Radio-Electronics

BUILD A SINEWAVE DESCRAMBLER

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A personal robot you can customize

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TOUCH-TONE CONTROL
DTMF encoding and decoding techniques

BUILD A CLOSED-CAPTION DECODER
Get more from your TV

TV DESCRAMBLER
How to build a sinewave decoder

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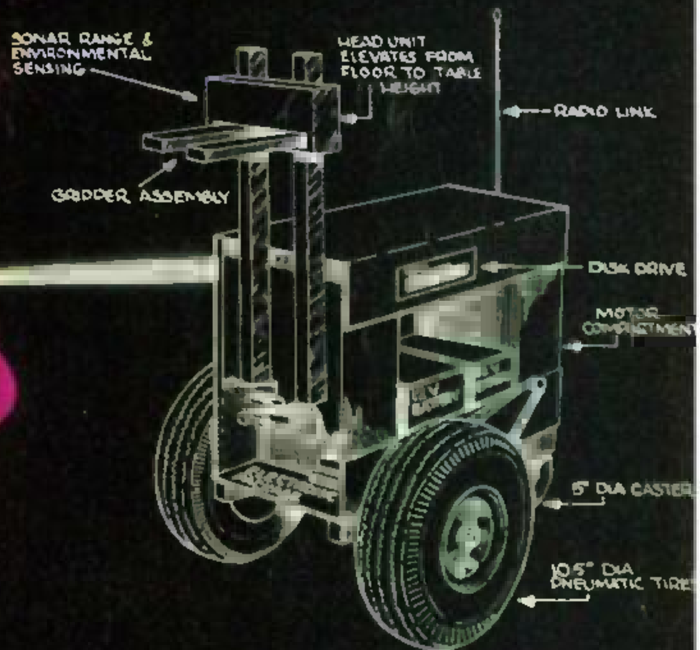

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New GPS Series: Tek sets the pace with SmartCursors™ and push-button ease.

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

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

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

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

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

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

Get out in front! Call toll-free today to order, to get more details or a videotape demonstration.

1-800-433-2323

In Oregon, call collect 1-627-9000

Features	2246	2245
Bandwidth	100 MHz	100 MHz
No. of Channels	4	4
Scale Factor Readout	Yes	Yes
SmartCursors™	Yes	No
Volts Cursors	Yes	No
Time Cursors	Yes	No
Voltmeter	Yes	No
Vertical Sensitivity	2 mV/div	2 mV/div
Max. Sweep Speed	2 ns/div	2 ns/div
Vert/Hor Accuracy	2%	2%
Trigger Modes	Auto Level, Auto, Norm, TV Field, TV Line, Single Sweep	
Trigger Level Readout	Yes	No
Weight	6.1 kg	6.1 kg
Warranty	3-year on parts and labor including CRT	
Price	$2400	$1875

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

Tektronix
COMMITTED TO EXCELLENCE

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DECEMBER '86

Radio-Electronics
Electronics publishers since 1908

Vol. 57 No. 12

SEASON'S GREETINGS

The editors and staff of Radio-Electronics join in sending holiday greetings and our best wishes for a happy new year

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COVER 1

This month we begin a continuing series detailing a versatile, powerful robot you can design and build yourself. The R-E Robot has several characteristics that set it apart from commercially available units or kits. For one, it can be customized to meet the demands of almost any user application. Further, it is backed by a powerful onboard computer that makes use of a custom robot control language. That language makes it possible to control the robot using simple commands. To help get the most out of the project, we have set up a special section of our computer bulletin-board (RE-BBS) for the rapid exchange of sources, applications, software, and updates among our readers, the author, and the editors. To learn more, turn to page 54.

NEXT MONTH

THE JANUARY ISSUE IS ON SALE DECEMBER 2

BUILD THE R-E ROBOT
Part 2. A closer look at the Robotic Personal Computer.

HOW TO APPLY FOR A PATENT
Learn how to patent your next brainstorm.

BUILD A NINE-STATION INTERCOM
A sophisticated, versatile communications system for the home or office.

TV SIGNAL SCRAMBLING
Part 7 looks at descramblers for the gated-pulse and outband systems.

AUDIO UPDATE
Larry Klein joins our staff as Audio Editor with the first installment of his new column.

Radio-Electronics

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

Advertising Sales Offices listed on page 112.

NEW!
Lower Price
Scanners

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

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

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

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

Regency® RH250B-GR
List price $859.00/CE **price $329.95/SPECIAL**
10 Channel • 25 Watt Transceiver • Priority
The *Regency* RH250B is a ten-channel VHF land mobile transceiver designed to cover any frequency between 150 to 162 MHz. Since this radio is synthesized, no expensive crystals are needed to store up to ten frequencies without battery backup. All radios come with CTCSS tone and scanning capabilities. A monitor and night/day switch is also standard. This transceiver even has a priority function. The RH250 makes an ideal radio for any police or fire department volunteer because of its low cost and high performance. A *60 Watt* VHF 150-162 MHz. version called the **RH600B** is available for $454.95. A UHF 15 watt version of this radio called the **RU150B** is also available and covers 450-482 MHz. but the cost is $449.95.

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

NEW! Scanner Frequency Listings
The new Fox scanner frequency directories will help you find all the action your scanner can listen to. These new listings include police, fire, ambulances & rescue squads, local government, private police agencies, hospitals, emergency medical channels, news media, forestry radio service, railroads, weather stations, radio common carriers, AT&T mobile telephone, utility companies, general mobile radio service, marine radio service, taxi cab companies, tow truck companies, trucking companies, business repeaters, business radio (simplex) federal government, funeral directors, veterinarians, buses, aircraft, space satellites, amateur radio, broadcasters and more. Fox frequency listings feature call letter cross reference as well as alphabetical listing by licensee name, police codes and signals. All Fox directories are $14.95 each plus $3.00 shipping. State of Alaska–**RL019-1**; State of Arizona–**RL025-1**; Baltimore, MD/Washington, DC–**RL024-1**; Buffalo, NY/Erie, PA–**RL009-2**; Chicago, IL–**RL014-1**; Cincinnati/Dayton, OH–**RL006-2**; Cleveland, OH–**RL017-1**; Columbus, OH–**RL003-2**; Dallas/Ft. Worth, TX–**RL013-1**; Denver/Colorado Springs, CO–**RL027-1**; Detroit, MI/Windsor, ON–**RL008-3**; Fort Wayne, IN/Lima, OH–**RL001-1**; Hawaii/Guam–**RL015-1**; Houston, TX–**RL023-1**; Indianapolis, IN–**RL022-1**; Kansas City, MO/KS–**RL011-2**; Long Island, NY–**RL026-1**; Los Angeles, CA–**RL016-1**; Louisville/Lexington, KY–**RL007-1**; Milwaukee, WI/Waukegan, IL–**RL021-1**; Minneapolis/St. Paul, MN–**RL010-2**; Nevada/E. Central CA–**RL028-1**; Oklahoma City/Lawton, OK–**RL005-2**; Orlando/Daytona Beach, FL–**RL012-1**; Pittsburgh, PA/Wheeling, WV–**RL029-1**; Rochester/Syracuse, NY–**RL020-1**; San Diego, CA–**RL018-1**; Tampa/St. Petersburg, FL–**RL004-2**; Toledo, OH–**RL002-3**. New editions are being added monthly. For an area not shown above call Fox at 800-543-7892. In Ohio call 800-621-2513.

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

Bearcat® 100XL-GR
List price $349.95/CE **price $203.95/SPECIAL**
9-Band, 16 Channel • Priority • Scan Delay Search • Limit • Hold • Lockout • AC/DC
Frequency range: 30-50, 118-174, 406-512 MHz.
The world's first no-crystal handheld scanner now has a LCD channel display with backlight for low light use and aircraft band coverage at the same low price. Size is 1¾" x 7½" x 2⅞". The *Bearcat* 100XL has wide frequency coverage that includes all public service bands (Low, High, UHF and "T" bands), the AM aircraft band, the 2-meter and 70 cm. amateur bands, *plus* military and federal government frequencies. Wow...what a scanner!

Included in our low CE price is a sturdy carrying case, earphone, battery charger/AC adapter, six AA ni-cad batteries and flexible antenna. Order your scanner now.

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

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

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

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

OTHER RADIOS AND ACCESSORIES
Panasonic RF-2600-GR Shortwave receiver $179.95
RD95-GR *Uniden* Remote mount Radar Detector ... $128.95
RD55-GR *Uniden* Visor mount Radar Detector $98.95
RD9-GR *Uniden* "Passport" size Radar Detector ... $199.95
BC-WA-GR *Bearcat* Weather Alert™ $49.95
DX1000-GR *Bearcat* shortwave receiver **SALE** ... $349.95
PC22-GR *Uniden* remote mount CB transceiver ... $99.95
PC55-GR *Uniden* mobile mount CB transceiver $59.95
R1060-GR *Regency* 10 channel scanner **SALE** ... $92.95
MX3000-GR *Regency* 30 channel scanner $229.95
XL156-GR *Regency* 10 channel scanner $139.95
UC102-GR *Regency* VHF 2 ch. 1 Watt transceiver ... $124.95
P1405-GR *Regency* 5 amp regulated power supply ... $69.95
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MA256-GR Drop-in charger for HX1200 & HX1500 ... $84.95
MA518-GR Wall charger for HX1500 scanner $14.95
MA516-GR Carrying case for HX1500 scanner $14.95
MA257-GR Cigarette lighter cord for HX12/1500 ... $19.95
MA917-GR Ni-Cad battery pack for HX1200 ..... $34.95
SMMX7000-GR Svc. man. for MX7000 & MX5000 ... $19.95
SMMX3000-GR Service man. for *Regency* MX3000 ... $19.95
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B-8-GR 1.2 V AA Ni-Cad batteries (set of eight) $17.95
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TIC-GR Techniques for Intercepting Comm. $14.95
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CIE-GR Covert Intelligenct, Elect. Eavesdropping ... $14.95
A60-GR Magnet mount mobile scanner antenna ... $35.95
A70-GR Base station scanner antenna $35.95
USAMM-GR Mag mount VHF/UHF ant. w/ 12' cable ... $39.95
USAK-GR ¾" hole mount VHF/UHF ant. w/ 17' cable ... $35.95
USATLM-GR Trunk lip mount VHF/UHF antenna $35.95
Add $3.00 shipping for all accessories ordered at the same time.
Add $12.00 shipping per shortwave receiver.
Add $7.00 shipping per scanner and $3.00 per antenna.

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

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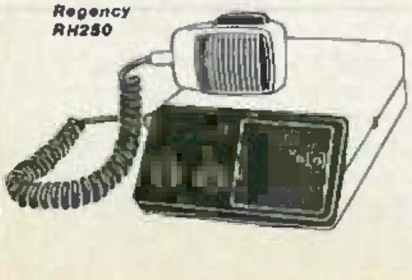
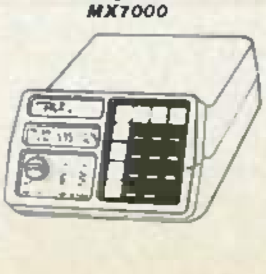
Regency RH250



Regency MX7000



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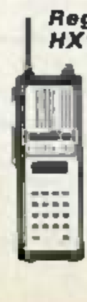

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CIRCLE 79 ON FREE INFORMATION CARD

WHAT'S NEWS

Closed-circuit "citizens band"

Subscribers to the CompuServe Information Service, based in Columbus, OH, have available a "closed-circuit" form of CB radio called the CB Simulator. Any of the 280,000 CompuServe subscribers can—by typing GO CB—switch to a CB menu that makes it possible to scan a complete listing of all persons speaking on all 36 channels of the band, and to join conversations on any of the bands. Private conversations may be held off-channel, as well.

The connect rate for the CB Simulator is $6.00 per hour from 6 P.M. to 8 A.M. weekdays, and all day Saturdays, Sundays, and holidays. For weekday service between 8 A.M. and 6 P.M. the rate is $12.50 per hour.

Numerous friendships have been made over the simulator, and at least two weddings have been reported.

Fast computer chips with "quasicrystals?"

Scientists from three departments of the University of Michigan, supported by a $1.5-million grant from the National Science Foundation, are working to produce extremely fast computer chips and other advanced microelectronic devices. They are working with a variety of metallic and semiconductor materials, sandwiched to form multilayered chips called superlattices.

In the past, researchers have depended on making semiconductor devices smaller and circuit leads shorter to make faster computers and other electronics devices. Already chips have been made that crowd more than a million electronics devices on a silicon chip less than a centimeter on a side.

Having reached the limit in reducing size, scientists are now seeking new ways of speeding up computers and other electronics equipment. Under the new grant, U of M scientists will focus on building and testing the properties of superlattices made of synthetic "quasicrystals," new materials invented at the University. The atoms of faster quasicrystals have a predictable arrangement that falls between the repeating patterns of crystals and the total disarray of glasses.

The research will also examine properties of metallic superlattices, with potential applications in modern superconducting devices. Research will also involve building and testing heterostructures, materials similar to superlattices but with fewer layers, that can be manipulated to produce a variety of electrical and optical effects.

New transparent conductor uses organic materials

The first transparent polymeric conductor is under development by Honeywell. Made in a thin film, it is versatile enough to defrost a car window or control a building's temperature by reflecting heat and cold. It is made from the polymer polydiiodocarbazole (PDICZ) doped with bromine and formed into film from 1 to 30 microns thick.

By varying the thickness of the film and the level of doping, Honeywell has varied the conductivity from insulating levels to conductivity appropriate for such applications as defrosting car windows. Light transmission is from 60 to 90 per cent.

The new film can be made more readily and more easily than earlier inorganic types, and it can be made with greater surface areas and thicknesses. Therefore it is expected to be considerably lower in cost than present types.

New devices authenticate money transfer messages

Researchers at the National Bureau of Standards Institute for Computer Sciences and Technology have completed the first validation of a security device that will be used to authenticate messages used for the electronic transfer of funds.

This validation is part of a program to help protect the billions of dollars in Federal funds that are transferred electronically every year.

NBS developed the test methods to ensure that devices used to transfer funds electronically comply with federal standards for computer data authentication and with the American National Standard for Financial Institution Message Authentication. The validation system can be used to test equipment remotely through an electronic interconnection with NBS.

Further information can be obtained from Miles Smid, Institute for Computer Sciences and Technology, National Bureau of Standards, A216 Technology Bldg., Gaithersburg, MD 20899.

High-efficiency solar panels

Solar panels designed to operate four or five times more efficienty than the best photvoltaic cells currently available, and at only a fraction of the cost, are currently under development by Massachusetts inventor Alvin Marks, and by Westinghouse.

Lepcon, the preliminary design patented by Marks, consists of a glass panel covered by millions of aluminum or copper strips, each less than a micron wide. Energy in the sunlight striking the panel is transferred to the electrons in the metal strips, generating electricity. Lumeloid, also patented by Marks, uses a similar approach, but substitutes film-like sheets of plastic.

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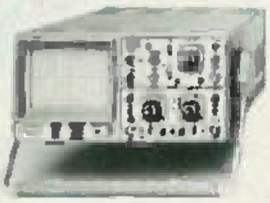
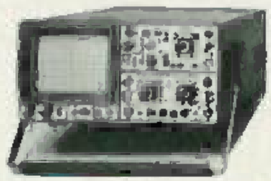


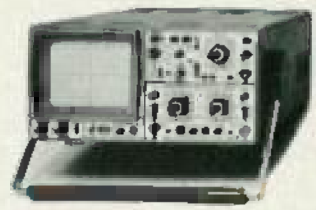
HM 203-6 DC to 20MHz **$489.00**

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



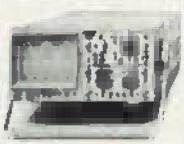
HM 204-2 DC to 20MHz **$629.00**

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



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

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

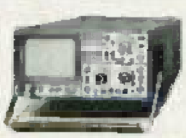


HM 205 **$799.00**

Real-time - See 203-6 Specifications

Digital Storage

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

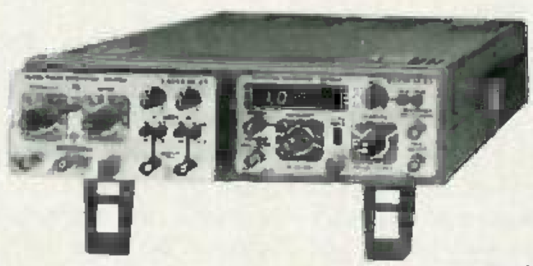


HM 208 **$2,380.00**
HM 208-1 **$2,860.00**
(with IEEE interface)

Real-time - See 203-6 Specifications

Digital Storage

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



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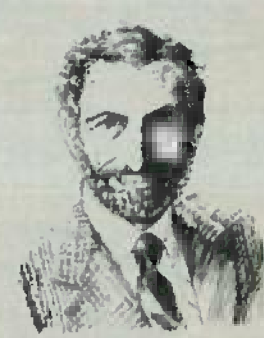
VIDEO NEWS



DAVID LACHENBRUCH,
CONTRIBUTING EDITOR

• **Picture-in-Picture.** Digital circuitry is making possible a number of hot new features in VCR's, the most spectacular of which is *P*icture-*In-P*icture, or PIP. That feature heretofore has been found only in a few digital TV sets. Now PIP VCR's are being introduced one after the other—the first three by RCA, Hitachi, and Sears, with others to come later. All three of the first PIP VCR's are made by Hitachi. RCA's is the most sophisticated and contains nine dynamic RAM's with a total storage capacity of more than two megabits.

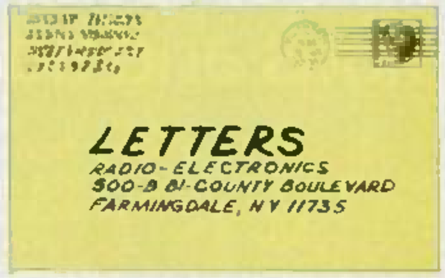
Using the hand-held remote-control unit, the user can superimpose a smaller picture in any corner of the main picture. The main picture may be the VCR tape playback, and the smaller picture can be from the VCR's TV tuner or from the video input terminal. The two pictures may be exchanged at will, and either one may be frozen, thanks to built-in field storage. The same field storage is used for fact motion without sound bars; there are unique special effects, such as "mosaic" and "posterization." The Hitachi and Sears recorders also have PIP but their special effects are limited. The RCA VCR uses two DRAM's for the PIP field memory, and six to enhance picture stability. The first PIP VCR's will sell for $500 to $700, depending on what other features are included.

• **Interactive VCR.** Worlds of Wonder, Inc., which brought us Teddy Ruxpin, the talking teddy bear, plans to introduce a unique computer attachment that will make any VCR interactive. Three years in development, it differs from programmable videodiscs in that the screen is never blanked during the interactive search. Special tapes for the system have four-way branching and give the effect of 20 tracks of information. There are four audio tracks, up to four branchable video tracks with motion, and up to 20 computer-generated tracks with limited motion. The entire attachment is scheduled to sell for less than $250 in a year or so, or could be built into a digital TV or VCR for $50 to $100. The first program cassettes will be educational, and several producers—the first being Heron Communications—are preparing programming. In addition, WOW is exploring the use of special cable-TV programming for the interactive machine. That is possible because the system is completely linear. The tape is never required to stop or reverse itself. The system can give quizzes with questions selected at random, keep score, provide music with a still picture, change pictures in response to the viewer's choice, react to user-manipulated arrows or cursors, and so forth.

• **The ultimate Beta.** The most elaborate, and probably the best, consumer VCR ever introduced is a new Beta model by Sony. The quality results from the fact that Sony didn't worry much about compatibility. It improved on Superbeta by shifting the carrier up to 1.2 MHz in the Beta I speed, as opposed to Superbeta's 800 kHz, thereby providing resolution of better than 300 lines. A switch preserves one-way compatibility—playback of standard Beta I tapes. The machine has features never seen before on a half-inch machine, such as flying erase heads, a frame counter, a character generator with eight-page memory, and a programmable assemble editing system to put together up to eight segments with accuracy within two frames. It even has an on-screen calendar for programming. Sony sees its principle use in editing onto VHS, Beta or 8mm VCR formats. It lists at $1,700.

• **Zenith adds Bose sound.** Who says you need a ten-foot audio system to get good TV sound? Not Zenith or Bose. The two companies have united to produce a series of high-end 27-inch digital color sets with a folded waveguide woofer built into the back and occupying no space beyond the normal outside dimensions of the set. Two *twiddlers*—combination midband and tweeter speakers—are front-mounted below the TV screen. The sets have three amplifiers—a 25-watter to power the woofer and two 5-watt units for the twiddlers—and they have built-in World System Teletext reception. They'll sell for around $1,400 for a table model, or $1,700 for the best console. R-E

LETTERS



OOOOPS!

A few errors crept into the the article "Build This Satellite-TV Descrambler" in the October 1986 issue of **Radio-Electronics**. In Fig. 2, the schematic diagram, pin 14 of IC's 2 and 3 should be tied to −5 volts, not +5 volts as shown. Resistor R29 should be tied to +5 volts. Transistor Q7 is misidentified: It should be a 2N3904. Finally, the positions of Q5 and Q6 have been reversed. The unit identified as Q5 should be Q6, a 2N3904 NPN transistor; the transistor identified as Q6 should be Q5, a 2N3906 PNP transistor.

In Fig. 3, the parts-placement diagram, two components are shown in the wrong location. Resistors R8 and R23 are shown vertically aligned; they should be mounted horizontally. Resistor R8 mounts between the top of what is shown as R8 and the top of what is shown as R23; resistor R23 mounts between the bottom of what is shown as R8 and the bottom of what is shown as R23.

