$34.95** New

D-SUBMINIATURE SOLDERLESS CONNECTORS, CRIMP TERMINALS (Mfr — TRW)

		9-Pin		15-Pin		25-Pin		37-Pin	
Description	Fig.	Item #	Price	Item #	Price	Item #	Price	Item #	Price
Hood w/Metal Male	A	10998	$1.29	11001	$1.39	O/S	$1.69	11002	$2.09
Hood w/Metal Female	A	10999	1.49	11000	1.49	O/S	1.79	11003	2.19
Hood w/Plastic Male	A	11004	1.19	O/S	1.29	11007	1.59	11005	1.99
Hood w/Plastic Female	A	O/S	1.39	O/S	1.49	11008	1.79	11006	2.19
Chassis mount, Metal Male*	B	10747	.79	10745	.89	10735	1.19	10752	1.59
Chassis mount, Metal Female	B	10746	.89	10734	.99	10711	1.29	10888	1.69
Chassis mount, Plastic Male**	C	10890	.69	10910	.79	10732	1.09	10891	1.49
Chassis mount, Plastic Female	C	10728	.79	10731	.89	10724	1.19	10729	1.59
QC Hood w/Metal Male	D	11025	1.39	10029	1.49	11033	1.79	11037	2.19
QC Hood, Rt. Angle w/Metal Male	E	11026	1.39	11030	1.49	11034	1.79	11038	2.19
QC Hood w/Metal Female	D	11027	1.59	11031	1.69	11035	1.99	11039	2.39
QC Hood, Rt. Angle w/Metal Female	E	11028	1.59	11032	1.69	11036	1.99	11040	2.39
QC Hood w/Plastic Male	D	11009	1.29	11013	1.39	11017	1.69	11021	2.09
QC Hood, Rt. Angle w/Plastic Male	E	11011	1.29	11015	1.39	11018	1.69	11022	2.09
QC Hood w/Plastic Female	D	11010	1.49	11014	1.59	11019	1.89	11023	2.29
QC Hood, Rt. Angle, w/Plastic Female	E	11012	1.49	11016	1.59	11020	1.89	11024	2.29

QC = Quick connect; *Without mounting device; **Can be used with quick connect hoods

Fig. A

Fig. B

Fig. C

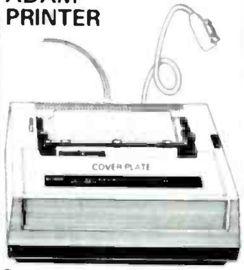
Fig. D

Fig. E

ADAM COMPUTER KIT
(Less printer & w/o cabinet)

Build it yourself from subassemblies. No wiring nec. (just plugs together). Hook-up diagram included. Includes: Keyboard, 1 cassette digital data drive, 2 game controllers, power supply, all memory boards, and one cassette. Capable of running CP/M, has built-in word processor. Item #7410.
Complete — **$99.00**

ADAM PRINTER



Complete, less top cover plate. Friction feed. Takes standard paper 8½" x 11". (Customer returns; tested — operational.)
Item #8839 **$69.50**

COLECOVISION to ADAM EXPANSION KIT

This expansion module just plugs into your ColecoVision. With printer power supply and data drive (both included), you will have a working Adam Computer. Adam keyboard, one Smart basic cassette and hook-up diagram also included.
Item #9918 **$59.50**

ADAM Accessories . . .