Finally, a trace is missing from the PC pattern. It runs from the positive end of C5 to the center of jack J2. Replace that trace with a jumper.—*Editor.*

RADAR SPEED-GUN CALIBRATOR

In regard to Anthony Stevens' article, "Radar Speed-Gun Calibrator" (**Radio-Electronics**, August 1986), there seems to be a little information that he left out—and the reader should be aware of it.

On the first page of the article, he mentions that the Doppler shift is about 31 Hz per MPH of target velocity. That is correct, but he fails to point out that that amount of Doppler shift only applies to radar guns operating at the 10.525GHz frequency (X-band). He also does not inform the reader that the Gunn diode and microwave horn

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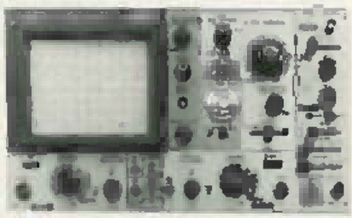

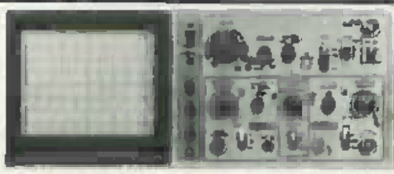

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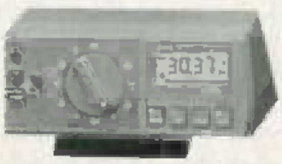

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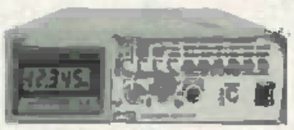

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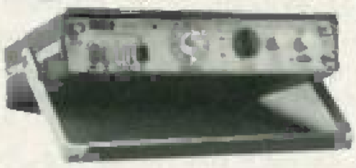

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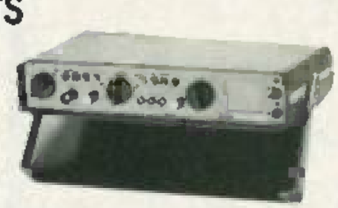

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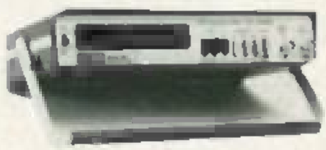

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in the parts list will only work in conjunction with the X-band radar units—that is, assuming that they are the same ones as shown on the lead page of the article. Also not mentioned is whether or not a K-band diode and horn is available.

While the K-band output is mentioned in passing on page 42, he does not elaborate on any of the details. The K-band output is derived from a different divider chain, because the Doppler shift on that band is different than it is on the X-band for a target traveling at the same speed.

Although there are several K-band frequencies used, I used 24.5 GHz for my computation. That results in a Doppler shift of 73.1 Hz per MPH. That can be figured out by one of two methods. One is to multiply the ratio of 24.5 GHz to 10.525 GHz (2.328) by 31.4; the other is to use the formula for Doppler shift, DS:

$$DS\ (Hz/MPH) = 89.49/\lambda$$

where λ is the wavelength in centimeters, which equals 30/frequency in GHz.

Another item of note from the "Ask-RE" column in that same issue. A reader asked about an IC that would convert from a RGB signal to a composite signal. The author of the column did not know of a chip for generating the sync. Refer to the article on Cable-TV descrambling on page 53, and you will find an IC to do just that. There is an article in a back issue of *Ham Radio* that provides complete construction instructions. I'm not sure which issue it was, but I think it came out four or five years ago.

And finally (I know, I know; my high school English teacher said never to start a sentence with *and*), who is the new advertiser on page 14? (Mr. Sestero refers to the NutriWheat Diet Program.—*Editor*) I'm sure that I speak for many of your faithful readers when I say that we don't need that kind of advertising in an electronics magazine. It reminds me of reading through the old *Mechanix Illustrated* magazines of 20 years ago. Please, let's not repeat that.

ROBERT T. SESTERO
Baltimore, MD

We start sentences with "and" regularly—in spite of what our high school English teachers said. We also use prepositions to end sentences with. Times change.—Editor

INACCURACIES

I am writing to correct some of the many inaccuracies in the article, "The Early Days of Radio," by Martin Clifford, which appeared in the July issue. Hugo Gernsback must be turning in his grave! It is perhaps possible that some of them were due to editing, but I suspect that most came directly from the author, who hadn't done his homework. (By the way, the picture of an early radio station on the first page of the article is most interesting, and It would be pleasant to know something more about it. On the right side of the picture is a device that appears to be a microphone, either for a recording device or, perhaps, for radiotelephony. The instrument with a large dial at the center of the left side of the picture is also of interest.)

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CIRCLE 182 ON FREE INFORMATION CARD

Perhaps the most glaring errors appear in Fig. 1 and Fig. 2, which show schematics for crystal receivers that cannot work. (I think that those schematics were copied from other articles I have seen during the past few years; they were also written by someone who apparently did not understand electricity.) In both of those figures, the crystal and the headset are wired in series with the antenna and ground, and there is no direct-current return path. As a result, no current could or would flow in the headphones, hence no reception. There should also be a bypass capacitor across the phones, but that is of no importance in a receiver that can't work.

Figure 3, while also flawed, does correspond to early practice. The problem with it is that the headset is connected to the "hot" end of the tuning coil, and capacitance from headset to ground would affect tuning. That wouldn't be of much importance in a receiver with such poor selectivity, however. Fig. 4 is OK, but Fig. 5 has the same problem as Fig. 3; in addition, there should be a bypass capacitor between the potentiometer arm and the detector, but its ommision was also typical of early receivers. Figs. 7 and 12 will work, although the use of a variable capacitor in series with the antenna will permit antenna circuit tuning and give much better selectivity.

A couple of other errors are less significant. The statement that "true solid-state receivers have been with us since 1918" would be more accurate if the date were 1906, when the Perikon detector was patented. The commercial use of crystal detectors in the following years was more limited by patent matters than by performance.

One more annoyingly incorrect statement is: "Early vacuum-tube rectifiers, such as the UX-201A and the UV-199 triodes, cost about $15.00." That statement contains three errors. First of all, those tubes were triode amplifiers and detectors, not rectifiers. Second, those particular tubes were not particularly early. Third, they never cost $15.00. The UV201, the predecessor to the UX201A, was announced in November, 1920, at a cost of $6.50. It was considered an amplifier, with the corresponding detector being the UV200, at $5.00. Although those were not the first tubes available to the public, they were the first sold by RCA, and correspond roughly to the beginning of broadcasting. The UV1999 is of interest as an early "dry battery tube;" it was announced in December, 1922, and it cost $6.50. The UX201A was a relatively late tube, introduced at $2.50 in August, 1925, to replace the UV201A, which had been introduced at the same time as the UV199, and at the same price. The UV201A and the UX201A, like the UV199, had thoriated tungsten filaments, which greatly reduced the required filament power.

There is really no excuse for such a poor article, because many excellent reference books are available these days. For early vacuum tubes, I would recommend *Saga of the Vacuum Tube*, by Gerald Tyne, and *70 Years of Radio Tubes and Valves*, by John Stokes.

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Both are available from Antique Electronic Supply, 688 W. First Street, Tempe, AZ 85281. A couple of other interesting histories are *The Development of Wireless to 1920*, Arno Press, New York, 1977, and *The Continuous Wave—Technology and American Radio, 1900–1932*, by Hugh Aitken, also available from Antique Electronics Supply. Anyone seriously interested in historical radio and wireless should join the Antique Wireless Association, Holcomb, New York. Dues are $8.00 per year and include four issues of *The Old Timer's Bulletin*, which contains excellent articles of historical interest, in addition to many want ads. Membership applications should be sent to Bruce Roloson, Box 212, Penn Yan, New York 14527.

EDWARD PHILLIPS
San Gabriel, CA

The circuits shown in Figs. 1 and 2 are correct, and they can and do work. Apparently Mr. Phillips doesn't know the difference between a DC ground and an RF ground. The circuit is grounded for RF, and current will flow in those circuits even if a capacitor is inserted in series with the antenna lead-in.

Hugo Gernsback need not turn in his grave, because those circuits, and others like them (surprise!) originally appeared in a book, How to Read Circuit Diagrams, *published by Gernsback about 50 years ago.*

It isn't necessary to put a bypass capacitor across the headphones. There is enough capacitance between the turns of the wire in the headphone to supply bypassing action for the carrier wave.

The headphones in Fig. 3 can be positioned before or after the crystal detector. The tuning is so extremely broad that the capacitance from headphones to ground is of little consequence.

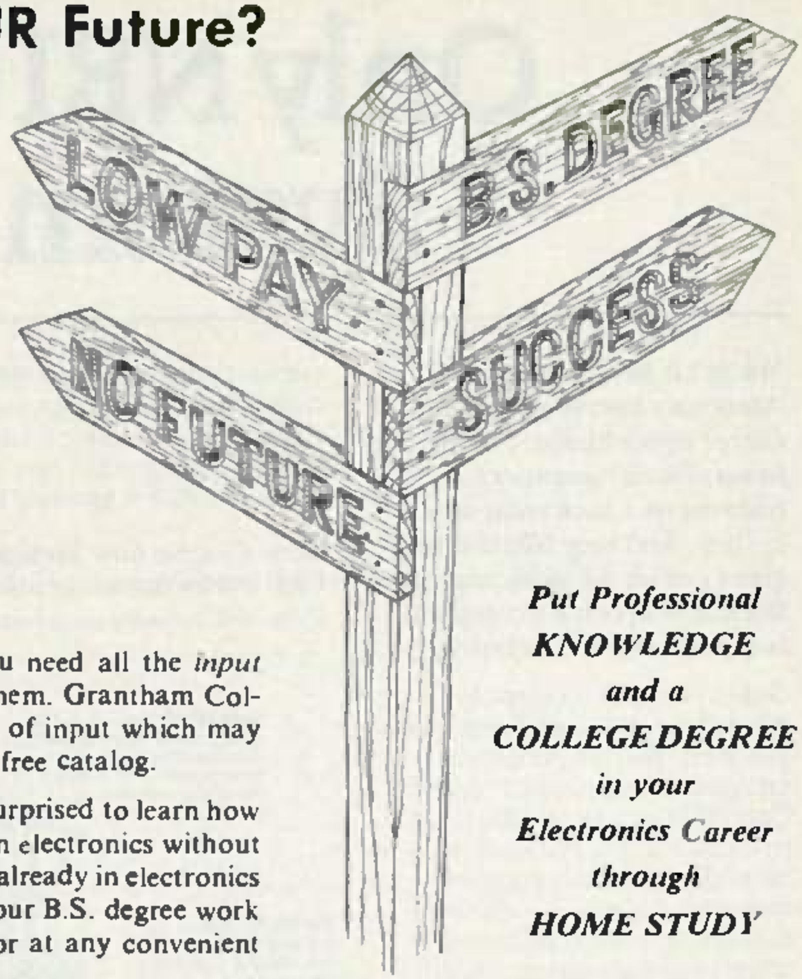
I am well aware of the Perikon detector. However, it wasn't until about 1919 or 1920 that the iron pyrites crystal detector became a household item. As far as the price of tubes is concerned, one must be aware that a new component is always at its highest price. As tube competition increased, and the supply of tubes went up, those early tubes dropped in price even lower than the figures Mr. Phillips stated.

I do not mind his comments on the article. What I do resent is the statement that Hugo Gernsback must be turning in his grave. That is arrogant and presumptuous, and implies that Mr. Phillips knew Gernsback. I doubt that he ever met the man. I used to have lunch with Hugo Gernsback from time to time, and was also a guest in his home. I was in France with him, and together we visited a noted technical publisher in Paris. I have no doubt that I was his friend; I have a photograph from him inscribed, "To my friend, Martin Clifford."

I was impressed with the books Mr. Phillips mentions in his letter. I would suggest that he take some time and read them.—Martin Clifford

continued on page 33

Which Way To YOUR Future?



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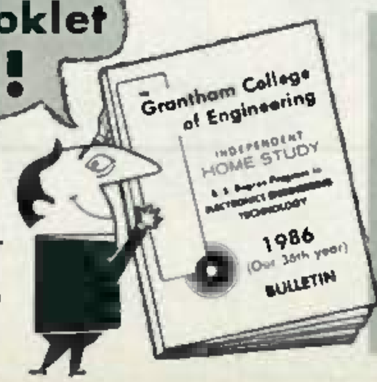

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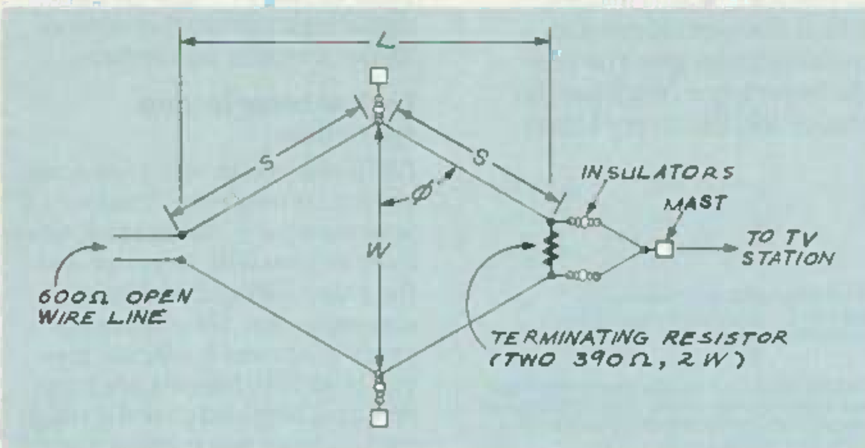

TABLE 1 - RHOMBIC DIMENSIONS

	Wavelengths Per Leg	S	L	W	Gain dB	Beam Width	Ø
VHF TV Channels 2-6	6	87'-0"	162'-0"	66'-0"	12	6°	68°
	4	58'-0"	104'-0"	54'-0"	10	8°	62°
	2	29'-0"	46'-0"	36'-0"	7	13°	52°
FM	3	30'-0	55'-9"	22'-6"	12	6°	70°
VHF TV Channels 7-13	6	30'-9"	58'-0"	23'-2"	12	6°	68°
	4	20'-6"	36'-6"	19'-0"	10	8°	62°
	2	10'-3"	16'-6"	12'-8"	7	13°	52°
UHF TV Channels 14-47	6	9'-7"	17'-8"	7'-2"	12	6°	68°

TV-RHOMBIC ANTENNAS

Your response to the request for a balun for a TV rhombic left me puzzled. Whoever heard of a rhombic for TV frequencies? I thought that rhombics are used to obtain directivity at low frequencies when you have enough real estate to establish an "antenna farm." What are the dimensions for a TV rhombic? How does its performance compare with that of a Yagi?—O. K. H., New Strawn, KS.

When the desired TV stations are 75 to 150 miles or so away and all in nearly the same direction, a good rhombic can provide high gain while offering broader frequency response and a constant impedance over a broader range than a Yagi. Specifically, a rhombic provides high gain over a 2:1 frequency range; in other words, the design frequency ±50%. Although any antenna for receiving distant stations should be as high as practical, a rhombic two or three wavelengths above ground may outperform a high-gain Yagi on a much higher tower.

Rhombic antennas were widely used in remote areas in the early days of television; they're still not uncommon in many rural areas today. A rhombic with six wavelengths in each leg can provide 12 dB of gain in the forward direction and it can be small enough to fit on many residential lots. Some high-band and UHF TV rhombics are small enough to be mounted on a rotator on a tower.

The diagram of a rhombic for TV frequencies is shown in Fig. 1. The dimensions of each leg for receiving signals at various frequencies are shown in Table 1. A rhombic's beam-width is usually much narrower than than that of a Yagi with equal gain, so you must be extremely careful to orient the antenna carefully to within a degree or two. Beam-width decreases and tilt angle increases with the number of wavelengths in each leg. For maximum gain, orientation must be accurate within ±3, ±4, and ±6.5 degrees for rhombics with six, four, and two wavelengths per leg, respectively.

The rhombic should be terminated by an 800-ohm non-inductive resistor. You can use two 390-ohm, 2-watt resistors in series.

DARKROOM TIMER

I need help in designing a darkroom timer for my enlarger. I'd like a countdown timer that can be set from 0 to 120 seconds in 0.1-

second increments. Time will be displayed on a 4-digit LED readout. A relay will energize the enlarger and turn it off at the end of the timer period. I've been thinking of a 10-digit keypad or three columns of individual switches for setting 0.1-, 1.0-, and 10-second increments.—G. K., Tampa, FL.

The design of a "dream" darkroom timer such as you describe is a project that would probably require much troubleshooting and several trips back to the drawing board before satisfactory performance is achieved. Unfortunately, we cannot undertake the R&D work needed to provide you with a foolproof design.

You can find some designs that do part of what you want in back issues of electronics and photography magazines. Consult the *Applied Science and Technology Index* and the *Readers Guide to Periodical Literature* in your local library. And try to get a copy of Intersil's *Timers, Counters, and Display Drivers Applications Handbook*. Write to Intersil at 10710 N. Tantau Ave., Cupertino, CA 95014. That 30-page booklet is chock full of circuits for programmable interval timers, stopwatches, counters, and digital displays and drivers. If it is not available, try for a copy of Intersil's *Hot Ideas in CMOS*. Chapter 6 of that work contains data sheets, application notes, and circuits covering the firm's line of counters, timers, and display drivers.

POWER DISTRIBUTION GRIDS

For a college research project, I'm doing a study on the losses in electrical power over long-distance power lines. I need maps showing the power distribution grids throughout the United States. Where can those maps be obtained?—D. D., Bloomington, IN.

Try the "Chief Transmissions Engineer" or the "Director of Power Distribution" of your local power company. If he can't help, contact your Congressman or Senator. The type of information you're looking for is probably available through a governmental agency such as the Department of Energy, the Energy Information Administration, or the Federal Energy Regulatory Commission.

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Lucky for you, the diskette buyer, there are many diskette brands to choose from. Some brands are good, some not as good, and some you wouldn't think of trusting with even one byte of your valuable data. Sadly, some manufacturers have put their profit motive ahead of creating quality products. This has resulted in an abundance of low quality but rather expensive diskettes in the marketplace.

A NEW COMPANY WAS NEEDED AND STARTED

Fortunately, other people in the diskette industry recognized that making ultra-high quality diskettes required the *best* and newest manufacturing equipment as well as the best people to operate this equipment. Since most manufacturers seemed satisfied to give you only the everyday quality now available, an assemblage of quality conscious individuals decided to start a new company to give you a new and better diskette. They called this product the *Super Disk* diskette, and you're going to love them. Now you have a product you can swear by, not swear at.

HOW THEY MADE THE BEST DISKETTES EVEN BETTER

The management of *Super Disk* diskettes then hired all the top brains in the diskette industry to make the *Super Disk* product. Then these top bananas (sometimes called floppy freaks) created a new standard of diskette quality and reliability. To learn the "manufacturing secrets" of the top diskette makers, they've also hired the remaining "magnetic media moguls" from competitors around the world. Then all these world class, top-dollar engineers, physicists, research scientists and production experts (if they've missed you, send in your resume to *Super Disk*) were given one directive...to pool all their manufacturing know-how and create a new, better diskette.

HOW SUPER DISK DISKETTES ARE MANUFACTURED

The *Super Disk* crew then assembled the newest, totally quality monitored, automated production line in the industry. Since the manufacturing equipment at *Super Disk* is new, it's easy for *Super Disk* to consistently make better diskettes. You can always be assured of ultra-tight tolerances and superb dependability when you use *Super Disk* diskettes. If all this manufacturing mumbo-jumbo doesn't impress you, we're sure that at least one of these other benefits from using *Super Disk* diskettes will:

1. **TOTAL SURFACE TESTING** - For maximum reliability, and to lessen the likelihood of disk errors, all diskettes must be totally surface tested. At *Super Disk*, each diskette is 100% surface tested. *Super Disk* is so picky in their testing, they even test the tracks that are in between the regular tracks.

2. **COMPLETE LINE OF PRODUCTS** - For a diskette to be useful to you and your computer, it must be compatable physically. *Super Disk* has an entire line of 5¼-inch and 3½-inch diskettes for your computer.

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5¼" DSQD Soft Sector (96 TPI) Retail 10 pack	6501-HR	1.09
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SSSD = Single Sided Single Density; SSDD = Single Sided Double Density; DSDD = Double Sided Double Density; DSQD = Double Sided Quad Density; SSHD = Single Sided High Density; DSHD = Double Sided High Density.

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WIND-GENERATED POWER FOR SALE

As an experimenter, I've long been interested in wind-generated electrical power. The idea of putting up a windmill and generating power for my own use and for selling to the power company is very attractive. However, the power company requires that I install a synchronous inverter between the wind generator and the power line. Can you supply the schematic of a synchronous inverter?—D. B., Astoria, OR.

A windmill generator produces direct current that must be inverted (converted) to alternating current before it can be used to power most household appliances, and certainly before it can be fed into the public-utility power lines. A synchronous inverter is a type of motor-generator set. The American National Standards Institute describes a synchronous inverter as "An inverter that combines both motor and generator action in one armature winding. It is excited by one magnetic field and changes direct-current power into alternating-current power."

Engineers from our tri-state regional power company and from an electric-power co-operative say that if you have enough power available to interest them—several hundred-thousand kilowatts—they would specify the inverter and you would have to have it built to their specifications.

PHILCO AM/FM SERVICE DATA

I need the schematic and service data for a Philco model N-1740-124 AM/FM radio that was manufactured around 1963. Can you help?—M. W., New Haven, CT.

The receiver that you are interested in is covered in Sams Photofact Set No. 794, Folder No. 8.