DATA DRIVE —
Item #6641
LAST CHANCE — **$19.95**

PRINTER POWER SUPPLY —
Item #6642 **$14.95**

ASCII KEYBOARD —
Item #6643 **$19.95**

CONTROLLERS (set of 4)
Item #7013 **$9.95**

ADAM CASSETTES
(Consisting of Buck Rogers & Smart Basic only.)
Item #7786
BAKER'S DOZEN — **$19.95**

140 VA MINI MICRO-COMPUTER REGULATOR

Provides voltage regulation and ultra-isolation for microprocessor-based equipment. Contains less than 3% harmonic distortion, better than 60 dB traverse noise rejection. Contains dual outlet for CPU & monitor, and 6 ft. line cord.
Input: 95 — 130V, 60Hz.
Output: 120V @ 1.17A
Dimen.: 11⅝"L x 4⅜"H x 5⅝"W
Mtd on metal base with rubber ft.
Mfr — Sola #63-13-114
Item #9999 **$99.00** New

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"The First Source"— for electromechanical & electronic equipment and components — AMERICAN DESIGN COMPONENTS!

PC 8300 HOME COMPUTER
(Advanced version of the Timex 1000)

42-key mechanical keyboard (not membrane). Contains 2K of RAM. Reverse video, Z80A, 6.5MHz processor, ROM 8K BASIC. Graphics capability/sound-music, TV or monitor. Joystick input operates on 115 VAC. Includes: AC adapter, TV cable, and pair of cassette cables. Will run all prerecorded tapes for Sinclair/Timex 1000-ZX81. Mfr — Power 3000. In orig. boxes.

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Accessories . . .
- ★ 16K RAMPACK upgrade Item #10337 **$9.95** New
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190W DISK DRIVE POWER SUPPLY

Input: 115V
Output: +12V @ 4.13A, +5.1V @ 3.04A } x 3
Contains 3 sets of dual outputs, allowing for simultaneous operation of 3 disk drives. Originally designed for the AT & T computer. Dim.: 11"W x 4½"H x 7"deep

Item #10006 **$59.95** New

12" TTL MONITOR
(HIGH RESOLUTION)

12 VDC, green phosphor. Originally used in portable computers.

Item #6811 **$24.95** New

CORDLESS TELEPHONE

700' Range
Wall or Base Mount

Full duplex: talk & listen simult. Auto redial: last number dialed recall. Comes w/ attachments for both types of mtg.; incl. AC power adaptor & battery indicator light. Color: brown w/cream. Famous make mfr.

Item #9997 **$29.95** New

1-PIECE TELEPHONE

Touch-tone-to-rotary (may be used even where there is only a rotary phone). Features: last number redial & mute button. Comes w/15" cord & standard modular plug. Color: Ivory. Mfr — Spectra-phone, Model OP 1

Item #10748 **$10.95** New 2 for **$20.00**

NS 87P50D-11 MICROCOMPUTER

8-bit single chip unit. Emulates 8048/49/50. Piggyback configuration. Allows you to plus in eproms: 2758, 2716, and 2732. Features: XMOS, 5V, 8-16 Bit, 4K direct access memory. 256 bits on chip ROM; 11 MHz. max. freq.

Item #8899 **$24.95** New

ANALOG to DIGITAL CONVERTER

Binary output: 12 bit; Conversion time: 8 ms. Linearity: 8 ms. ± ½ lbs. Parallel and series outputs; internal reference. Mfr — Datel ADC-HZ-12BGC

Item #7052 (RFE, tested good!)

Originally ~~$130.00~~
Special — **$39.95**

COMPUTER GRADE POWER SUPPLY

Other uses—runs CB & car radios. Comes ready to plug in!
DC Output: −5V @ .5 amp, +5V @ 3 amp, +12V @ 6 amp.
Input 115V/60H. Dim.: 9¼"W x 3¾"H. (Rubber ft. incl.)