Other readers who need schematics and service data on many makes and models of consumer electronics products that were manufactured between 1946 and the present may find that information in a Sams Photofact folder. You can call Sams toll-free at 800-428-SAMS and ask for the name and address of the Photofact distributor in your area. You may also be able to obtain information on availability of the data you need. R-E

EQUIPMENT REPORTS

HOWEVER DIFFICULT IT IS TO DESIGN digital circuits, it's even more difficult to get them working properly. In a world where the delay of a few microseconds can mean the difference between a hit and a miss, pinpointing problems can be a problem in itself. There are lots of ways to debug circuits but all of them have one thing in common—you need tools to do the job.

If you can't afford an oscilloscope and a logic analyzer, all is not lost: You can still do a good amount of troubleshooting with a logic probe. Once upon a time, logic probes only indicated logic highs and lows, and they did that by using a resistor and an LED. Today's commercially available probes are a lot more sophisticated—and a lot more useful.

The *Circuitmate LP25* logic probe from Beckman Industrial (630 Puenta Street, Brea, CA 92621) is an inexpensive way to peek inside a digital circuit. It has every one of the features you'd like to see on a probe and, wonder of wonders, a reasonable price tag as well. At a suggested list of $39.95, the LP25 will pay for itself the first time it saves you hours of debugging.

The *LP25* is extremely easy to use and is compatible with any of the logic familes you might be using. A small switch on the probe lets you select either a TTL or CMOS detection threshold, which is necessary because the industry standards for those two families are different. TTL specifications are less than 0.8 volt for a low and greater than 2.3 volts for a high. CMOS normally switches at about 50% of the supply rail but the industry standard is 70% of V_{CC} for a high and 30% of V_{CC} for a low. The TTL setting on the probe also is good for use with DTL, RTL, and HTL.

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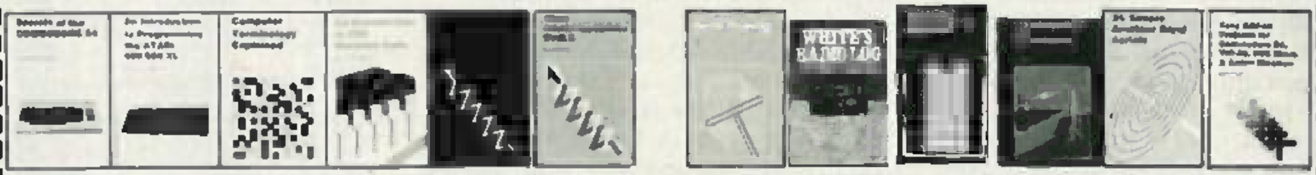

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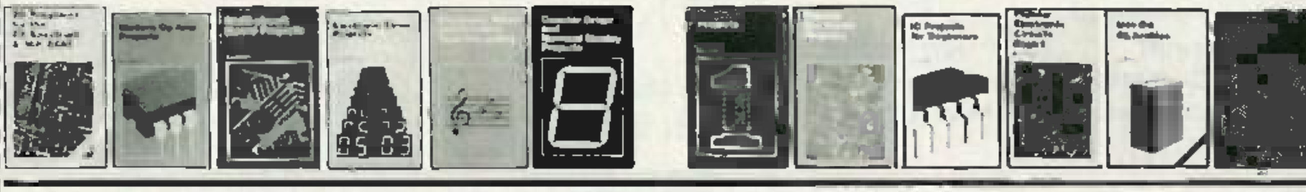

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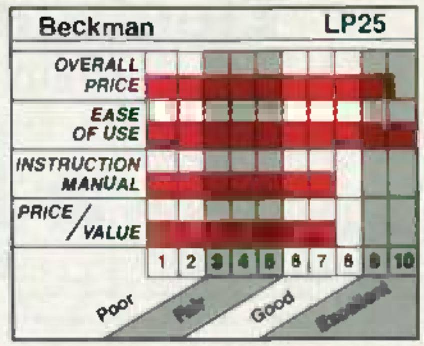
High and low logic levels are indicated with red and green LED's as well as high and low tones. Since the audio is generated by a small piezo element, the output level Is rather low and you'll have to turn down your radio to hear it. The tones produced by the *LP25* are about 2 kHz for a high and 1 kHz for a low. If you've never used a probe with an audio signal before, you'll wonder how you ever got along without one. It's really a tremendous convenience to be able to test circuit points without having to look at the probe.

The *LP25* can do more than show logic levels. If you're looking at clock pulses, the probe indicators will not only modulate, but they'll also give you some idea of the waveform. Different types of waveforms will produce both different LED combinations and sounds. The instruction sheet has a small chart to use in understanding what the probe is telling you.



The frequency range of the *LP25* goes from DC to 25 MHz but its state indicators are responsive only up to 200 kHz. For any higher frequencies, circuit conditions are shown on the pulse catcher. A yellow LED near the back of the probe will flash whenever a logic transition occurs and the circuitry will see pulses as narrow as 30 nanoseconds. If you're looking at clock pulses faster than 200 kHz, the high and low LED's may or may not light, but the yellow LED will be flashing so rapidly it will appear to be on constantly.

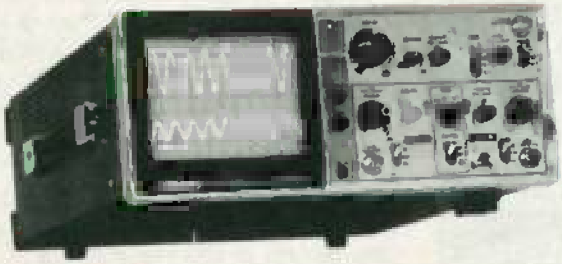
Since the pulse-detector circuitry is triggered by both positive- and negative-going transitions, the LED will be flickering at twice the clock rate. Although Beckman lists 25 MHz as the upper limit of the probe, it didn't start to get flakey until the test frequency was past 40 MHz.

The pulse-detection circuitry in the probe can be made either to reset itself after each detection or to latch. That is done using the PULSE/MEMORY switch on the probe. In normal use, you would put the switch in the PULSE position. But if you're looking out for an occasional line glitch or pulse, flip the switch to MEMORY and go out for a pastrami sandwich. If the pulse shows up, the probe will detect it and latch the LED on.

There's no way that a logic probe, even one like the *LP25*, can substitute for a more powerful instrument such as a scope. If you want to do heavy-duty circuit debugging, a scope is the way to go; but for quick and dirty troubleshooting, you'll have to do a lot of looking before you find something as simple and useful as Beckman's *LP25*. It's powerful, well made, and won't put a big hole in your wallet. R-E

continued on page 28

HITACHI OSCILLOSCOPES



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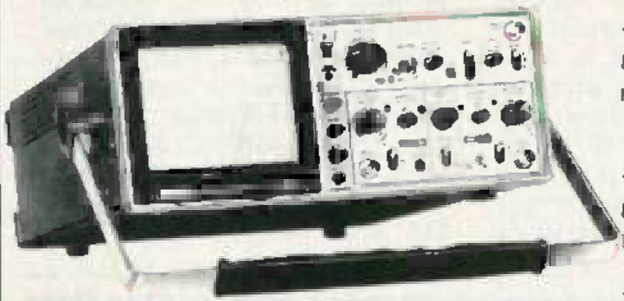

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Same as above with DC offset to measure signals having DC components, CH1 output and DC offset voltage monitor outlet available for external counter or DVM*, alternate magnify function provides x1 and x10, sweep waveforms to be simultaneously displayed. **$511.**

*The purchase of a Model V222 oscilloscope entitles you to purchase a Revere Model RDMT10 3 1/2 digit, 10 amp. scale digital multi-meter for $39.95! Regular price is $49.95. Offer applies only to Hitachi Model V222.

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A LOGIC PROBE LIKE THE THE *LP25* IS A very useful stand-alone circuit-debugging tool, but its utility can really be increased by using a logic pulser, such as the *Circuitmate PR41* from Beckman Industrial Corporation (630 Puente Street, Brea, CA 92621). Both are perfect tools for people who don't want to spend a whole bunch of money on a set of basic instruments to help in designing and building digital electronic circuits. The *PR41* lists for just $44.95.

Logic pulsers are invaluable for forcing digital IC's to change state. You can do the same thing with a clip lead and a resistor; but the hallmark of digital circuitry is *controlled* changes and, as we all know, you can't be very precise if you're debugging stuff with nothing more than a hunk of wire. Logic pulsers do their thing accurately—and safely. That's important since a heavy-handed approach usually produces nothing more than smoke.

The *PR41* draws its power from the circuit under test. The coiled cord coming out of the back of the pulser ends in two clip-leads. All you have to do is to connect them to power and ground on your board, and the pulser is operational. Putting the unit to use involves nothing more than touching the tip to the input of the IC.

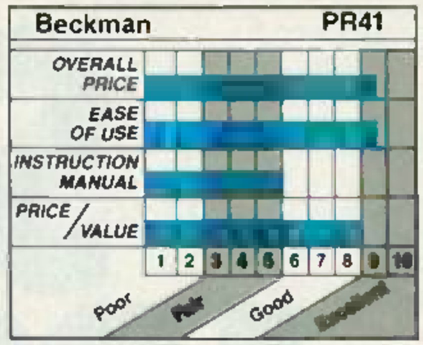
The circuitry in the pulser can operate at two different rates. Which one you choose will depend on what you're trying to do. The small slide switch allows you to select between pulse rates of 400 Hz and .5 Hz. The higher rate is useful if you want to clock part of your circuit and watch the results farther down the line. If you just want to force a logic translation, you're better off at the slow rate, since it will give you enough time to remove the tip from the IC before the second pulse is generated. You can see the number of pulses produced by watching the LED at the tip of the pulser.

The pulses being injected into the circuit have a risetime of 2 μs, last 15 μs, and then take about 30 μs to decay. The *PR41* has push-pull output circuitry so it can source or sink up to 100 mA, which is more than enough to drive any IC input—whether it's already being driven by an IC output, or even tied to one end of the supply rail through a resistor. And since the pulses are so short, the chances of doing any damage to the IC being pulsed are low.

Being able to trigger in-circuit logic transitions is a great aid in circuit debugging but, unless you're looking at unclocked inputs, it still doesn't give you a true picture of circuit operations. The people at Beckman understood that when they designed the *PR41*. The unit can put out pulses in sync with an external clock. There are three pins on the pulser - ground, clock in, and clock out. The pin labeled EXT SYNC is an input that accepts a clock signal and then forces the unit to output pulses at the clock-signal's rate. The clock pulses are isolated and cleaned up by an internal Schmitt trigger and appear at the pin labeled SQ.

There are two points to keep in mind if you want plan on using an external clock. If the clock you're feeding in has a frequency less than 400 Hz, the *PR41* will put out pulses at the clock rate. If it sees a clock faster than 400 Hz, the output frequency isn't very easy to predict. The *PR41* will lock to the input frequency and put out pulses at some indeterminate rate. The pulses will be synced to the incoming clock, but the maximum frequency will be 400 Hz. In other words, you'll be sure that every pulse the *PR41* puts out coincides with an external clock pulse, but the output frequency won't be more than the pulser's maximum of 400 Hz.

The external clock input of the *PR41* has an impedance of 1 megohm, so you can be confident that it will be invisible to just about any clock line you tap; there's very little chance of loading down your circuit. The pulser is extremely easy to use and, since it's built around CMOS circuitry, it can operate over a wide range of supply voltages. Even CMOS, however, has outside limits and you should be careful to stay within them or you'll damage the probe. The clock pulses produced by the *PR41* swing very close to the supply voltage so you should make sure the input you're testing can safely handle that voltage. If it can't, you'll have to use a resistive voltage divider or some other arrangement to cut the pulses down to a safe level. **R-E**



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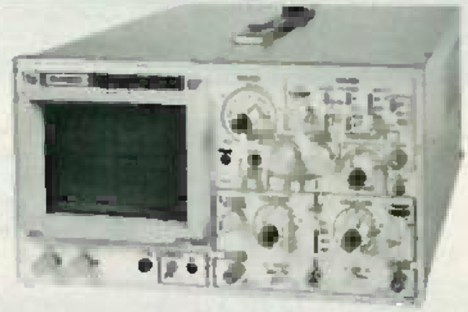

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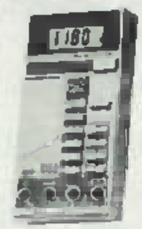

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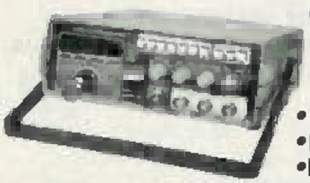

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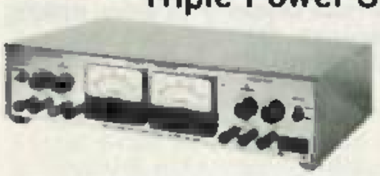

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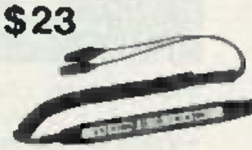

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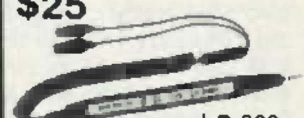

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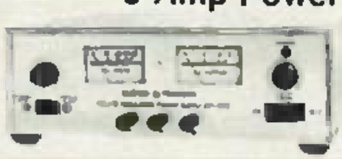

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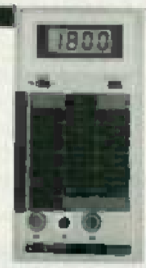

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LETTERS

continued from page 14

BUILDING CRYSTAL SETS

I enjoyed Martin Clifford's article, "The Early Days of Radio," in the July 1986 **Radio-Electronics**. I have been building crystal sets as far back as I can remember. I would like to bring up a few things you missed, and make a suggestion or two.

First, as I remember, and according to the tradition that my father handed down to me, you could almost always get a better signal with a galena crystal and a cat's whisker than with a germanium diode (1N34). Also, the galena crystal and cat's whisker were never handled. Any film or oil from your skin would impede operation.

Second, all of the between-components wiring was done with "litz" wire, which you never touched the pure copper ends of. I doubt that many experimenters knew about the skin effect, but litz wire was part of the tradition.

Third, you needed 2000-ohm headphones. I have gotten results with lower-impedance headphones, but high-impedance headphones are a necessity for any degree of performance.

Fourth, you cannot overstress the importance of a good earth ground. The old cold-water pipe trick may suffice, but an eight-foot copper rod with a litz wire is really superior.

Then there are the little things. The wooden base, ideally, is made out of well-dried hardwood that is coated with several layers of varnish. The coil(s) are wound out of a medium-gauge pure copper wire with varnish insulation. Personally, I'm fond of oatmeal boxes as coil forms.

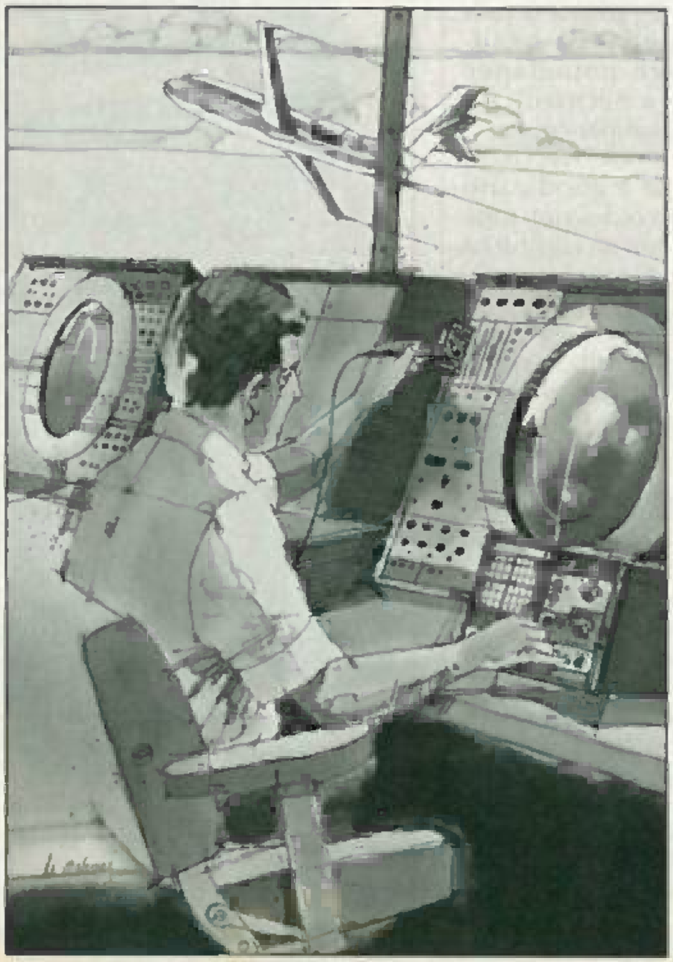
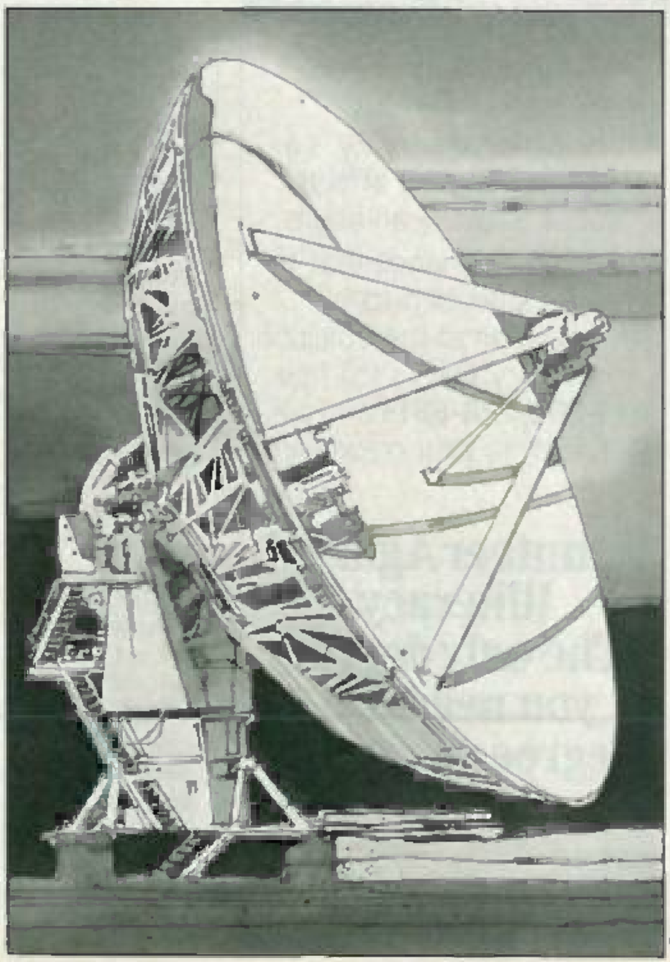
One thing that you made no mention of is the World War 1 crystal set. The heart of it was supposedly a razor blade and a piece of pencil lead. I have tried to duplicate that design with no luck but people tell me that it can be done. Perhaps you could offer some insight into that piece of lore.

Thanks again for the article.

MATTHEW KLEINMANN
Binghamton, NY

R-E



NEW PRODUCTS

DMM, the model *4800,* measures DC/AC voltage, DC/AC current, resistance, frequency (Channel A, 10 Hz to 100 kHz; Channel B, 10 Hz to 1000 kHz), period, dBm, diode test, continuity test and temperature (with K-type thermocouple). Also included are comparator, data hold, peak hold, relative, and auto-ranging.

The large 5-digit LCD display indicates pushbutton-selected functions and low line voltage or overrange conditions. Both manual and auto ranging are provided. A relative measurement mode is available, which stores the applied input as a zero-reference point from which subsequent measurements will be displayed as deviations.

The comparative measurement mode permits input of high or low values as percentages, and a beeper sounds (and "GO" appears on the LCD) if the value being measured falls within the set limits. "Hi" or "Lo" will be displayed if the value is beyond the set limits. A

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relay contact is provided for the external comparator output. A "key lock" function prevents all switches except power-off from being actuated.

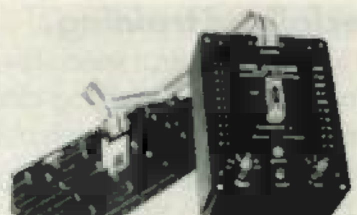
Accessories include: power cable, spare fuses, signal cable, alligator test leads, and comprehensive instruction manual. Optional accessories include various K-type thermocouples, bench "hold" probe, and 10-amp measurement probe.

The model *4800* is priced at $600.00.—**Triplett Corporation,** One Triplett Drive, Bluffton, OH 45817.

IN-CIRCUIT IC TESTER, the *Chip Checker* model *TTL-1* is a full-mode in-circuit IC tester with the capability of detecting and displaying IC errors during actual operating conditions; it can do so automatically.

It is designed to test most 14, 16, 18, and 20-pin TTL IC's, including low-power Schottky TTL. That includes logic gates, flip-flops, buffers, and interface elements. Newer and older logic families may also be tested.

Two front-panel-mounted switches are available for selecting the V_{CC} and GND pins on the IC under test. Lighted LED's indicate errors or differences between the IC under test and a reference IC:



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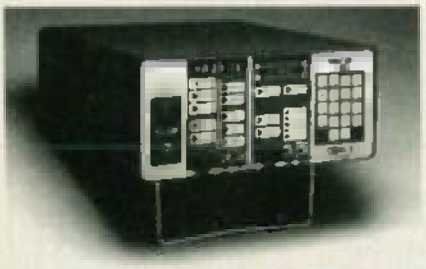
The model *TTL-1* can be used to troubleshoot suspect IC's on a PC board, because the IC's do not have to be removed from the board to be tested. Good IC's can be verified without soldering or causing board damage. The *TTL-1* In-Circuit IC tester can be adapted for low-volume incoming inspection and screening of IC's, and it can also be used as an in-circuit logic monitor.

The model *TTL-1* is priced at $299.95.—**Microcraft Corporation,** P. O. Box 513, Thiensville, WI 53092.

SERVICE MONITOR, the model *COM-3,* is designed to analyze and test transceivers in the 100-kHz to 1000-MHz range, in 1-kHz steps. It features a programmable microprocessor memory that



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stores and recalls on command up to 10 commonly used test setups. An easy-to use keyboard offers programmable offset keys that simplify frequency entry for duplex or repeater radios, and incremental-step keys facilitate the testing of a receiver throughout its frequency range.

The model *COM-3* is portable and has a built-in, rechargeable battery pack that makes it ideal for off-site testing; the *COM-3* weighs less than 10 lbs. For additional portability, a durable Cordura travel case with zippered pockets and shoulder strap is available.

The model *COM-3* is priced at $1995.00.—**Ramsey Electronics Inc.,** 2575 Baird Road, Penfield, NY 14526.

MARINE PACK is a submersible housing designed for use with a Sony *Handycam* 8 mm camcorder

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- And Much More!!!

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Model 1524

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South and Central American Sales, Empire Exporters, Plainview, NY 11803 inside it. The *Marine Pack* can be submerged to a depth of almost 140 feet. Made of plastic and glass, it is sealed with special buckles and a rubber ring clamp system. *Handycam* camcorder functions that can be controlled from outside the housing.

The *Marine Pack* features a piezoelectric underwater microphone for audio pickup, and a wide conversion lens. The unit weighs about 8 pounds, including ballast weight, and measures 11.80 × 10.25 × 10.45 inches.

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The Marine Pack is priced at $995.95; with video light, $1400.95. (The *Handycam* camcorder is sold separately.)—**Sony Corporation of America**, Sony Drive, Park Ridge, NJ 07656.

CELLULAR ANTENNA, the model *CMR750*, is designed to be mounted on a window *inside* a vehicle; no outside radial is needed. The design enables the antenna to operate with minimum signal loss or pattern distortion.

CIRCLE 22 ON FREE INFORMATION CARD

Installing the cellular antenna inside the vehicle lowers the possibility of theft and vandalism, and the antenna is protected from damage resulting from automatic car washes and harsh weather conditions. Although the model *CMR750* is factory pretuned for the U. S. cellular band, a trimmer is provided for further adjustment. It comes complete with 12′ of RG58XM/U low-loss cable and all connectors.

The model *CMR750* is priced at $72.95.—**Alliance Research Corporation**, 20120 Plummer Street, P. O. Box 4029, Chatsworth, CA 91313.

DMM, the model *DM-1000*, has 3½ digits and a rotary switch. Designed for the professional engineer and technician, as well as for hobbyists and students, its features include: pocket-size, overload protection, 10A DC current readings, 0.5″ LCD, and 200-hour battery life. The model *DM-1000* incorporates 6 funtions in 17 ranges, including DCV, ACV, DCA, OHM, diode test, and battery test.

Ranges include 200 mV, 2/20/200/1000 volts DC; 200/750 volts AC; 200 μA, 200mA, 10A DC;

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200/2K/200K/2M ohms; diode test (0-2K ohms); battery test: 2 volts DC.

The model *DM-1000* is priced at $39.95.—**A. W. Sperry Instruments**, 245 Marcus Boulevard, Hauppage, NY 11788.

THYRISTOR TESTER, the model *20*, is an easy-to-use instrument capable of measuring the basic DC parameters of thyristors and diodes. Important triggering characteristics are obtained without guesswork, confusion, or compromise. Forward and reverse blocking voltage measurements are safely made with the peak maximum current limited to the programmed condition. Two-terminal devices, such as rectifiers and diodes, may be tested as well.

The model *20* can be connected to a variety of devices—other test equipment, handlers, printers, or computer systems—through its IEEE-488 interface. The interface is activated easily by pressing the appropriate front-panel buttons. Bus commands emulate the front-panel controls and have similar mnemonics. The tester is a stand-alone unit; neither external power supply nor curve tracer is needed.

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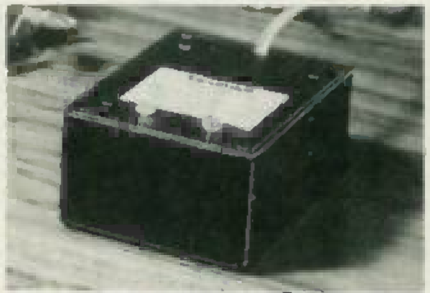
The model *20* Thyristor Tester is priced at $1995.00.—**Markenrich, 14946-A Shoemaker Avenue, Santa Fe Springs, CA 90670.**

VACATION/HOME SENTRY, the model *GD 1702* is a device that monitors internal house conditions and relays that information over the telephone.

The easy-to-assemble unit automatically detects low temperatures, and can also be used to detect water, and other problems through the addition of various sensors. If any of the sensors detect an abnormal condition, that fact is relayed to the homeowner via a beeping signal when he calls in.

The model *GD-1702* easily plugs into a phone line, and operates on



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two 9-volt batteries, which are tapped only when relaying information in response to a phone call. It is priced at $29.95.—**Heath Company,** Benton Harbor, MI 49022.

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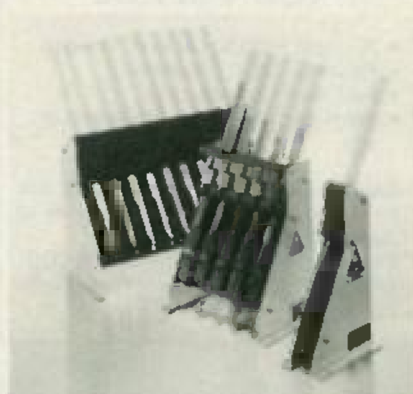

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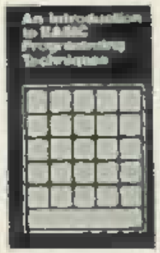

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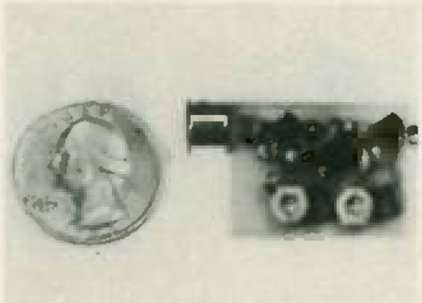

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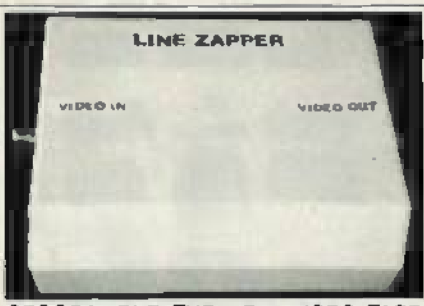

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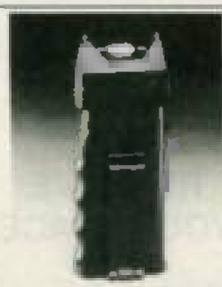

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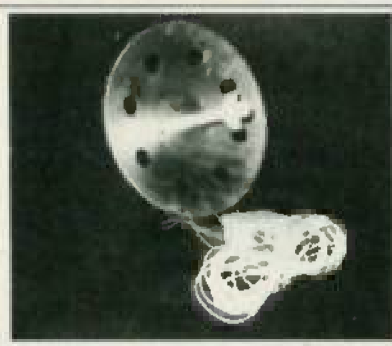

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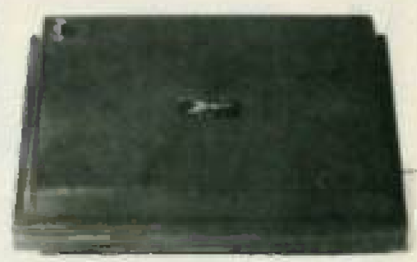

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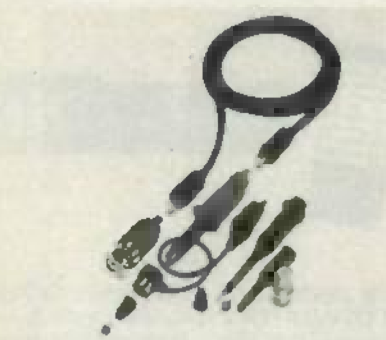

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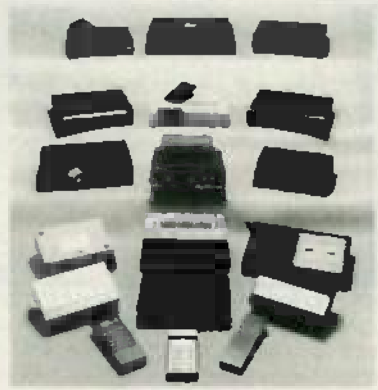

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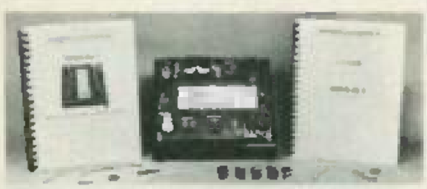

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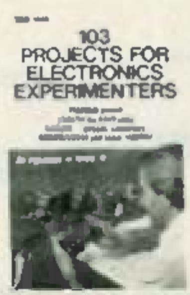

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Computers on the WORKBENCH

The personal computer does some surprising things in the electronics lab these days. Find out what and how right here.

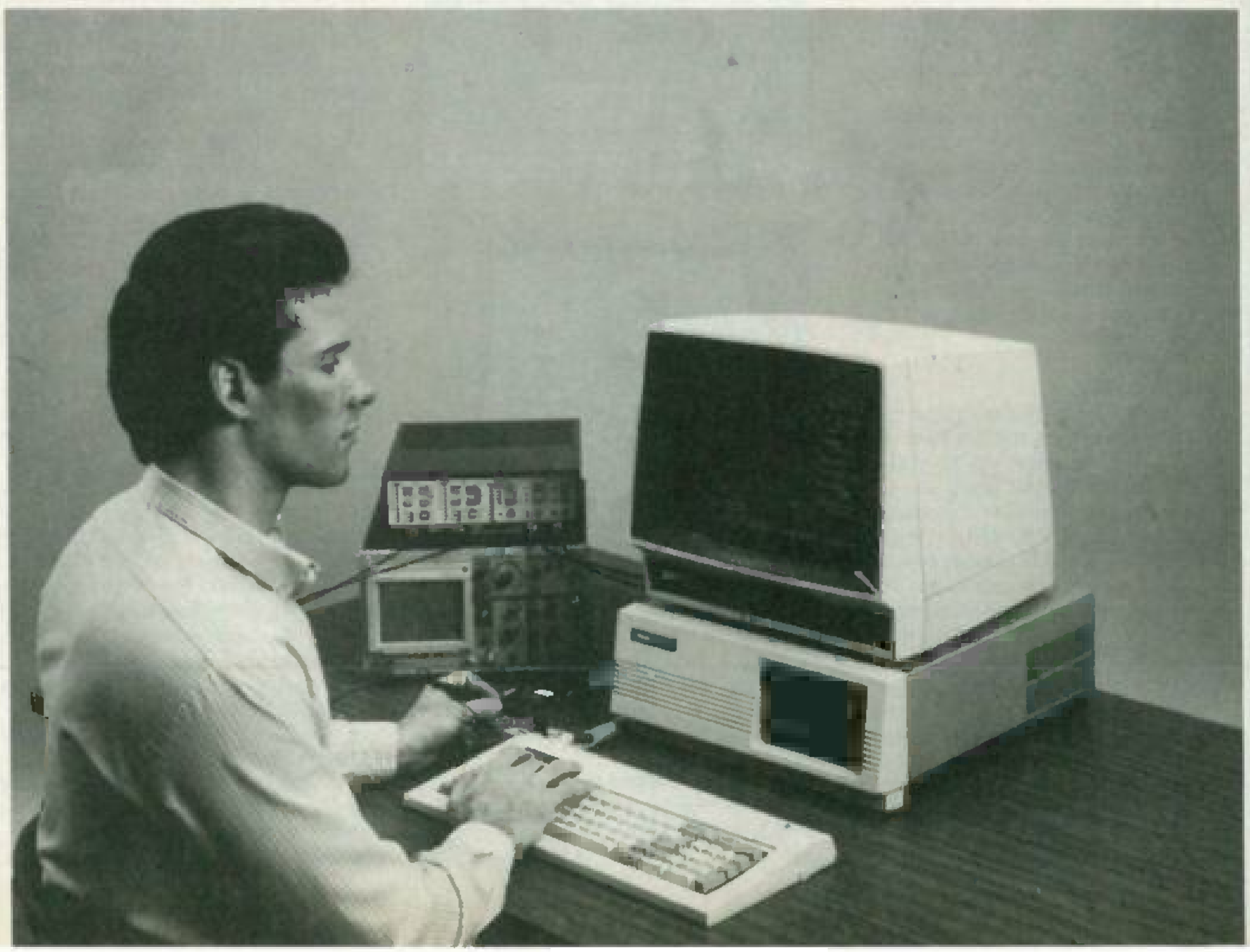
ROBERT GROSSBLATT, CIRCUITS EDITOR

THERE ARE AS MANY APPROACHES TO ELECTRONIC DESIGN AS there are designers. Each one has his own way of going from initial idea to final circuit. Of course, it takes a combination of both experience and creativity to produce working circuitry. But no matter how you arrive at a design, success often depends on the tools you use. Scopes, multimeters, function generators, capacitance meters—all those (and many more) are invaluable when you're working on a circuit. The problem is that the more tools you have, the less space you have on your workbench.

One solution to the space problem is to use a multi-purpose test instrument. If you browse through the ads, you'll find that many different test-instrument combinations are available. For example, many DMM's now come with built-in frequency counters; and they can measure capacitance and transistor gain, too. Some top-of-the-line scopes even have built-in multimeters. Now the trend to combine various pieces of equipment has been carried over to personal computers as well. More and more companies are producing hardware add-ons for computers so they can be used as bench instruments.

Before we talk about what sort of computer-based instruments are available, it's important to understand what advantages there are to using them. As a general rule, computer add-ons are much more expensive than traditional stand-alone instruments—but they have features that may simply be unavailable on traditional instruments.

For starters, since a computer is (or becomes) an integral part of the instrument, you get data storage and programmability for nothing. This means that the instrument can run



in an unattended mode, take periodic readings, and store them on a disk. You can find that feature on top-of-the-line stand-alone instruments, but you'll pay a top-of-the-line price for them as well.

There's another bonus to using a personal computer as the brains of a test instrument: flexibility. Everyone who has ever used a traditional test instrument has had the experience of not being able to perform some essential test. The desired test could be anything from measuring capacitance on a multimeter to doing distortion analysis with a VU meter. Upgrading a standard instrument, if possible at all, is a hardware hassle; but with a computer-based instrument it may be just a matter of upgrading the software.

Another point is accuracy. As with standard instruments, you can get computer-based instruments with as much accuracy as you want. The number of significant figures is a function of the add-on hardware, not the computer. In fact, the front end of a stand-alone instrument may be very similar to that of a computer-based instrument. The differences between the two come further downstream: LCD display circuits *vs.* bus-interface circuitry.

There's one BIG problem with computer-based instruments: Not all instruments work on all computers. Designing a computer peripheral is an expensive, time-consuming business. When you open the box and plug it into your computer, you're using a product that represents many man-hours of labor. As a result, the more sophisticated the instrument, the more computer-specific it's going to be.

The instruments we'll talk about here are no exception. If you are interested in a particular instrument, but own a non-supported computer, check with either the manufacturer, a local user's group, or both, for information on a device that is compatible with your hardware. Don't run out and spend your money on anything until you're certain that it will work on your machine.

The IBM DMM?

A multimeter is probably the most basic instrument that you can have on a bench. No matter what you're working on, the chances are that you'll use your multimeter often. The Virtual Instrument Corporation (73 Redding Road, Georgetown, CT 06829) has introduced a computer-based instrument for the IBM that not only works as a multimeter, but gives you a full-featured function generator and universal counter/timer as well. Its specs are shown in Table 1.

As with any other computer Instrument, the Virtual Cat is a two-part system. The hardware, shown surrounding the IBM PC in Fig. 1, takes the input signal, processes it, and converts it into data that can be passed to the second half of the system—the software controlling the computer. The hardware for the Virtual Cat consists of a card for the IBM and a box that's used to connect the probes. Since the unit plugs into an expansion slot, it gets its power from the computer. That reduces on-board parts, and results in production savings.

TABLE 1—VIRTUAL CAT SPECIFICATIONS

4½-digit autoranging multimeter	
Volts (AC & DC)	200 mV to 200 V in 4 ranges
Amps (AC & DC)	2 mA to 2 A in 4 ranges
Resistance	200 ohms to 20 Megohms in 6 ranges
Decibels	−30 to +48 dB
Accuracy	±0.05%
Isolation	600 V to ground
Counter, timer, frequency meter	
Frequency	10 Hz to 100 MHz
Inputs: Channel A	10 Hz to 100 MHz
Channel B	10 Hz to 10 MHz
Period	0.5 μs to 10 s
Time interval	250 ns to 10 s
Maximum count	100 MHz
Resolution	100 ns
Function generator	
Waveforms	Sine, square, triangle
Frequency range	0.01 Hz to 10 MHz
Resoltuion	±10%
Accuracy	±4%
Amplitude	0.5 to 20 V
Sweep range	0.1 to 1000 sweeps/sec
Price	
Basic unit	$1995

FIG. 1—THE VIRTUAL CAT puts a rack of test instruments inside an IBM PC.

FIG. 2—SCREEN DISPLAY of the Virtual CAT: the hardware/software combination provides a function generator, a universal counter, and a digital multimeter.

The noise circulating in a personal computer can be a problem for many boards, and it can be a major problem for the Virtual Cat. The reason is that there are several high-gain amplifiers on the board that are perfectly capable of amplifying noise as well as legitimate signal. The problem is solved, or at least considerably reduced, by housing the card in a metal shield. As you can see from the details in Table 1, the system's specifications are as good as the better stand-alone units.

As shown in Fig. 2, the software puts a sexy display up on the graphics screen that resembles a rack-mounted three-instrument set. That's a clever way to display the data, because it cuts the learning curve way down. Either a mouse or the keyboard can be used to move the cursor to any of the switches and change the settings. Doing so seems a bit strange at first, but after a while it becomes second nature.

You can use the Virtual Cat as a standard-instrument set, but the real strength of the product is its ability to be programmed. It's possible to write BASIC programs that control the operation of any of the three modules in the instrument. A simple program will cause the Virtual Cat to take measurements and record the information on a disk. Not only that, but the files can be loaded into a spreadsheet or database manager for later analysis. Each of the individual measurements will be time- and date-stamped, so you can get an annotated listing of circuit behavior.

If you plan on using the programmable feature of the Virtual Cat, there is a high-level language package available that gives you much more control over the instrument than you have from BASIC. For most applications, however, the

BASIC package will probably be more than adequate. You can load and save instrument setups, and program it to work in an unattended mode. Virtual Instruments plans to add more instruments to the basic package; by the time you read this there should be a digital scope, an IEEE-488 interface module, and a relay switch.

Computer scope

If you're in the market for a scope and you own a computer, you should seriously consider a computer scope. They're more expensive than stand-alone units, but they give you lots of goodies for the money. RC Electronics (5386-D Hollister Ave., Santa Barbara, CA 93111) makes various devices that work in Apples and IBM's, and Heathkit (Benton Harbor, MI 49022) makes two different models for the IBM. All units from both companies are hardware/software combinations that use the graphics capability of the computer to display a scope screen on the monitor.

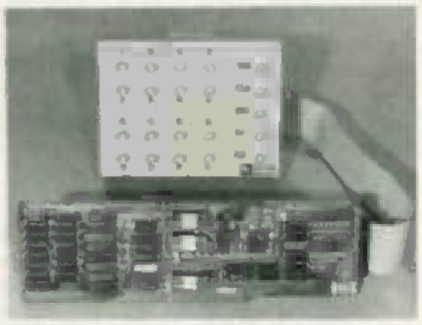


FIG. 3—RC'S IBM COMPUTERSCOPE provides 16 input channels; all interface circuitry fits on a standard IBM expansion card.

The hardware component of the RC Computerscope is a plug-in card and a front panel. The Apple scope is a two-board set, but, as shown in Fig. 3, there is enough room on the larger IBM board to mount everything on a single card. The spec sheets reveal that there is a considerable difference in performance between the two versions of the scope. The IBM scope is much more powerful, has a larger bandwidth, more input channels, and so on. The Apple scope comes in two versions; the difference between them is in the A/D converter used. The APL-D2 uses an 8-bit tracking A/D converter with a worst-case conversion time that provides a bandwidth of 100 kHz. In practice, bandwidth depends on the shape and amplitude of the signal. Some signals will cause the APL-D2 to fall apart at frequencies less than 100 kHz, but others will be measurable up to 1 MHz.

The APL-HR14 is based on a 14-bit A/D converter designed as a combination of tracking and flash converters to provide it with 14-bit accuracy up to a worst-case frequency of 500 kHz. As with the APL-D2, the upper frequency limit depends on the characteristics of the signal being measured.