Item #9501 **$24.95** New

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Output: +5.15V @ 70A, +12V @ 4A, −12V @ 4A, +5.2V @ 5A
Input: 115/230V nominal, .725KW cont. 47-63Hz. Enclosed in metal housing. Dim.: 15"W x 2½"H x 6" deep. Mfr — Todd Prod. #4XS815-A

Item #9749 **$29.95** New

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LM310N	1.16
LM311N	.41
LM317K	2.65
LM317LZ	.62
LM317MP	.80
LM317T	.90
LM318N	1.07
LM319N	1.07
LM324N	.35
LM334Z	1.07
LM336Z	.98
LM337MP	1.03
LM337T	1.34
LM338K	3.55
LM339N	.44
LF347N	.90
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LM350K	3.55
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LF356N	.80
LM358N	.44
LM380N	.80
LM380N-8	.98
LM381N	1.16
LM383T	1.34
LM385Z	1.70
LM386N-4	.80
LM389N	.90
LM393N	.41
LF398N	2.15
LF411CN	.71
TL494CN	1.75
TL496CP	1.34
TL497ACN	1.97
NE555V	.26
XR-L555	.62
LM556N	.53
NE558N	1.07
NE564N	1.75
LM565N	.90
LM566CN	1.25
LM567V	.80
NE570N	2.24
NE571N	1.75
NE592N	.80
LM709N	.44
LM709CH	.80
LM710N	.62
LM711N	.62
LM723CN	.41
LM725CN	2.24
LM733CN	.62
LM739N	2.30
LM741CN	.26
LM741CH	.53
LM741-14N	.53
LM747CN	.53
LM748CN	$ .53
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LM2907N	1.75
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RC4151NB	.90
RC4193NB(DE)	2.65
7805K	1.21
7812K	1.21
7815K	1.21
7818K	1.21
7824K	1.21
7805T	.44
7812T	.44
7815T	.44
7818T	.44
7824T	.44
78S40	1.75
7905K	1.21
7906K	1.21
7912K	1.21
7915K	1.21
7918K	1.21
7924K	1.21
7905T	.53
7912T	.53
7915T	.53
7918T	.53
7924T	.53
79L12AC	.53
79L15AC	.53
LF13201N	2.33
LM13600N	1.07
LM1889	1.85
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75110A	1.34
75115	1.07
75123N	1.34
75124N	1.34
75138N	2.65
75154N	1.25
75450N	.53
75451CN	.44
75452CN	.44
75453CN	.44
75463N	.53
75472	.80
75492N	.71
76477	3.55

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Z80-DMA	4.45
Z80-PIO	1.61
Z80-SIO/1	4.45
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Z80A-DART	4.72
Z80A-DMA	5.35
Z80A-PIO	1.75
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2764-25	2.95
68701	9.95
68766	16.25

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6800	$2.12
6821	2.72
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COMPUTER & GAME EQUIPMENT—ACCESSORIES—MODULES
ELECTRONIC COMPONENTS—INTEGRATED CIRCUITS—OPTICS

AT-STYLE COMPUTER CABINET

Contains 10 full-length expansion slots (w/guides). With room for an internal 5¼" hard disk drive. Has 3 half-height disk drive slots. Rear on/off switch, notched to hold in power supply (not incl.), and security switch w/ key.

Item #12266 **$49.95** New

STEPPING MOTORS for ROBOTICS

Precision steppers with increments from 1 to 7.5 degrees. Speeds up to 5,000 steps.

Fig. 1

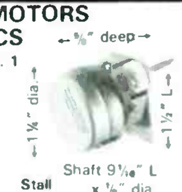

Fig. 2

Item No.	Step Angle	Volts DC	Stall Torque oz/In	Type	Mfr. & Part No.	Fig	Price
5431	1	5	17	PM	N.A. Phillips A82310-M2	1	$9.95 ea. 2/$14.95
7630	1.8	3.0	200	PM	Superior Electric M092-FT-402	2	$34.50 ea. 2/$59.50
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ELECTRONIC CASH REGISTER DRAWER
(Computer Operated)

Fits right underneath your PC. Comes w/ metal cash drawer and cover, which are removable. Security switch w/key allows you to open or lock drawer manually.

Item #12265 **$49.95** New

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MINIMUM ORDER $15.

RE-627

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Item No.	How Many?	Description	Price	Total

Total

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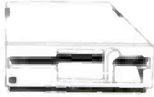
CIRCLE 201 ON FREE INFORMATION CARD

CIRCLE 82 ON FREE INFORMATION CARD

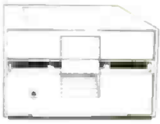
CIRCLE 113 ON FREE INFORMATION CARD

EGA CARD AND MONITOR NOW ONLY $569!

DISK DRIVES
FOR APPLE COMPUTERS

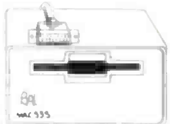


AP-150
$99.95
- ½ HT. DIRECT DRIVE
- 100% APPLE COMPATIBLE
- SIX MONTH WARRANTY

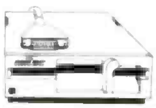


AP-135
$129.95
- FULL HT SHUGART MECHANISM
- DIRECT REPLACEMENT FOR APPLE DISK II
- SIX MONTH WARRANTY

DOUBLE SIDED!



MAC535
$249.95
- 3.5" ADD-ON DISK DRIVE
- 100% MACINTOSH COMPATABLE
- DOUBLE SIDED 800K BYTE STORAGE
- HIGH RELIABILITY DRIVE HAS AUTO-EJECT MECHANISM
- FULL ONE YEAR WARRANTY



AD-3C
$139.95
- 100% APPLE IIc COMPATIBLE, READY TO PLUG IN, W. SHIELDED CABLE & MOLDED 19 PIN CONNECTOR
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- SIX MONTH WARRANTY

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FDD CONTROLLER CARD	$49.95
IIc ADAPTOR CABLE	$19.95

ADAPTS STANDARD APPLE DRIVES FOR USE WITH APPLE IIc

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EGA MONITOR
- EGA & CGA COMPATIBLE
- SCANNING FREQUENCIES 15.75 21.85 KHz
- RES 640 x 200 350
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- 16 COLORS OUT OF 64
- 14" BLACK MATRIX SCREEN

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RGB MONITOR
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- DIGITAL RGB-IBM COMPATIBLE
- 14" NON-GLARE SCREEN
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- .39mm DOT PITCH
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SAMSUNG
MONOCHROME
- IBM COMPATIBLE TTL INPUT
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- RESOLUTION: 720 x 350V
- ATTRACTIVE CASE WITH SWIVEL BASE
- ONE YEAR WARRANTY

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MONOCHROME
- IBM COMPATIBLE TTL INPUT
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- VERY HIGH RESOLUTION: 1100 LINES (CENTER)
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EPROM PROGRAMMER
- DUPLICATE OR BURN ANY 27xx SERIES EPROM (2716 TO 27128)
- MENU-DRIVEN SOFTWARE
- HIGH SPEED WRITE ALGORITHM

RP-525 $59.95

16K RAMCARD
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- CAN BE USED IN PLACE OF THE APPLE LANGUAGE CARD

RAM-CARD $39.95

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ST-277	HALF HT 60MB 40ms (RLL)	CALL
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KIT INCLUDES MOUNTING HARDWARE TO FIT 5¼" & FACEPLATES FOR AT & XT

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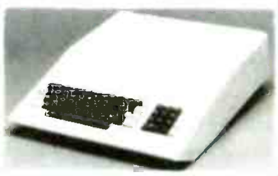
CASE WITH KEYBOARD FOR APPLE TYPE MOTHERBOARD
- USER DEFINED FUNCTION KEYS
- NUMERIC KEYPAD WITH CURSOR CONTROL
- CAPS LOCK
- AUTO-REPEAT



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ALL LINES SWITCHED, GOLD PLATED CONNECTORS, QUALITY SWITCHES

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NASHUA DISKETTES WERE JUDGED TO HAVE THE HIGHEST POLISH AND RECORDED AMPLITUDE OF ANY DISKETTES TESTED (COMPARING FLOPPY DISKS, BYTE 9/84)

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5¼" SOFT SECTOR, DS DD W/ TYVEC SLEEVES & HUB RINGS