TABLE 2—RC COMPUTER SCOPE SPECIFICATIONS

Parameter	APL-D2	APLHR-14	IBM	Units
Number of channels	2	4	16	
Vertical sensitivity	0.3–9	1–10	0.200–10	volts
Vertical accuracy	1	0.1	0.1	%
Vertical impedance	44	1000	20	k ohm
Frequency response	100	50	250	kHz
Maximum vertical input	±9	±9	±10	volts
Timebase	3.3×10^{-9}	2×10^{-9}	1.0×10^{-10}	sec/
	3.5	−1	−99	datapoint
Sampling rate	3.5	0.5	1	MHz
Accuracy	0.1	0.1	0.1	%
Price	$985	$1195	$2495	

TABLE 3—HEATH SCOPE SPECIFICATIONS

Number of channels	2	
Vertical sensitivity	5 mV to 5 V/div	
Vertical accuracy	5%	
Vertical impedance	1 megohm	
Frequency response	DC to 50 MHz	
Maximum vertical input	125 V	
Time base	500 μs to 20 s/div	
Sampling rate	100 kHz	
Accuracy	5%	
Price	Kit	Assembled
SD-4802	$399.95	$575
SD-4850	$499.95	$750

TABLE 4—SYSTEM ONE SPECIFICATION

Frequency Generator	
Frequency range	10 Hz to 204.775 kHz
Resolution	0.005%
Maximum output	30 dBm (600 ohms)
Accuracy	0.1 dB at 1 kHz
Flatness	0.05 dB (20 Hz to 20 kHz)
Maximum distortion	0.01%
Analyzer Module	
Input range	0 to 140 V rms
Accuracy	0.1 dB at 1 kHz
Resolution	0.1%
Flatness	0.05 dB (20 Hz to 20 kHz)
Noise	−114 dBu
Distortion Module	
Frequency Range	10 Hz to 100+ kHz
THD Range	0 to 100%
Minimum Input	10 mV
Accuracy	0.5 dB
Resolution	0.1%
Price	
Basic unit, single channel, 3 modules	$5475

The IS-16 and IS-16AT are RC's IBM scopes. The former is made to work in the XT and the latter is designed for the AT. Both are built around high-speed 12-bit converters with 1-MHz sampling rates. The Nyquist criterion indicates that you need a sampling rate that is at least twice the frequency of the measured signal in order to obtain meaningful results. RC claims only 250 kHz as the bandwidth. In practice the limit will vary for the same reason that it does with the Apple versions. Specifications for all versions are shown in Table 2.

All versions of the RC scopes offer digital storage, programmability, and a minimum of two-channel, triggered operation. The APL-HR14 has an optional four-channel upgrade, and the IBM versions can handle as many as sixteen channels. All scope controls are set by command keys on the keyboard, and switching from one mode to another is very simple.

The resolution of the displayed signals depends on the computer. The IBM screen presents a much better image than the Apple screen, but any part of the signal can be examined in greater detail by expanding the scale. Sample screen and printer output is shown in Fig. 4.

Since the RC units are storage scopes, you can save their signals on disk, and load them for analysis at your leisure. Once you use a storage scope it's really hard to go back to a non-storage type.

You just know that computer instrumentation is where things are going if Heath is getting into it. They have two scopes, both of which are available either in kit or assembled form. Both scopes convert an IBM-PC compatible computer to a 50-MHz storage oscilloscope; one, the *4850*, will also talk to an older stand-alone scope and convert it for use as the display of a 50-MHz storage scope. Consequently, the *4850* (shown as this story's lead photo) has a slew of front-panel controls that determine how it works when you use it as a smart front end for a regular scope.

FIG. 4—THE IBM VERSION of RC's Computerscope provides both screen and hard-copy output.

The *4850*, and its less expensive counterpart, the *4802*, are stand-alone boxes that output serial data to your computer on a standard RS-232 line. The specs for both units are shown in Table 3. The serial interface lets you forget about computer-generated noise, but it also puts an extra box on your workbench. The Heath scopes put their display on a standard IBM CGA (Color Graphics Adapter) card and are dual-trace triggered oscilloscopes. The current settings, as well as the keyboard command options, are always displayed on the screen, so it doesn't take long to get comfortable with changing parameters and operating the instrument.

Waveforms can be frozen, stored on disk, and then recalled for examination later. One nice feature of the Heath scopes is that you can display two stored waveforms on the screen and simultaneously view a live dual-trace representation of the input signal. Since the stored waveforms are shown using the currently-set timebase and vertical-sensitivity settings, a real comparison can be made with the live traces. You can use any print utilities, including the PrtSc (Print Screen) key, to get a hardcopy image of the displayed waveforms.

The scope's operating software is written in BASIC, and a compiled version of the program is what actually drives the system. The disk also contains the uncompiled version of the program, so that if you're into programming, you can customize the operation of the scope to fit any application you have in mind. And since the scopes deliver data via the RS-232 port, you can talk to the instrument via modem and do remote signal measurements. Heath supplies the necessary software on the disk that comes with the scope.

Stand-alone storage scopes are coming down in price, but even the most expensive ones don't have all the features you get on a computer-based scope. Both Heath instruments are reasonably priced when you add up all the goodies you get.

Computerized audio testing

Computer-based test instruments aren't limited to standard bench meters. Several companies make high-quality products designed for special markets. Audio Precision (P. O. Box 2209, Beaverton, OR 97075) is a small company that produces a set of instruments specifically designed for audio analysis. Their IBM system consists of a short-slot plug-in board as well as a set of external rack-mount boxes. The measuring hardware is external because of noise in the IBM. A DB-25 on the rear of the plug-in card allows the internal and external hardware to communicate. Specifications are shown in Table 4.

Although Audio Precision uses a DB-25 connector, communications between the two parts of the hardware are not done serially. As we mentioned earlier, when doing A/D conversion, the sampling rate must be at least twice the frequency of the signal being measured, depending on the accuracy you want. The lower limit is twice the measured frequency, but the upper limit is set by the designer, circuit costs, etc.

Audio Precision's *System One* was designed with no compromises in mind, and its performance specs are as good as, if not better than, many stand-alone instruments. The sampling rate is so high that it would require a rate of about 40 kilobaud on a standard RS-232 channel. As a result, the system uses a parallel interface. The rack (i. e., the external hardware) contains the notch and bandpass filters used for various kinds of analysis, as well as the generators for producing various test tones.

The *System One* is a computer-based instrument, so the rack and the device under test are controlled via software. To take a simple example: if after connecting the hardware you want to test to the rack, the rest of the test procedure is done from the computer's keyboard. Software is loaded and the instrument panel is selected from a menu that appears at the bottom of the screen. The output of the frequency generator can be set on the left, and the measured data will be shown in the center. The present analyzer settings are also displayed in the center panel. You can change frequency, phase, bandwidth, and so on with a few keystrokes, and immediately see the results of those changes on the computer's screen.

The real advantage of the *System One* is the fact that it's being run on a computer. Not only can any of the test results be graphed, but the software lets you define the coordinates, scaling, signal source, and other parameters. And, like the computer-based scopes, test results and setups can be saved in disk files.

System One also allows unattended testing. In addition, a text editor can be called from the menu to let you write test procedures in an English-like language. Once you're familiar with the syntax, you can link several tests together and have them run sequentially at specified times. Procedures can have conditional statements in them, so you can run unattended tests with as much nested conditional branching as you need. You can also specify limits in any test or procedure. And since a procedure can call in as many previously-saved test and limit files as you want, the *System One* is flexible enough to do even the most complicated sort of audio testing automatically.

The basic Audio Precision hardware does a wide range of audio testing, but its utility can be increased with optional extras. The extra hardware allows you to measure several kinds of IM distortion and wow and flutter; the addition of a switcher will let several devices be connected to the system at the same time.

Sceptre III

Even major semiconductor manufacturers are recognizing the power available on today's personal computers. Gould-AMI (3800 Homestead Road, Santa Clara, CA 95051) has a system available for the IBM that aids the design of gate arrays and other IC's. The *Sceptre III* is a graphics-oriented package that allows OEM's to design and debug gate arrays. When the design is complete, you send the disk to AMI where its data is used to build an actual IC.

Conclusions

The computer-based instruments we've discussed are only the tip of the iceberg. There are many others, and more are showing up every day. In general, they're more expensive than their stand-alone counterparts, but you get much for your money. And as for IC-design software, it's interesting to note that several semiconductor companies have software packages that run on VAX workstations. But few have awakened to the incredible power waiting inside the very same box used for blasting aliens with a joystick. **R-E**

Computer–AIDED ELECTRONICS Design

High-powered design tools now run on personal computers; those tools eliminate much of the drudge work of design, increase productivity, and are fun to use!

ROBERT GROSSBLATT, CIRCUITS EDITOR

WHEN PERSONAL COMPUTERS STARTED TO SHOW UP IN THE late 1970's, the two most important qualifications for buying one were a healthy amount of both cash and curiosity. Even a basic machine cost a great deal of money, and there wasn't much software available. As a matter of fact, you could do little more than enter simple programs via front-panel switches, and read data on front-panel LED's. Not the most exciting way to spend a rainy evening.

Fortunately, the capability of the personal computer has increased dramatically in the ten or so years since it first appeared. As things stand now, the gap between the mainframe and the PC is narrowing rapidly. New silicon superstars such as the 68020 and the 80386 can address gigabytes of memory, run as fast as 25 Mhz, and do real multi-tasking. What that means is that, within a few years, about the only thing you'll need a mainframe for is operating NORAD—and who wants to do that in the living room?

As PC hardware gets more and more sophisticated, so does the software that runs on it. For example, the primitive graphics programs of a few years back have matured into sophisticated CAD packages with features specifically designed for particular applications—architecture, mechanical engineering, and, of course, electronics.

The number-crunching power of the typical PC has been used to eliminate the brain damage and tedium usually associated with a whole range of design activities. And nowhere is that more evident than in electronics design. As things stand now, a modest investment in software will not only save you countless hours of bench-time and breadboarding, but will also allow you to do waveform analysis and troubleshooting without ever touching a component!

There are many types of computers and many types of software; but there are also, unfortunately, no standards. A disk containing software for one computer is unusable on

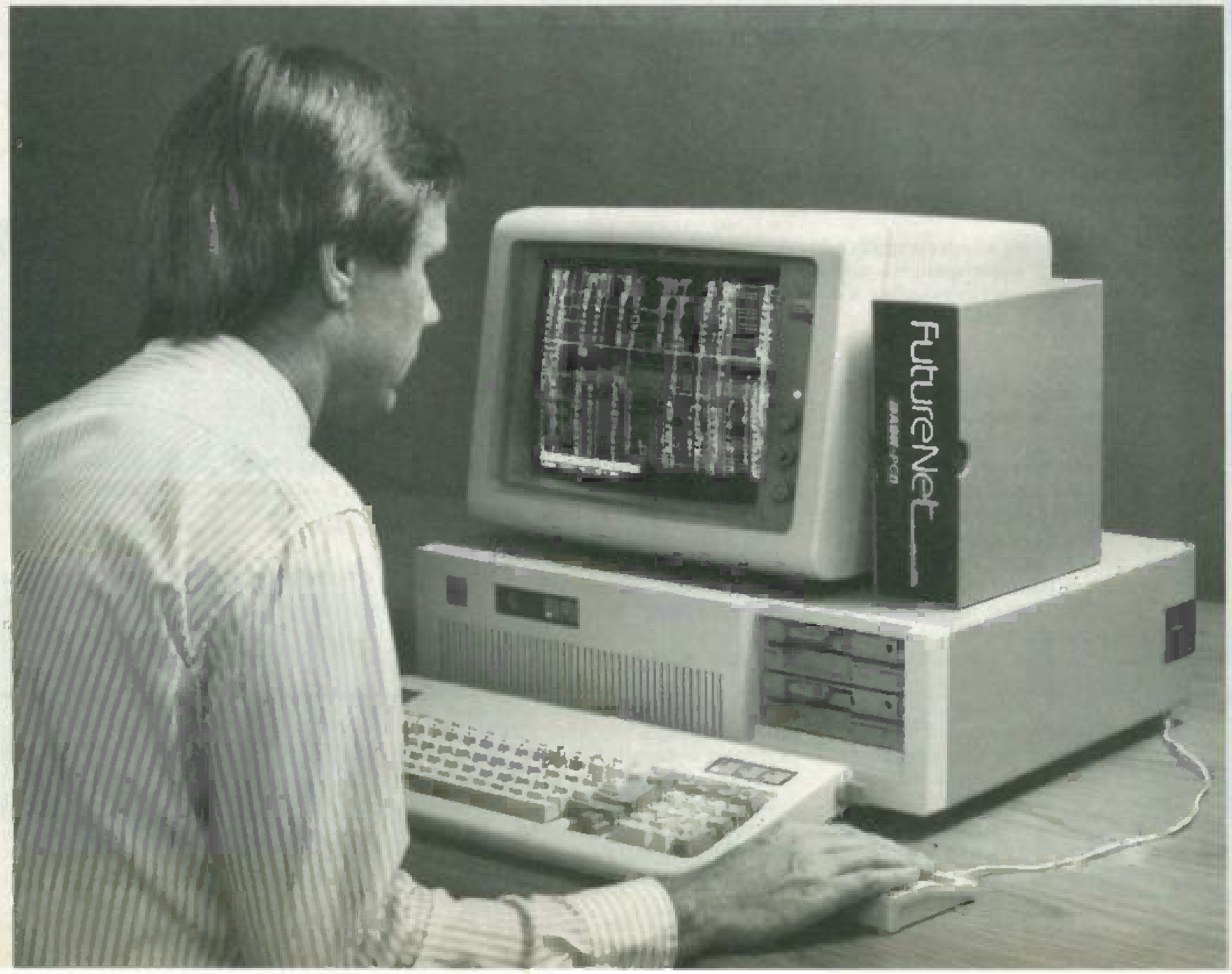


TABLE 1—PROGRAMS AND PRICES

	Apple II	*Macintosh*	*IBM-PC*	*HP-150*
Microcap	$475	—	$475	$475
Microcap II	—	$895	$895	$895
Micrologic	$450	—	$450	$450
DADiSP (1)	—	—	$795	—
Modeler	—	(2)	—	—

Notes: 1. DADiSP is available for a number of computers. Contact the manufacturer for details.
2. Contact the manufacturer for current licensing information.

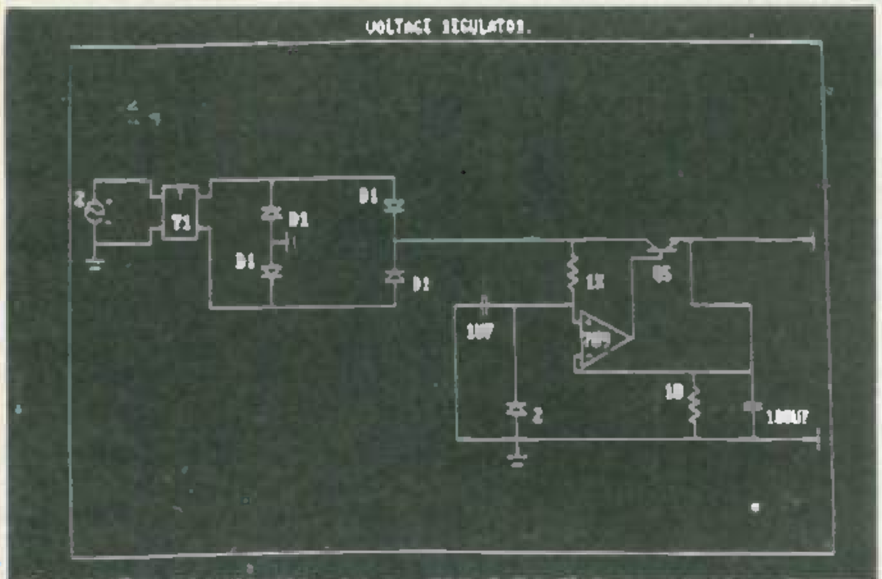


FIG. 1—THIS VOLTAGE REGULATOR was drawn by Microcap; the numbered nodes represent points where signal analysis can be done.

another. Some of the software we'll be describing is available for several different machines, but much of it runs on one and only one computer. Table 1 shows which of the programs that we'll discuss are presently available for which computers, but check with the manufacturers—new versions of hardware and software are announced from time to time.

1986-style design

In the past, the first thing you might do when you had an idea for a new circuit was to sit down with paper and pencil and start drawing circuits. Now you can use a computer for brainstorming; doing so gives you several advantages. For example, many general-purpose graphics programs will let you draw pictures on the screen, save them to disk, edit them, and print them. However, a few programs take things a step farther. Micrologic and Microcap from Spectrum Software (1021 S. Wolfe Road, Department F, Sunnyvale, CA 94087) work together to allow you to draw a circuit on the screen and then analyze it by looking at the waveform generated at any node in the circuit.

Although the look and the program flow of both Microcap and Micrologic are similar, Microcap deals with analog circuits, and Micrologic deals with digital circuits. If you're familiar with one program, you'll have no trouble using the other.

Software simulation of a circuit is an easy way to check a design without risking turning silicon into scrap. And, given the complexity of those programs, the learning curve is surprisingly short. Circuit data can be entered graphically or by generating a netlist that describes the components and how they're connected.

A separate part of the program lets you define the characteristics of each of the components you'll be using. Doing so allows you to specify things like transistor gain, op-amp slew rate, logic-element truth tables, and so on. Then, after you've defined the operating characteristics of your components, you can lay out the circuit using the graphics editor. The last step is to analyze the circuit.

Example output

Figure 1 is a voltage regulator that was drawn with Microcap. The symbols used in that drawing come from a standard library that is supplied with the program.

Adding components to the drawing is a simple matter of moving the cursor to the desired position and then telling the program that you want to add a part. You'll be asked for the type of part, its orientation, and other parameters. As soon as the software knows exactly what you want, it will draw the component on the screen.

If you're going to use a sub-section of a circuit more than once, you can save a great deal of time by building a circuit macro, analogous to a spreadsheet macro. The resistor network shown in Fig. 2, for example, could be converted to a macro and used in other drawings simply by loading it from disk.

Because a macro is a shorthand way of including a pre-drawn circuit in a new design, an additional step must be followed when the macro is defined. After the macro is complete, you must label the points in it that will connect to the circuit using it. (It's much easier to do than to describe.) In Fig. 2, we labeled four points (A, B, C, and D) and saved the drawing to disk. Then we could add it to another drawing just as we would add any component.

To insert a macro, move the cursor to the point in the circuit where you want the macro to appear, and then use the same keystrokes as in adding any other component. The result can be inserted as many times as you want. Macros not only simplify circuit creation, but they also make it easier to understand the drawing.

Figure 3 shows the drawing of a simple RLC circuit that is driven by a pulsed voltage source. By doing a transient analysis on the circuit, Microcap processes the drawing and comes up with a netlist similar to the one shown in Table 2. Microcap shows you the parameters used for the analysis and lets you change them, if desired. Then Microcap does the circuit

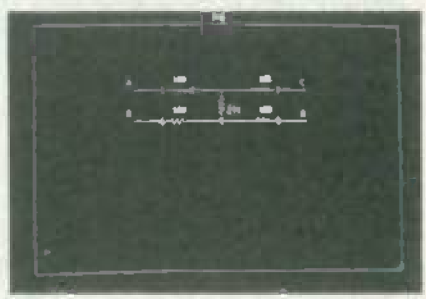


FIG. 2—THIS RESISTOR NETWORK is a "macro" circuit that can be inserted into another circuit as if it were a single component.

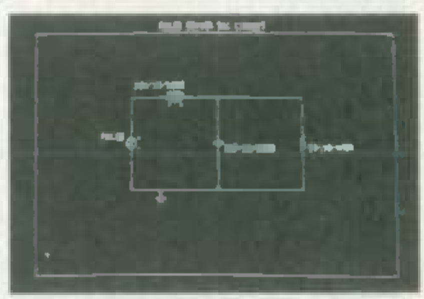


FIG. 3—THIS SIMPLE RLC NETWORK is driven by a pulsed voltage source; the pulse parameters can be defined independently.

TABLE 2—RLC NET LIST

No.	Type	A	B	C	D	Parameter
4	V(T)		0		1	Pulse
7	Inductor		1		2	1 µH
10	Capacitor		2		0	0.001 µF
17	Resistor		2		0	50 ohms

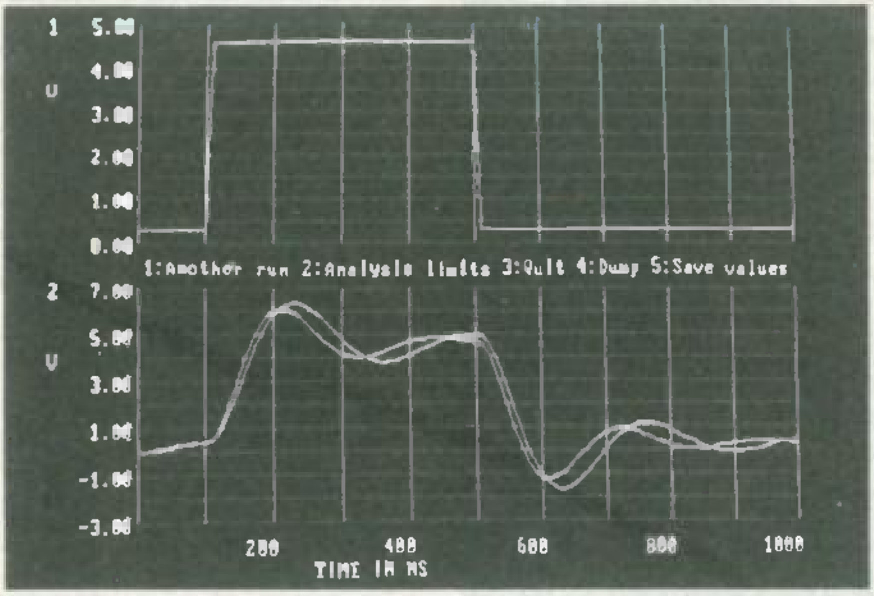


FIG. 4—THE UPPER WAVEFORM shows the output of the pulse source in Fig. 3; the lower waveform shows the waveform at the right edge of the coil (node 2).

math and graphically presents you with the results, as shown in Fig. 4. The top curve is the voltage waveform at node 1 (the output of the squarewave generator), and the bottom curve is the waveform generated at node 2.