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- SET X-Y AXIS FOR AUTO CENTER OR FREE MOVEMENT
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- INCLUDES ADAPTOR CABLE FOR IBM, APPLE II, IIe, II c, ATARI AND VIC 20/64

BUILD STEVE CIARCIA'S INTELLIGENT EPROM PROGRAMMER
AS SEEN IN BYTE, OCT 86
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ONLY $199

KIT INCLUDES PCB AND ALL COMPONENTS EXCEPT CASE & POWER SUPPLY

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5¼" DISKFILE	3½" DISKFILE
HOLDS 70	HOLDS 40
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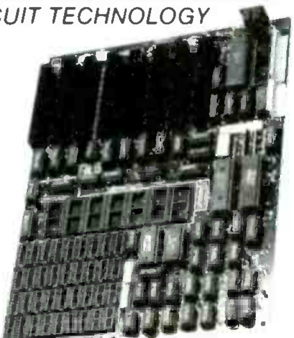
QUALITY IBM COMPATIBLE MOTHERBOARDS

FROM MODULAR CIRCUIT TECHNOLOGY



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- 4.77 OR 8 MHz OPERATION WITH 8088-2 & OPTIONAL 8087-2 CO-PROCESSOR
- DYNAMICALLY ADJUSTS SPEED DURING DISKETTE OPERATION FOR MAXIMUM THROUGHPUT AND RELIABILITY
- CHOICE OF NORMAL TURBO MODE OR SOFTWARE SELECT PROCESSOR SPEED

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- ALL ICs SOCKETED-HIGHEST QUALITY PCB
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BOTH WITH FREE MCT BIOS!

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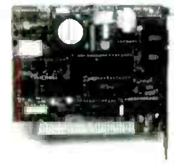
All models feature auto-dial/answer/redial on busy, Hayes compatible, power up self test, touchtone or pulse dialing, built-in speaker, PC Talk III Communications software, Bell Systems 103 & 212A full or half duplex and more.



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1200 BUAD 10" CARD

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NO SOFTWARE INCLUDED

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JDR PART #: FAR-FDD

- SUPPORTS UP TO 4 INTERNALLY MOUNTED FDDs
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- INCLUDES CABLE FOR 2 DISK DRIVES

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IBM COMPATIBLE FLOPPY DISK DRIVE

JDR PART #: FDD-360

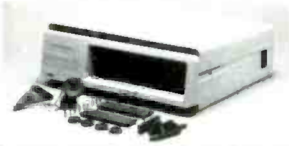
GOOD QUALITY DRIVES BY MAJOR MANUFACTURERS SUCH AS QUME, TANDON & CDC

- 5¼" HALF HEIGHT
- 360K STORAGE CAPACITY
- DS, DD
- 48 TPI

$69.95

IBM STYLE COMPUTER CASE

AN ATTRACTIVE STEEL CASE WITH A HINGED LID FITS THE POPULAR PC/XT COMPATIBLE MOTHERBOARDS



- SWITCH CUT-OUT ON SIDE FOR PC/XT STYLE POWER SUPPLY
- CUT-OUT FOR 8 EXPANSION SLOTS
- ALL HARDWARE INCLUDED

$34.95

SLIDE TYPE CASE $39.95

BUILD YOUR OWN 256K XT COMPATIBLE SYSTEM

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360K DRIVE	$69.95
FARADAY CONTROLLER	$24.95
MONOCHROME ADAPTOR	$49.95
FORTRONICS MONITOR	$99.95
TOTAL:	$536.15

DISPLAY CARDS

FROM MODULAR CIRCUIT TECHNOLOGY

MCT-EGA $179.95

100% IBM COMPATIBLE, PASSES IBM EGA DIAGNOSTICS

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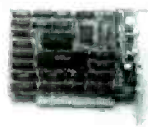
- TRIPLE SCANNING FREQUENCY FOR DISPLAY ON EGA, STANDARD RGB OR HIGH RESOLUTION MONOCHROME MONITOR
- FULL 256K OF VIDEO RAM ALLOWS 640 x 350 PIXELS IN 16 OF 64 COLORS
- LIGHT PEN INTERFACE

MCT-CG $49.95

COMPATIBLE WITH IBM COLOR GRAPHICS STANDARD

- SHORT SLOT CARD USES VLSI CHIPS TO INSURE RELIABILITY
- SUPPORTS RGB, COMPOSITE MONOCHROME & COLOR AND AN RF MODULATOR OUTPUT
- 320 x 200 COLOR GRAPHICS MODE
- 640 x 200 MONOGRAPHICS MODE
- LIGHT PEN INTERFACE

SHORT SLOT



MCT-MGP $59.95

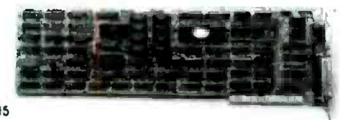
COMPATIBLE WITH IBM MONOCHROME AND HERCULES GRAPHICS STANDARDS

- SHORT SLOT CARD USES VLSI CHIPS TO INSURE RELIABILITY
- PARALLEL PRINTER PORT, CONFIGURABLE AS LPT1 OR LPT2
- 720 x 348 GRAPHICS MODE
- LOTUS COMPATIBLE
- CAN RUN WITH COLOR GRAPHICS CARD IN THE SAME SYSTEM

SHORT SLOT

MCT-MG $79.95

COMPATIBLE WITH IBM MONOCHROME AND HERCULES GRAPHICS STANDARDS



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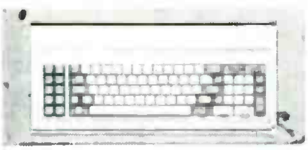

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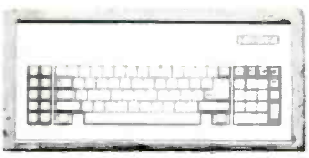

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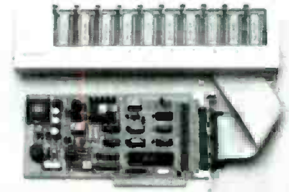

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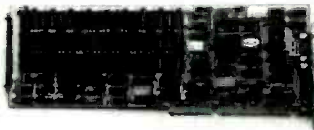

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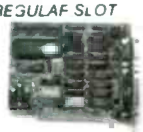

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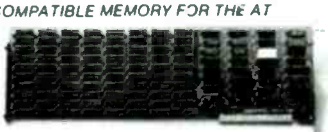

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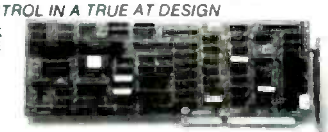

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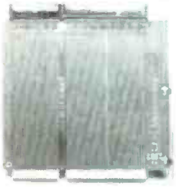

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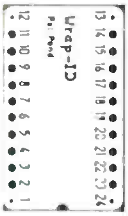

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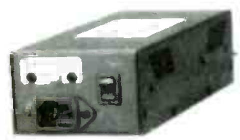

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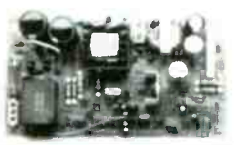

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33	50V	.05	.005	50V	.05
47	50V	.05	.01	50V	.07
68	50V	.05	.02	50V	.07
100	50V	.05	.05	50V	.07
220	50V	.05	1	12V	.10
560	50V	.05	.1	50V	.12

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.047µf	50V	.15	.47µf	50V	.25

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4.7	50V	.15	22	16V	.14
10	50V	.15	47	50V	.20
47	35V	.18	100	35V	.25
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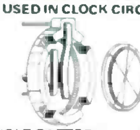