In addition to transient analysis, Microcap can also do AC, DC, and Fourier analysis. Micrologic can do similar things with digital circuitry. Without going into detail, both the schematic (Fig. 5-*a*) and the timing diagrams (Fig. 5-*b*) are typical of what Micrologic can do for you.

Circuit-design spreadsheet

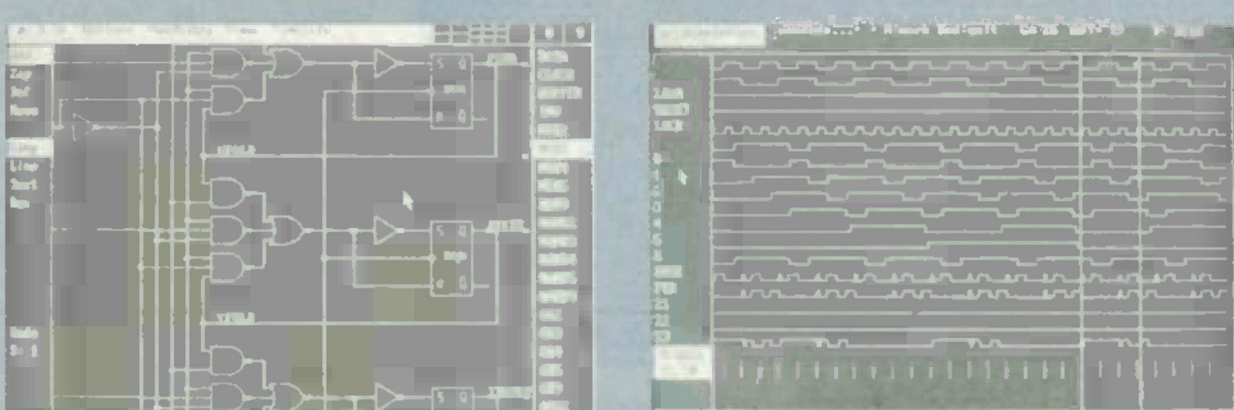
The real usefulness of Microcap and Micrologic is their ability to analyze the drawings they produce. There are more powerful graphics-only programs, but, as far as electronics is concerned, being able to simulate real-world circuit operation is much more important than generating pretty artwork.

Spreadsheets let you manipulate financial data and play "what if" games. Micrologic and Microcap let you examine the operation of a circuit without ever touching a single piece of silicon. However, it takes much time and many keystrokes to analyze a circuit, change a few things, and then analyze it again. More than that, there's just no way to do a side-by-side comparison of several versions of a circuit. However, within the past year or so, software has become available that gives you the flexibility of a spreadsheet for doing that type of circuit analysis.

For example, DADiSP (*Da*ta Acquisition and *Di*gital *S*ignal *P*rocessing) is a piece of software from DSP Systems (1 Kendall Square, Cambridge, MA 02139) that gives circuit designers the same power that Lotus 123 gives to accountants. It's a scientifically oriented spreadsheet whose cells display graphs rather than numbers. DADiSP has more than 150 different scientific functions built in, so entering the formula for a particular waveform is relatively painless.

Let's suppose that you've designed a circuit and have collected data by operating the circuit with a range of different input signals, time constants, and so on. Once you've entered your data in a file, it can be loaded into one of the spreadsheet cells and the program will display the data in graphic form. See Fig. 6. DADiSP will let you perform a number of different analyses, as well as manipulate any of the graphs displayed on the worksheet. Available functions range from simple signal arithmetic to complex calculations that use trig and calculus.

One strength of the program is its ability to refer to one window as a variable. For example, as shown in Fig. 7, you can see the result of a point-by-point multiplication of two signals (which are displayed in windows 1 and 2) by moving the cursor to a third window and entering the formula W2 · W1. Then you can integrate the output of the third window, and display it in a fourth. That sort of analysis and



a

b

FIG. 5—MICROLOGIC, the sister program of Microcap, can also do digital circuit analysis.

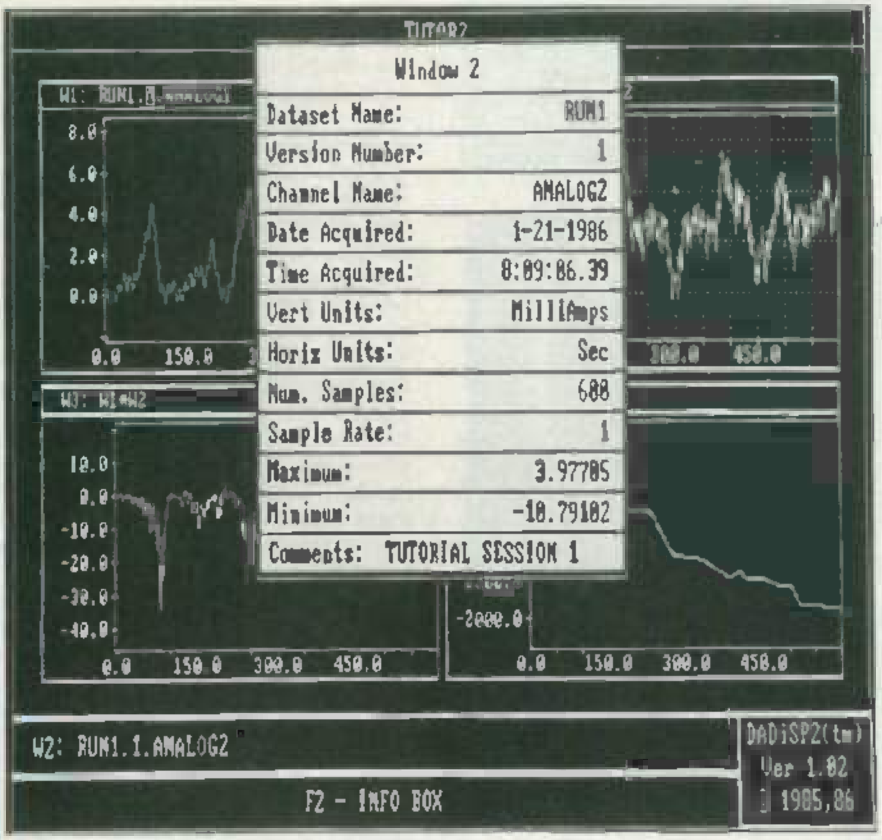


FIG. 6—A SPREADSHEET FOR ELECTRONICS DESIGNERS. DADiSP converts a circuit's operating parameters into graphic form and displays it in one of 64 cells. The software allows you to perform a wide variety of analyses and to manipulate the graph displayed in any of the cells. Mathematical operations ranging from simple arithmetic to complex calculations can be performed on the data.

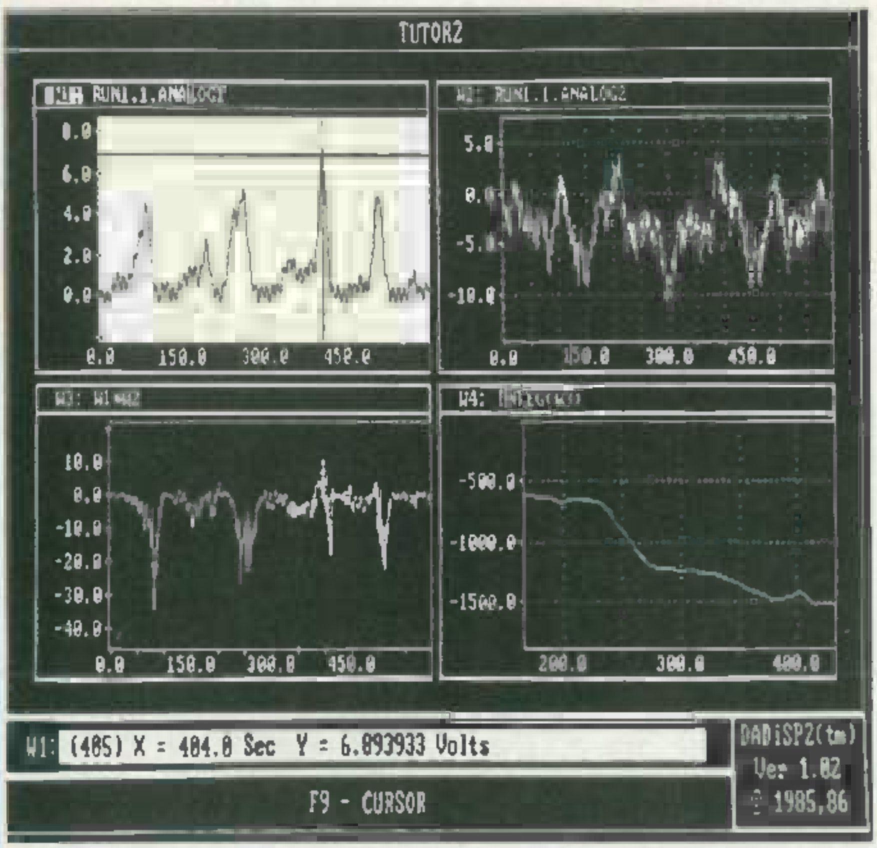


FIG. 7—THE DADiSP SPREADSHEET lets you relate cells and derive results by combining those cells in various ways. Windows 1 and 2 show two independent signals; Window 3 shows their product; and Window 4 shows the integration of Window 3.

editing can be done with any of the program's built-in functions and arguments.

DADiSP is a 64-cell spreadsheet; the graphs contained in each cell can be interrelated. That means that changing the data in one cell will change the data in any related cells. Playing "what if" using those capabilities can enable you to fine-tune a complex analog circuit without physically changing a single component in the actual circuit.

One of the program's neatest features is its ability to graph the measured points and then interpolate the plot. DADiSP lets you look solely at a plot of your data, or at a curve that represents the best fit. After the program fits a curve to your data, you can activate a cursor that moves along the the curve and shows you the interpolated coordinates. For example, if you've plotted voltage versus time, DADiSP will give you interpolated values of voltage as you sweep the cursor across the time scale.

That type of interpolation can be a real time-saver when you do some kinds of analog circuit design. Imagine, for example, designing an oscillator or a filter circuit and calculating the values for the RC components. Doing the math isn't difficult, but attaining a specific frequency using standard-value parts can be exasperating. A good deal of that type of brain damage can be eliminated with DADiSP by plotting a graph of the circuit's time-constant formula and then running the cursor along the result. As you move the cursor, the relevant RC values will show up at the bottom of the screen.

Other useful features include the ability to expand and compress the displays and automatically take care of scaling. Those features are important when you want to examine just a small part of a curve or look at an expanded time scale.

DADiSP isn't for everyone. It's an expensive piece of software, and it's only useful for some kinds of design and some kinds of designers. If you decide on component values by plugging things in and crossing your fingers, you won't get much use from the program. But for designers who do a lot of calculating and reading before ordering parts, DADiSP can be tremendously helpful.

DADiSP is like any other sophisticated analytical tool: the more it's used, the more useful it becomes. If your circuit designs are heavily math intensive, the software may be well worth the investment in time and money you'll have to make. The program goes a long way toward helping you visualize the effects of varying circuit parameters and making sense out of real-world data.

Bose's Modeler

The number-crunching and graphics capabilities of computers are slowly being put to use to solve problems in just about every area of electronic design. Paper-work and guesswork are being replaced by software and keystrokes. One field that is just starting to benefit from the use of the computer is acoustic design. Setting up a successful sound system in a large room has traditionally been the result of a combination of physical measurements, past experience, speaker dynamics, and a great deal of personal bias.

Before any attempt can be made to decide on the installation for a particular room, an enormous amount of data must be collected. Room dimensions and construction details, architectural features, reflectivity, and speaker characteristics are only a few of the specifications that must be known before design work can begin. Even then the math is time-consuming and must be re-done if any of the data changes.

The Bose Corporation has recently introduced acoustic design software called Modeler that simplifies data entry and uses extensive graphics to display an acoustic model of the room. The designer uses the program's graphics front end to create a set of planes that define the room, and then he specifies the physical material of each of the planes.

Next the computer builds a three-dimensional model of the room, taking account of the degree of sound absorbency and reflectivity of all surfaces. The model is displayed on-screen; it can be rotated around any of the three axes and redrawn to show the view from any angle. Figure 8-*a* shows a three-dimensional view of a room. You can see how the model was defined by building a series of planes. The location of any point in the room can be found because the plane dimensions and elevations were entered into the program while the room was being drawn on the screen.

The locations of the speaker clusters are entered by putting the cursor at the desired point and indicating which way they point. Since we're dealing with a three-dimensional model, the speaker direction is specified by entering three figures to represent pitch, roll, and yaw. See Fig. 8-*b*. The speaker's characteristics are contained in data files, so all that the designer must do is to tell the program what kind of speakers will be used.

After the speaker data has been entered, the computer has everything it needs to calculate and display any of the standard acoustic parameters at any point in the room. Those parameters include both direct and reflected components, time delay, relative loudness, and so on. If a change is made in any of the architectural features or speaker characteristics, the program will recalculate the parameters as necessary.

Being able to spot-check the acoustic parameters at any point in a room is nice, but the sexiest feature of the Bose software is its ability to draw an acoustic map of the room. It does that by calculating the sound-pressure level at every point in the room; it then displays the results using varying shades of gray to represent different acoustic levels.

The resulting gray-scale map gives the designer a graphic representation of the sound level anywhere in the room. That lets him spot areas that need reinforcement or muting, all without installing any hardware.

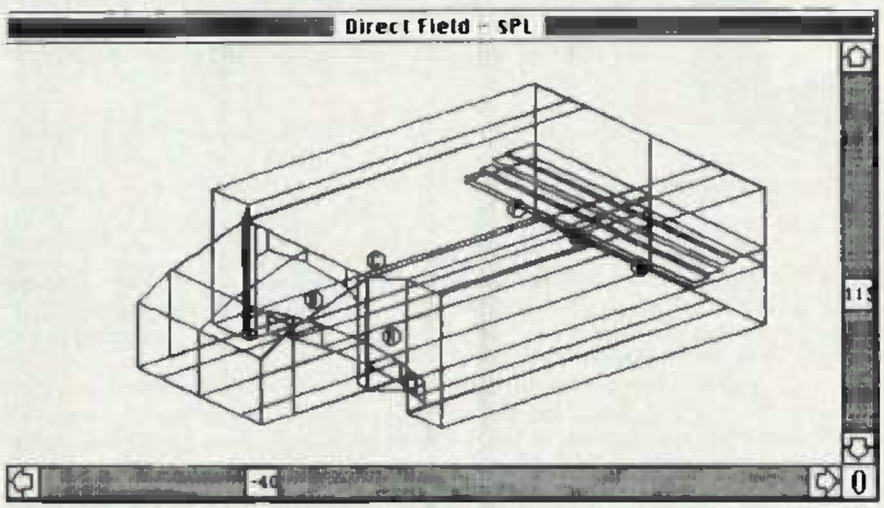
Modeler provides the acoustic designer with a diagnostic tool that is as powerful in its field as are the other software packages we discussed earlier in theirs. In this case the computer has given the designer capabilities that were unheard of as few as five years ago. The result is greater accuracy, lower design cost, and increased productivity.

Conclusions

The growth of sophisticated hardware and software for the personal computer has been unbelievably rapid since the days of the Altair and the Imsai (the mid-1970's). It's a bit of a mind-bender to realize that some of the things routinely done on personal computers today weren't possible even on mainframes ten years ago.

And there's no end in sight. Even those of us that only like to fool around on the weekend can use computerized tools on a PC to reduce the donkey work of electronics design.

The software we've discussed here is only the tip of the iceberg. Many more products are available and just about every area of electronics, from designing IC's to laying out printed-circuit boards, has benefited from the popularity of the personal computer. If you find yourself spending a great deal of time at the workbench, there's a good chance that your work can be made much easier by using a computer. And you don't need a mainframe to enjoy the benefits that sophisticated design circuitry can produce. Besides, you can't play Pacman on a mainframe. R-E

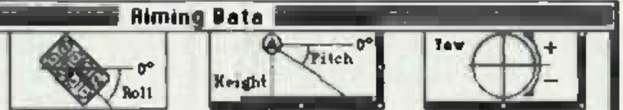


a

-GREELEY 6.5

Aiming Data

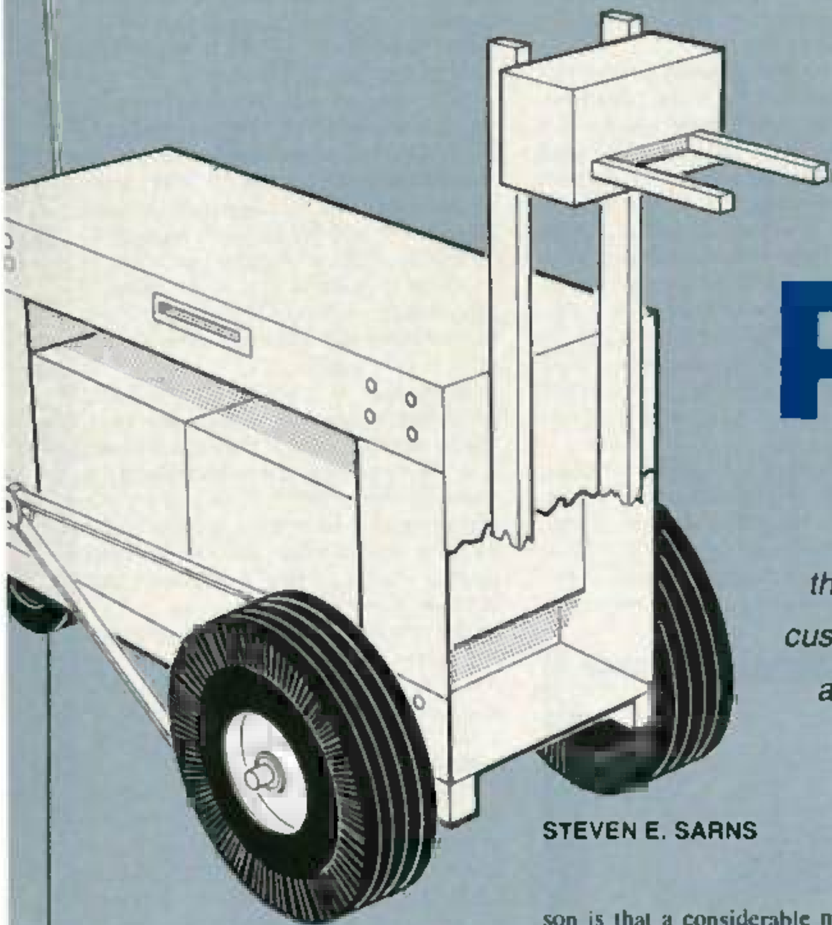
Date 9/1/86
SerialNo 0
Dimensions Feet



Speaker	Cluster	Height	Roll°	Pitch°	Yaw°	Power(W)	Time(mS)
BOSE ST802 1 kHz	A	8.0	0.0	22.0	0.0	0.0	0
BOSE ST802 1 kHz	B	8.0	0.0	22.0	0.0	0.0	0
BOSE 802 1 kHz	C	16.0	0.0	28.0	0.0	400.0	0
BOSE 102 -- 1 kHz	D	9.0	0.0	30.0	0.0	25.0	37
BOSE 102 -- 1 kHz	E	9.0	0.0	30.0	0.0	25.0	37
BOSE 102 -- 1 kHz	F	9.0	0.0	30.0	0.0	25.0	37

b

FIG. 8—BOSE'S MODELER lets you do acoustic design on the screen of your computer. The three-dimensional model of a room shown in *a* is defined by building a series of planes. As shown in *b*, speaker direction is defined by pitch, roll, and yaw parameters.



R-E ROBOT

You needn't be satisfied with a robot that looks and acts like all the rest. You can customize our robot to your heart's content—and share your designs with other readers!

STEVEN E. SARNS

THE BIG ONE FINALLY CAME THIS AUthor's way: a job providing both financial reward and a fascinating challenge for his company, Vesta Technology. The project: To design a robot, including a control computer, an arm, and additional subsystems for motion control, navigation, and operator input/output. While designing the robot, we discovered much about the personal robot industry. For one, it appears to be dominated by expensive robots with limited capabilities. We felt that a new approach could make a home robot more affordable and more exciting.

Designing a robot requires expertise in a number of areas, including mechanics, electronics, and computer hardware and software. In order to augment Vesta's limited abilities in the field of mechanical engineering, we enlisted Stock Drive Products to aid our development effort. That company is the major supplier of mechanical components to the industrial robotics market. See the Sources box for their address.

The cost of a robot

Stop for a moment and consider why personal robots are so expensive. One reason is that a considerable markup takes place at each point in the distribution chain. A manufacturer's purchasing department must have a secure supply of parts, so it may be willing to pay higher prices to attain that security. The hobbyist, however, has the advantage of being able to buy from less-expensive sources of parts. He can, for example, take advantage of surplus outlets, thereby eliminating middlemen; the result is a substantial savings over manufacturers' prices.

As for the controller, we designed a complete low-cost single-board computer that is highly compatible with the IBM-*PC*. Our approach emphasizes the use of flexible electronics that allow you to customize your robot with available mechanical parts.

By providing the electronic-control system and minimizing mechanical costs, we believe that building a personal robot can be both entertaining and affordable. In the upcoming series of articles, we will show you how you can adapt our designs to your problems.

The main components of our system are the single-board development system, a control/sensing board, and control software. Because the electronics systems are efficient and adaptable, you are free to interface them with whatever mechanical system meets your needs. The systems software that we have developed (and are still developing) is quite sophisticated, but the applications programming is left to you.

The bottom line is that we are not offering a kit for the type of ready-to-assemble robot that so many other companies offer; rather, we are suggesting that you can build the robot that you really want or need by integrating our control system with your mechanical design.

Overview

As we discuss the specifications of the R-E Robot, keep in mind that you can build your robot with other components, and in other configurations.

Our robot is powered by two 12-volt lead-acid batteries; it has a top speed of five miles per hour. Although we used utility batteries, we could have used auto or motorcycle batteries. Circuitry that indicates when power is low is included onboard, as is a 117-volt AC battery charger.

The robot's drive system consists of two independent 10.5-inch pneumatic tires that are connected to two toothed belt drives and to two 1/20-horsepower DC torque motors. A caster mounted at the rear provides lateral stability and ease of movement.

The robot is equipped with sensors for measuring temperature, light, and sound.

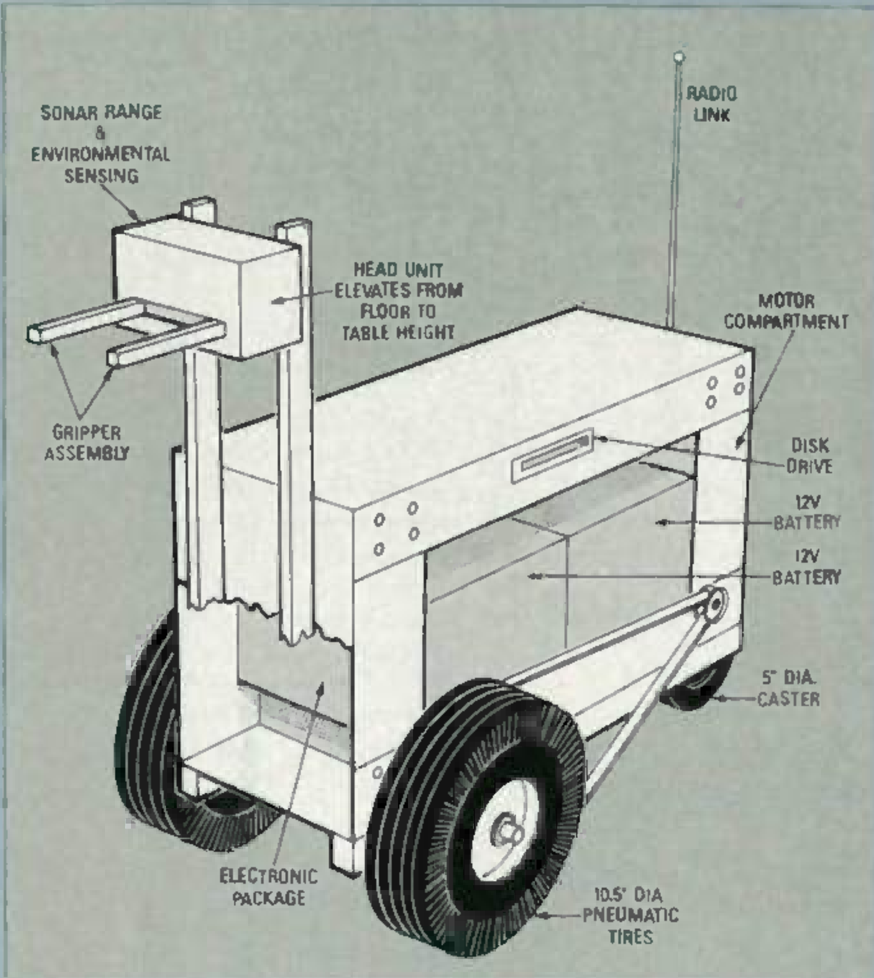


FIG. 1—R-E'S PERSONAL ROBOT has a unique mechanical configuration. This artist's conception shows the overall structure of our prototype. The robot can be modified to suit just about any application.

Microswitch collision detectors and sonar ranging, usable at distances as great as 20 feet, are also provided.

The robot lacks a traditional robot arm. Instead, it features a powerful gripper that rides a vertical track at the front of the unit. The arm, as shown in Fig. 1, somewhat resembles an industrial forklift. While some flexibility is sacrificed using that approach, some important advantages are gained. For one thing, the mechanical design is greatly simplified. That means that greater lifting capacity could be provided without greatly increasing cost. The gripper is capable of vertical travel from floor level to about table height.

In addition, the robot has options for an RF link, a speech synthesizer, and even a speech-recognition system.

The RPC

The hardware that makes it all possible is the RPC (*R*obotic *P*ersonal *C*omputer). The heart of the RPC is a highly integrated Intel 80188 microprocessor; it significantly reduces costs by including—in the IC package—many support devices that are external to the 8088 (used in a true-blue IBM-*PC*). The entire computer occupies a PC board that is less than eight inches on a side.

The interface between the RPC and the I/O unit is an adaptation of the IBM-*PC* bus. Signals from that bus are available at a 60-conductor IDC connector. That bus allows prototype circuits to be built without using special prototype cards.

Control boards

The RPC controls three custom boards. Board 1, shown in Fig. 2, contains most of the basic control circuits; with it and the RPC, the robot is capable of unsupervised operation. Board 1 controls the two torque (drive) motors. Each PWM (*P*ulse-*W*idth *M*odulation) drive-motor controller can deliver as much as 500 watts per wheel. A feedback encoder allows the RPC to keep track of speed and position. Torque load is also monitored.

Other Board-1 functions include gripper-motor control, and control of the sonar ranging system. Based on the Texas Instruments and Polaroid sonar systems, the ranging system can be used for collision avoidance, navigation, and security. Board 1 also contains several miscellaneous systems, including the battery charger, the DC-DC converter, and a beeper alarm. The environmental sensing systems (temperature, light, and sound detectors) are also on Board 1. Last, the collision detector outputs are processed on that board.

The robot differs from many projects presented in **Radio-Electronics** in that it is an evolving project. Many of its circuits are still in the design or testing phase. As a result, some of the final details may differ from those presented here. The other two control boards fall into the still-being-designed category. As of now, Board 2 will contain the speech synthesis and recognition hardware, and that Board 3 will house the RF data link.

Software

Complementing the hardware is a flexible programming environment that allows the programmer to choose his favorite and most productive language. The RPC may be programmed in two different ways.

One approach involves use of either of the onboard languages: BASIC and FORTH. Each language is a combination operating system, development system, and high-level language. Each includes debugging support, inherent ROMability, and access to mass storage, and each supports interrupt programming, integrated procedures, and multitasking. An onboard EPROM programmer allows software to be written, tested, and burned into EPROM for dedicated use.

The other approach makes use of the RPC's IBM-*PC* compatibility. The RPC boots most operating systems designed for the *PC*, thereby allowing the programmer to choose his favorite language. Assembler, Fortran, Pascal, C, BASIC, Compiled BASIC, and many others are all available. Programs in those languages can also be burned into ROM, if the compiler used generates ROMable code. Program code can also remain stored in battery backed-up static RAM for power-on execution. In addition, programs and data can also be stored on floppy disks. The RPC can accommodate any mixture of as many as four 3.5- and 5.25-inch floppy-disk drives.

RCL

Although the robot's software is not yet as extensive as we would like, modules have been written to test each of the robot's capabilities. The next step is an extremely sophisticated *R*obotic *C*ontrol

SOURCES

Can you imagine what a robot we could build with a staff of 250,000 (the entire readership of **Radio-Electronics**)? One key to the success of the R-E Robot is the collective development capability of that readership. In an effort to encourage the exchange of programs, sources of parts, hardware enhancements, and any other items of general interest, **Radio-Electronics**, Stock Drive Products, and Vesta Technology are each offering special support.

Radio-Electronics will open a special section of its new remote bulletin board system (RE-BBS) to builders of the R-E robot. You can reach the bulletin board by calling 516-293-2283.

Stock Drive Products (55 S. Denton Ave., New Hyde Park, NY 11040 516-328-0200) has agreed to supply a kit of parts for the drive sub-system, including two 10-inch pulleys and two 2-inch pulleys. Part number 2Z6-RL11882 is available for $32.00.

To simplify the mechanical aspects of building a robot, Vesta will sell, for a limited time, an aluminum chassis (resembling the one in Fig. 1) at cost, approximately $45. The fully-populated RPC will be available for $294, including 16K of RAM and the FORTH operating system. The Board-1 PC board is available as a bare board for $41, or fully assembled for $289. All source code for testing the robot and implementing RCL is available on a 5.25-inch disk for $2.00. All Vesta products are covered by a 15-day return policy. MasterCard or Visa accepted; no purchase orders or terms available. Please add $8.00 for shipping and handling for the computer board. Vesta Technology, Inc., 7100 W. 44th Avenue, Suite 101, Wheatridge, CO 80033. 303-422-8088.

Additional sources for various parts and sub-systems will be listed in future installments of this article. **R-E**

TABLE 1— SPECIFICATIONS COMPARISON

	RB-5X Robot	HERO 2000	R-E Robot
Dimensions	13" diameter × 23" high	16.5" wide × 22.5" long × 32.4" high	19" long × 18" wide × 20" high
Weight	24 pounds with arm	78 pounds with arm	55 pounds with arm
Speed	.23 mph	1 mph	5 mph
Arm	4 axes and gripper	4 axes and gripper	1 axis and gripper
	12 oz payload	16 oz payload	10 pound payload
	1"/second	6"/second tactile feedback	8"/second
Language	Tiny BASIC	Interpreted BASIC with specialized robotic commands	Multitasking FORTH with user alteraable Robot Control Language (RCL) overlay
Subsystems	Two RS-232 ports	Two RS-232 ports	Two RS-232 ports
	8 I/O lines	Cassette I/O	Disk drives (4)
	Sonar system	Sonar system	Sonar system
	8 perimeter bumper panels	Environmental sensing	Environmental sensing
	Speech synthesis	Speech synthesis	Speech synthesis
		Motor speed control Real-time clock	Motor speed control Real-time clock
		Keyboard LCD	Collection sensor
Sleep Mode	No	Up to 6 days	Months
Battery	6 VDC 90 WH Sealed	12 VDC 288 WH Sealed	2 × 12 VDC 480 WH
Operator	Terminal	Teach pendant	Terminal
Interface		Keyboard with special function keys and keypad LCD on robot	Direct or remote connection
Remote Control	None	RF link, 100' range built in to teach pendant	RF link attaches to user supplied RF transceivers
Microprocessor	8073, 4MHz	8088, 5MHz	80188, 8MHz
Mass Storage	2K ROM	Cassette tape, disk optional in future	Disk, optional
Memory	8K/16K RAM 2K ROM	24K/576K RAM 64K ROM	16K/768K 48K ROM
Bus	None	Proprietary 12 slot back plane, based on S-100	Modified IBM "PC" bus using flex cable and simple "ROBUS" expansion bus
Wheels	2" casters 4" solid wheels	3" casters 6" solid wheels	5" casters 10.5" pneumatic tires.
Cost (Basic unit)	$2,500 assembled	$2,500 kit	$850 components

Language (RCL). The inclusion of RCL on-board is possible only because of the power of the RPC.

The onboard RCL puts our robot a step ahead of almost all other home robots. Most robots are controlled with obscure software commands. A typical motion function could be programmed as follows:

```
OUT (1,1):REM Turn on drive motors
DELAY 1000:REM For one second
OUT (1,0):REM Then turn off motors
```

RCL allows the operator to program the same function as:

```
10 FEET FORWARD
```

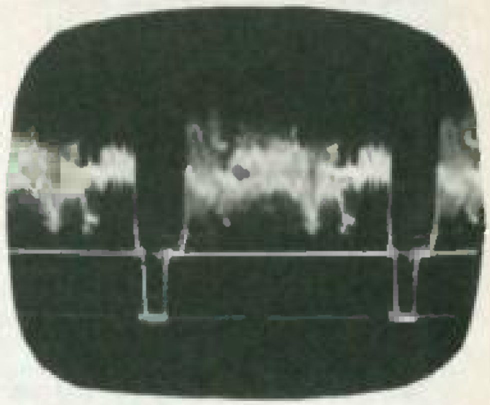
Choosing a language in which to implement RCL was not an easy task. Because RCL was to be interpreted, we had to implement it in a language that executes quickly. To ease development and to allow people to customize RCL for their own purposes, it had to be written in a high-level language. We also wanted to minimize the cost of the hardware required for developing the RCL interpreter.

After considering BASIC, C, FORTH, and Pascal, we decided that FORTH met our requirements best. It runs much faster than interpreted BASIC, but it allows interactive program development, testing, and debugging. In addition, that language promotes the writing of modular, structured programs (as do Pascal and C), but it does not require a disk-based development system.

Another benefit is that FORTH is extensible, which means that the code we write becomes a part of FORTH. Because most

continued on page 94

TV SIGNAL DESCRAMBLING



This month we put our theories to work and build a functional descrambler.

WILLIAM SHEETS and RUDOLF F. GRAF

Part 6

DURING THE PAST FEW months we've been looking at some of the principles behind television-signal encoding and decoding. Now it's time to put some of what we've learned to work. Beginning this month, we will look at three practical descrambler circuits that will decode sinewave-, gated-sync-pulse-, and outband-sync-encoded signals. Complete schematics, parts lists, and PC patterns will be provided; in addition, a kit of parts will be available.

But before we begin, take heed of this warning:

The decoding circuits that will be presented are for educational or experimental purposes only. It may be illegal to use the circuits to decode encrypted signals before obtaining prior permission from the programming supplier. It is up to the user to determine the conditions for legal use of these circuits and to obtain any permission required.

Sinewave scrambling

As discussed in the June 1986 issue of **Radio-Electronics**, in sinewave scrambling a 15.75-kHz sinewave is added to the video signal. If the sinewave is synchronized to the video signal, the sinewave's negative peaks occur during the video sync's positive peaks. The result is that the peak level of the sync is suppressed below that of the video. See Fig. 1. That suppression confuses the sync separator circuit in a television receiver and stops it from functioning properly. The picture that results is unwatchable: There is a dark vertical band and the video is color-distorted.

The audio may or may not be scrambled. Actually, it's not really scrambled; instead, it's stripped away from the main audio channel and placed on a hidden subcarrier. In sinewave scrambling, that subcarrier usually is located at 62.5 kHz.

Sinewave descrambling

Unscrambling a sinewave-encoded signal is relatively simple. It involves mixing the scrambled signal with a sinewave of the same amplitude and frequency as the scrambling sinewave, but shifted 180 degrees. The result is that the scrambling sinewave is canceled, leaving a standard video signal. A block diagram of an appropriate descrambler is shown in Fig. 2.

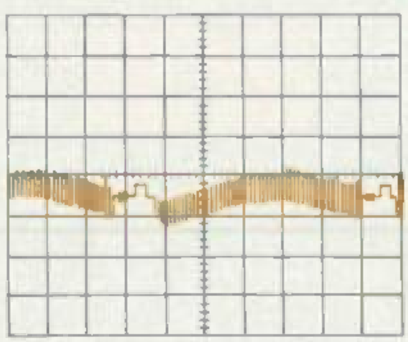


FIG. 1—A SINEWAVE-ENCODED VIDEO SIGNAL. The peak sync is suppressed below the level of the video, confusing the TV set's sync-separator circuitry.

Leaving theory behind, let's look at a practical sinewave descrambler circuit. The bulk of the circuit is shown in Fig. 3. The input and output circuitry is shown in Fig. 4; that circuitry is mounted within a shielded "interface" box. We'll speak more about the box and why it is used when we look at how to install and align the decoder.

The first thing a sinewave descrambler must do is to extract the 15.75 kHz sinewave from the incoming signal. That can be done by filtering it directly from the video envelope after detection.

An IF and video-detector system is formed by Q1, IC1, and their associated circuitry. The output of the TV set's tuner is picked off and fed to that stage via the input/output circuitry. Resistor R1 is used to set the gain of the IF stage while C1 is a DC-blocking capacitor. Resistor R1 should be set so that the input to Q1 is on the order of 1 millivolt. That signal level is provided by most cable systems, but with the value shown for R1, the circuit can accommodate signal levels from 300 µV to 5 mV.

Transistor Q1 is configured as a single-tuned bandpass amplifier with a gain of

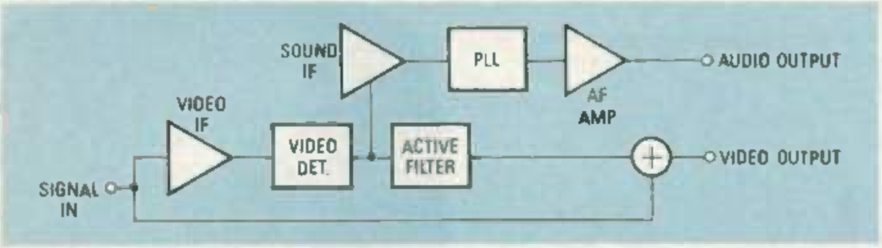


FIG. 2—THE STEPS REQUIRED TO DESCRAMBLE a sinewave-encoded signal are shown here. For more on the theory of sinewave scrambling and descrambling, see the June and August 1986 issues of Radio-Electronics.

about 15–20 dB. It is biased so that the collector current is about 3 mA. A bandpass network and matching transformer is formed by the circuit of L1, C3, and C4. The output of that circuit, at the junction of C3 and C4, is fed to pin 7 of IC1, the video detector. That IC is tuned by the L2-C6 circuit to accept either a Channel 3 or a Channel 4 input.

A 200-mV composite-video signal appears at the output of IC1, pin 4, and is fed to a narrowband active filter formed by IC2-a, R9, R10, C8, and C9. That filter extracts the 15.75-kHz decoding sinewave. The sinewave appears at the output of IC2-a, pin 1. That sinewave is shifted 180° by a sinewave-phasing network connected to the non-inverting input, pin 3, of IC2-a. That network consists of R12, R13, and C10. The passband of the filter can be adjusted using R10. However, altering the setting of R10 will not alter the bandwidth of the filter, as that potentiometer also adjusts the Q of the filter. The nominal gain of the active filter is 20 dB. That gain can be altered by adjusting R14.

The output of the filter is coupled via C12 to a bias network consisting of R15 and R16. That network is used to set the DC level on D1, an MPN3404 PIN diode located within the interface box; see Fig. 4. That diode acts as a voltage-variable resistor. A positive-going voltage will cause the impedance of the diode to decrease; a negative-going voltage will cause the impedance of the diode to increase. An isolation network made up of L3 and R17 keeps the input RF isolated from the output sinewave. Capacitors C15 and C14 pass the RF signal but block the output sinewave. Therefore, to the RF input, D1 appears to be effectively across the input (from tuner) and output (to TV

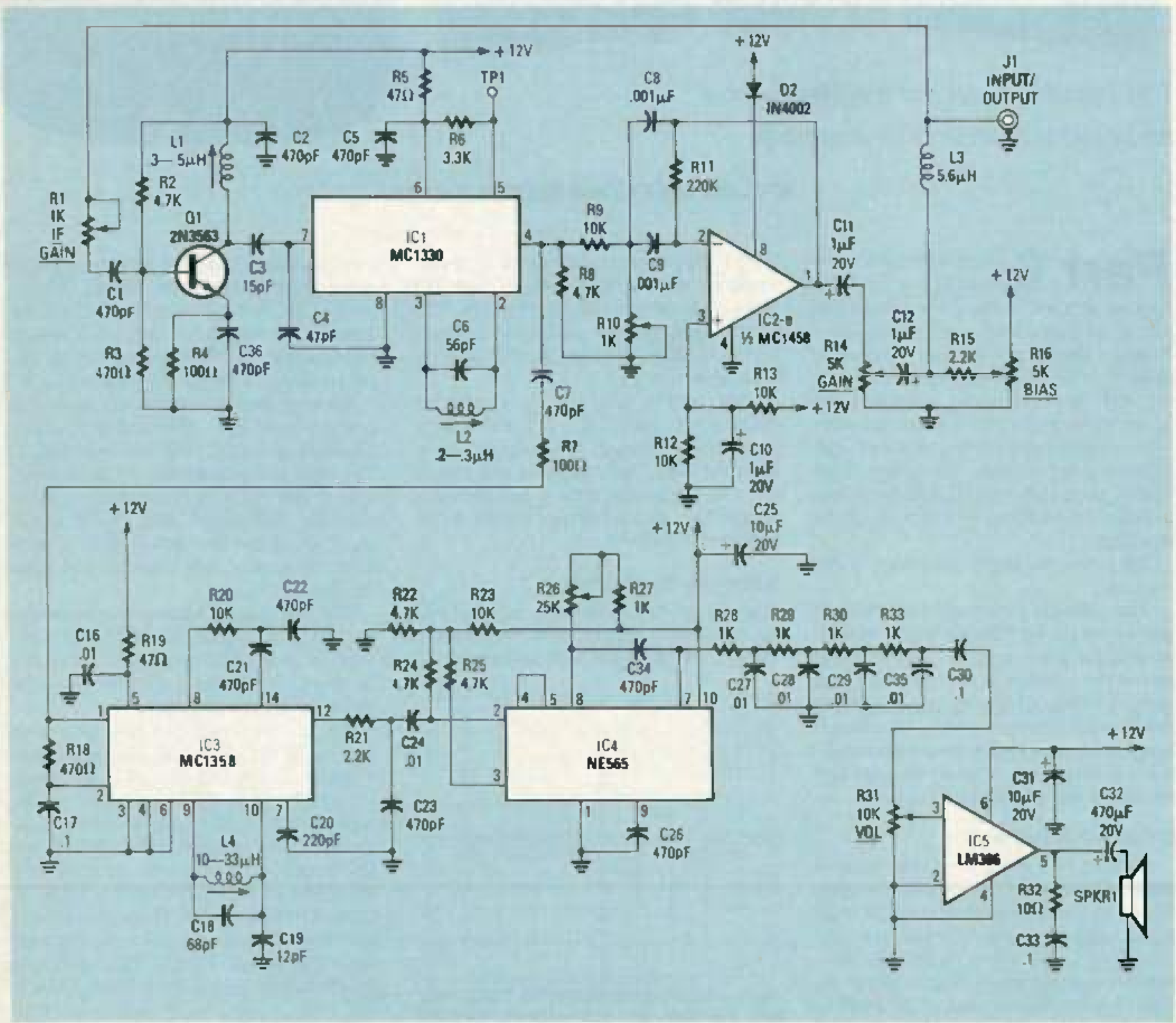


FIG. 3—A COMPLETE SINEWAVE DESCRAMBLER. Easy to build, and relatively easy to align, this circuit completely removes the 15.75-kHz scrambling sinewave.