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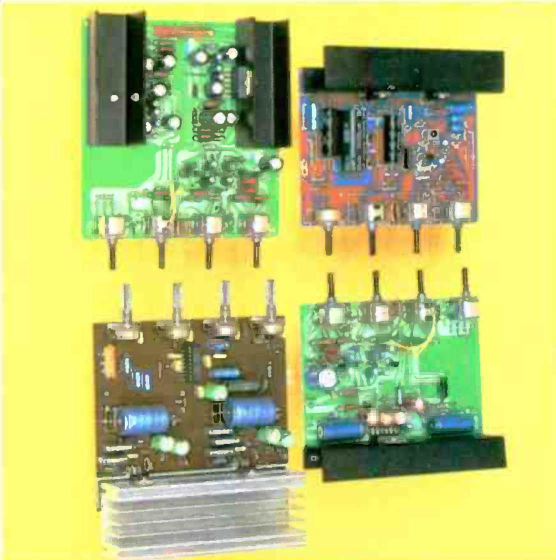

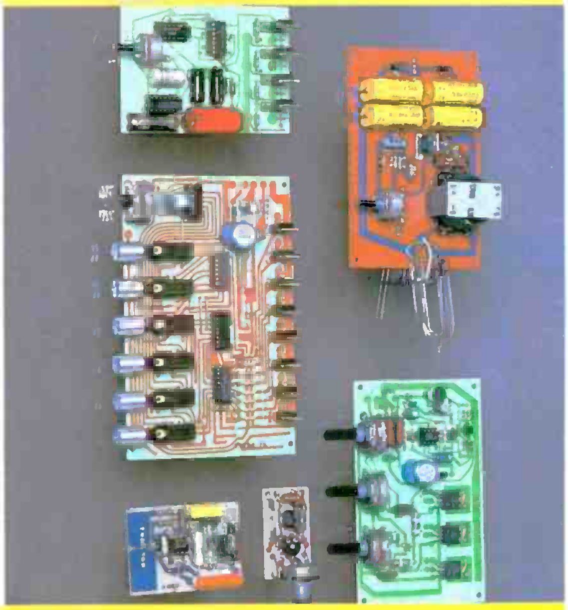

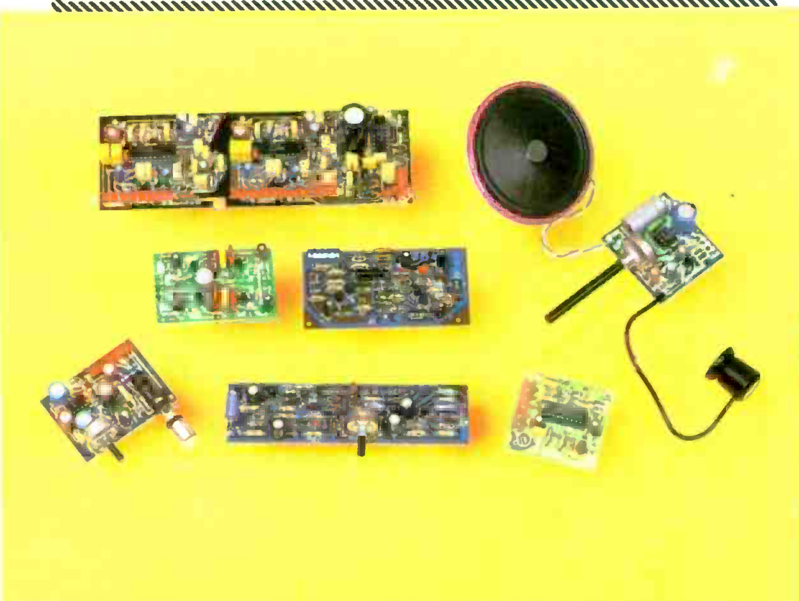

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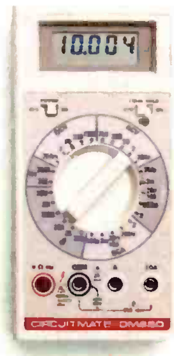

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