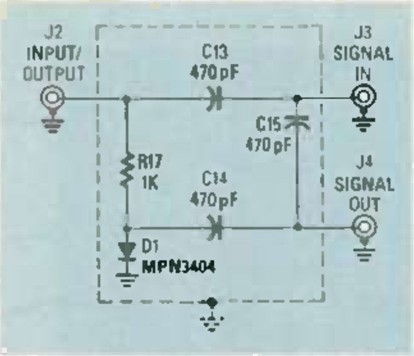


FIG. 4—THE INPUT/OUTPUT CIRCUITRY is mounted in a separate, shielded enclosure. That allows for greater flexibility in installing the circuit in a TV-set.

network located between pins 9 and 10. The inductor, L2, should be tuned for maximum signal at pin 12. While 62.5 kHz is the most common audio subcarrier frequency, with the values shown virtually all other possible subcarrier frequencies can be tuned by adjusting L2.

The pin-12 output is filtered to extract the audio subcarrier and that signal is fed to the input (pin 2) of IC4, an NE565 PLL. The VCO control voltage appears at pin 7. Assuming that the PLL is in a locked condition, that voltage will correspond to the program audio. For more detailed information on PLL operation, see Part 4 of this series In the September 1986 issue of **Radio-Electronics**.

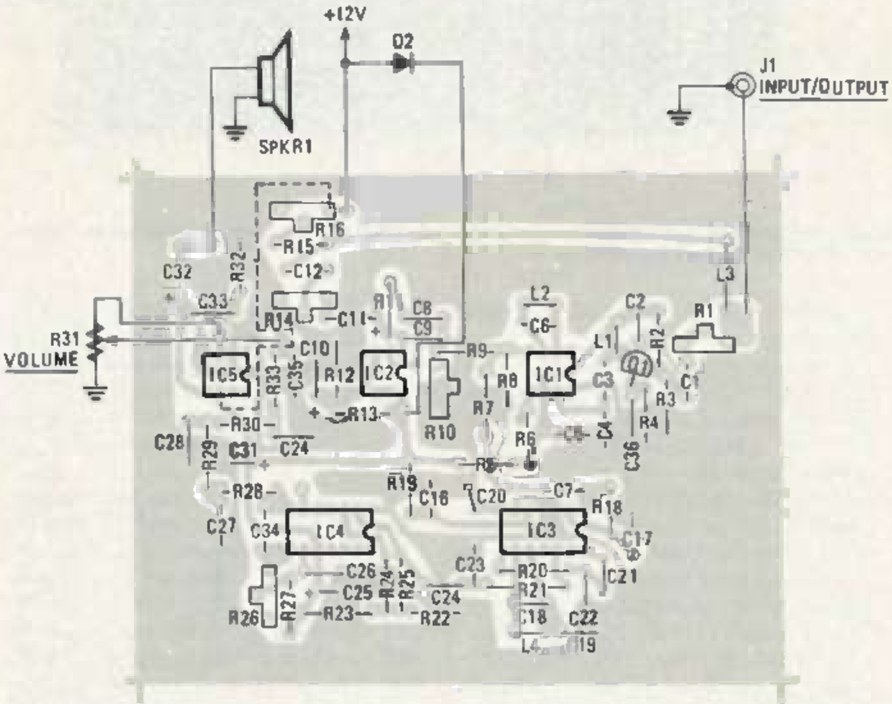


FIG. 5—USE THIS PARTS-PLACEMENT DIAGRAM when building the descrambler. The board may be etched using the pattern found in PC Service or ordered from the supplier listed in the Parts List.

IF) terminals and acting as a lossy shunt. By biasing the diode correctly, the descrambling sinewave can be mixed with the scrambled video, cancelling the scrambling sinewave. The result is a descrambled video signal that is fed back to the TV IF stage via capacitor C14.

Descrambling audio

In sinewave scrambling, the programmer also has the option of encrypting the audio. For systems where the audio is scrambled, IC3, IC4, IC5, and their associated circuitry are used to recover the audio. If it is not needed, that part of the circuit may be omitted.

Part of the video signal at the output of IC1 is picked off and fed to IC3, an MC1358 TV-sound IF amplifier via a high-pass filter made up of C7, R7, and R18. That versatile IC provides 4.5-MHz detection, amplification, and limiting. The detector stage is tuned by the LC

The pin-7 signal is then filtered and coupled to an audio amplifier built around IC5. The output of the amplifier is fed to an external 8-ohm speaker. Volume is controlled via R31. A stabilizing network for the LM386, consisting of R32 and C33, is included to prevent the possibility of undesired high-frequency oscillation.

Building a descrambler

Most of the circuitry is mounted on a single PC board. The foil pattern for that board is found in PC Service. The parts-placement diagram is shown in Fig. 5 and a photograph is shown in Fig. 6.

Other than R31, the volume control, the only components not located on the board are those that make up the interface circuit of Fig. 4. Those parts should be mounted in a small shielded (metal) box. The circuit is simple and its placement within the box is not critical. Strictly speaking, the interface circuitry could have been located

PARTS LIST

All resistors ¼ watt, 10% unless noted
R1, R10—1000 ohms, trimmer potentiometer
R2, R8, R22, R24, R25—4700 ohms
R3, R18—470 ohms
R4, R7—100 ohms
R5, R19, R33—47 ohms
R6—3300 ohms
R9, R12, R13, R20, R23—10,000 ohms
R11—220,000 ohms
R14, R16—5000 ohms, trimmer potentiometer
R15, R21—2200 ohms
R17, R27, R28, R29, R30—1000 ohms
R26—25,000 ohms, trimmer potentiometer
R31—10,000 ohms, potentiometer, audio taper
R32—10 ohms
R33—1,000 ohms
Capacitors
C1, C2, C5, C7, C13–C15, C21–C23, C26, C36—470 pF, ceramic disc
C3—15 pF, NPO or silver mica
C4—47 pF, NPO or silver mica
C6—56 pF, NPO or silver mica
C8, C9—0.001 µF, Mylar
C10–C12—1 µF, 20 volts, electrolytic
C16, C24, C27–C29, C35—0.01 µF, ceramic disc
C17, C30, C33—0.1 µF, Mylar
C18—68 pF, NPO or silver mica
C19—12 pF, NPO or silver mica
C20—220 pF, NPO or silver mica
C25, C31—10 µF, 20 volts, electrolytic
C32—470 µF, 20 volts, electrolytic
C34—470 pF, NPO or silver mica
Semiconductors
IC1—MC1330 video detector
IC2—LM1458 dual op-amp
IC3—MC1358 TV sound IF amplifier
IC4—NE565 PLL
IC5—LM386 audio amplifier
Q1—2N3563 NPN transistor
D1—MPN3404 PIN diode
D2—1N4002 rectifier diode
Other components
L1—0.3–0.5 µH, see text
L2—0.2–0.3 µH, see text
L3—5.6 µH choke
L4—10–33 µH (North Country Radio LX10-33 or equivalent), see text
J1–J3—phono jacks
SPKR1—8-ohm speaker
Miscellaneous: PC board, metal box for interface circuit, cabinet (optional), wire, solder, shielded cable, etc.
The following are available from North Country Radio, P.O. Box 53, Wykagyl Station, New Rochelle, NY 10804: Complete sinewave decoder kit, including PC board (metal box for interface circuit not included), item SW-1, $52.95 plus $2.50 shipping and handling; Pulse decoder kit, including PC board, item PD-1, $49.95 plus $2.50 shipping and handling; Outband decoder kit, including PC board, item OB-1, $34.95 plus $2.50 shipping and handling. All three kits may be purchased for $129.95 plus $3.50 shipping and handling. The LX10-33 coil (L4 of the sinewave descrambler) is available for $4.00. NY state residents please include sales tax.

on the main board; but separating it from the main board allows for much more flexibility.

With our scheme, you can mount the interface box within the TV cabinet, physically close to the tuner and IF sections, but leave the remainder of the circuit outside for easier adjustments. Input and output signals are routed between the box and the board using shielded cables. With other schemes, either the whole circuit is mounted within the TV cabinet, making access difficult, or long signal runs are required, inevitably causing signal degradation.

Coils L1 and L2 are hand-wound. Coil L1 consists of 10 turns of number 22 enameled wire wound on an 8-32 screw. Coil L2 consists of 6 to 7 turns of number 22 enameled wire wound on an 8-32 screw. Once those coils are wound, remove the screws and replace them with ferrite slugs. You can salvage those slugs from an old TV set (from a coil in the IF circuit) or the front end of an old FM radio. Coil L4 is a custom part. It is designated as LX10-33 and is available only from the source given in the Parts List.

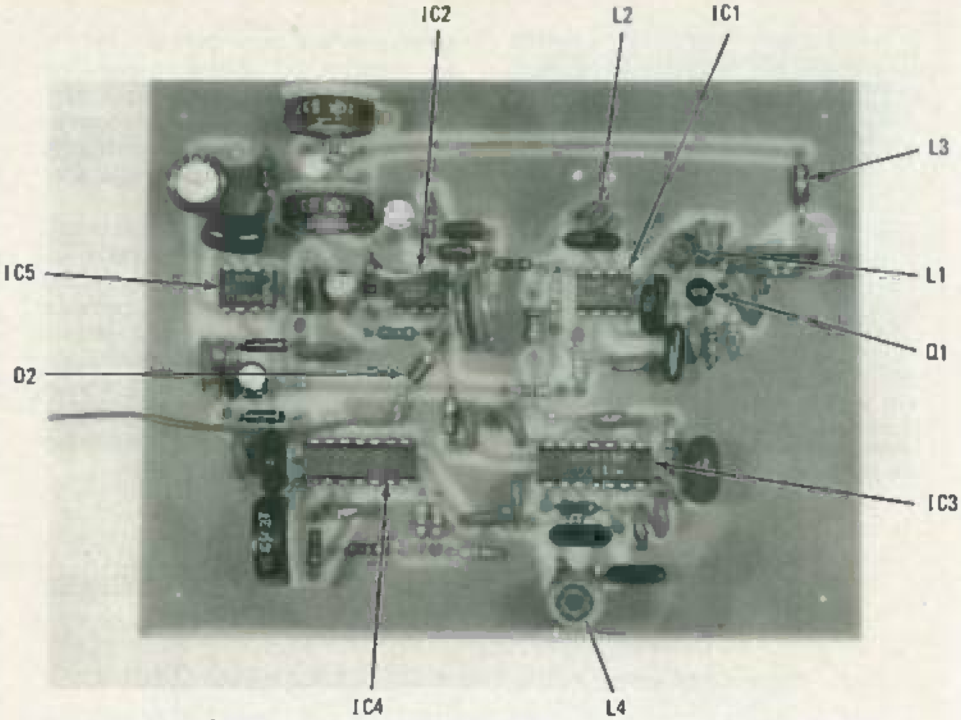


FIG.6—THE COMPLETED SINEWAVE DESCRAMBLER BOARD contains everything except the volume control and the circuitry shown in Fig. 4.

Aligning the circuit

It may be illegal to use or even align the circuit with the signal from an over-the-air or cable pay-TV programmer without obtaining prior permission. **Do not use the circuit in that manner without first obtaining such permission.**

In the meantime, it is possible to align the circuit "off-the-air." Doing that can give you greater insight into the way that signal descrambling works. Let's see what equipment is needed to perform such off-the-air alignment before looking at the procedure itself.

The circuit should be powered using a well-regulated, filtered +12-volt DC supply. Any excess ripple can interfere with circuit operation to the point where alignment is not possible.

You will also need an oscilloscope. It should have a bandwidth of at least 5 MHz and preferably 15 MHz, and a sensitivity of at least 100-mV/div. The scope should be equipped with a low-capacitance (less than 10 pF) probe.

You will need some way to simulate the 15.75-kHz scrambling sinewave. That can be done using an AF generator. Your VCR will suffice as a source of normal (descrambled) video. If one is available, a signal generator capable of outputting frequencies to about 70 MHz would be helpful, but it is not absolutely required and you can get away without one.

Connect J1 to J2 using a short length of shielded cable. Then connect power and apply a video signal to the signal-input jack (J3). Nothing should run hot. If it does, measure the resistance between the power supply and ground rails. If it is less than 100 ohms, you likely have a short somewhere. Correct any problems before proceeding.

Next, connect the oscilloscope probe to pin 4 of IC1. Adjust the settings of L1 and L2 for a maximum video signal display on the scope. Then adjust R1 for a video signal of about 250-mV p-p.

Move the scope probe to pin 12 of IC3. Adjust L4 for maximum audio signal as displayed on the scope.

Disconnect the video source. Set the signal generator to output either a 61.25-MHz (Channel 3) or 67.25-MHz (Channel 4) signal. Modulate that signal (30% modulation) with a 15.75-kHz, 1 millivolt p-p signal from the AF generator, and apply it to J3. Connect the scope probe to pin 1 of IC2-a and adjust R10 for maximum sinewave display.

If you do not have a signal generator, place a 1-megohm resistor in series with the AF generator and set the generator to output a 15.75-kHz, 1-volt p-p sinewave. Inject the signal at the junction of R9 and R10. Connect the oscilloscope probe to pin 1 of IC2-a and peak R10 for a maximum display.

Remove the sinewave signal. Replace the series 1-megohm resistor with a 0.01 µF capacitor and couple the signal generator's output to the junction of C24 and R24. Set the generator's output to a 61.5-kHz, 300-mV p-p signal. Connect the scope to pin 7 of IC4. Adjust R27 so that phase lock occurs. You'll know that you have phase lock when you obtain a rock-steady DC display on the scope. Once you have phase lock, try varying the output frequency of the AF generator. The voltage at pin 7 should track those changes over a range of a few kHz.

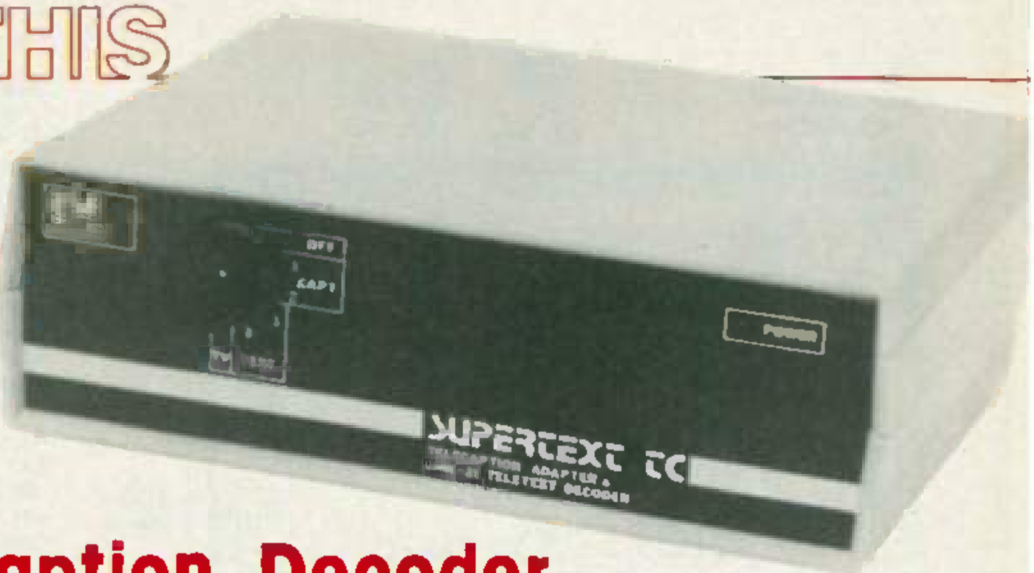
That completes the essential checkout procedures. If you have a signal generator, there is one final test you can perform. Once again, modulate a 61.25- or 67.25-MHz signal with a 15.75-kHz sinewave from an AF generator. Apply the resulting signal to J3.

Connect a TV receiver to J4, the signal output jack. Normally, applying just the video carrier to the set will cause a uniform white raster. However, the sinewave should cause a rippling effect. If the circuit is working properly, you should be able to eliminate that ripple by adjusting R16, R10, and R14. If you can, it proves that the circuitry is capable of suppressing the scrambling sinewave.

That completes alignment. If you obtain permission to use the circuit with an over-the-air or cable signal, you will likely need to tweak up performance when the circuit is installed. However, those adjustments should be minor.

Installing the circuit is relatively simple. However **working inside a TV can be very dangerous** unless you are sure what you are doing. We urge you to be cautious. Basically, the sinewave decoder interface box is installed between the TV's tuner and it's IF section. Coaxial cable should be used, and you should provide a bypass switch to take the decoder out of the circuit. You may prefer to use a separate tuner as decoder's front end. Then the only connection required is to the TV's IF. Either way will work, but using a separate tuner may be more desirable.

Next time, we will look at gated-sync and outband-sync descrambling circuits that you can build yourself and experiment with. R-E



Closed-Caption Decoder

J. DANIEL GIFFORD

Last month we looked at the theory and the circuitry behind the closed-caption decoder. Now let's build one.

Part 2

WHEN WE FINISHED UP last time, we discussed the basics of how closed captioning works, and we presented the complete schematic diagrams of our closed-caption decoder. Now you can warm up your soldering iron—we're ready to build the circuit.

Construction

Building the decoder is fairly easy because it has only a single IC, and because all components, except the switches and power jack J1, mount on the PC board.

The NCI telecaption module, the heart of the decoder, mounts in the bottom of the case, and the PC board mounts in the top. The close quarters in the case require that all components on the PC board be low-profile types with heights less than one inch. The only problem component is the 7805 regulator, which requires a relatively large heatsink. We solved the problem by installing a vertical-mount heatsink horizontally.

To begin construction, first inspect the PC board (whether you make your own or buy the kit) for plugged holes and broken or shorted traces. Fix any and all faults before proceeding.

Following the component-placement diagram in Fig. 7, install the three jumpers using 22-gauge bus wire. Keep the jumpers tight and flat against the surface of the board to prevent shorts. Next, insert 26 PC pins into the holes in the board where wires will connect: 15 along the right edge of the board (where the NCI module will connect), two for J1, two for S2, and seven for S1. Turn the board over carefully and rest it on the pins while you solder them in place.

Next install the 59 fixed-value resistors. The holes for all the resistors are spaced so that the leads of each resistor can be bent right at the body. To ease troubleshooting, mount the resistors so that the color codes point the same way.

Install the capacitors, taking care to orient the polarized electrolytic and tantalum types correctly. Keep all the capacitors as close to the board as possible, bending their leads if necessary to match the hole spacing.

Install the diodes next, taking care both to orient them correctly and not to mistake the different types. In particular, be certain that the 6.2-volt Zener is inserted in the D3 position, and that the 8.2-volt Zener goes in the D11 spot. Use care in bending the leads of the diodes, particularly the glass types.

Now install the transistors. To avoid mixing up the two types, first insert and solder the five PNP devices (Q3, Q5, Q10, Q13, and Q14). Then insert the nine NPN transistors in the remaining positions, and solder them in place. Keep the transistors close to the board—their cases should be no more than ¼ inch from its surface.

Press the four RCA jacks (J2, J4, J5, and J6) into the board and bend their tabs over to hold them in place. Check that they are all firmly and squarely seated, then solder them in place, using a fair amount of solder to obtain firm joints.

Insert the two trimmer resistors, R50 and R55, into the board and solder them in place. Be certain that they are well mounted, so that repeated adjustments will not work them loose.

Press the RF modulator into the board and twist its lugs to hold it in place. Solder the lugs to the foil, using plenty of solder to make a secure joint. Not only do the lugs hold the relatively heavy modulator in place, but they are used as jumpers to extend the ground plane to two points near the center of the board. Poor mounting will cause problems. Insert the modulator's four leads into their holes, noting that they angle back from the edge of the board slightly. Pull the leads tight, then solder them.

Now install the 7805 regulator and its heatsink. The heatsink supplied with the kit has two pins extending from one end to facilitate vertical mounting. Since the heatsink will be mounted horizontally, remove the pins with a pair of pliers.

Insert the 7805 regulator into the board with its metal tab toward C1, and then bend it so that the hole in its tab lines up with the hole in the board. DO NOT solder its leads yet.

Pass the heatsink's mounting screw through the PC board and through several metal washers to hold the regulator slightly above the board. Apply a layer of heatsink compound to the back of the 7805 and attach the heatsink, tightening the screw firmly. Solder the regulator's leads now.

The last step in building the PC board is to mount power-on indicator LED2. It must extend from the edge of the PC board to meet its mounting hole in the front panel. The easiest way to determine its mounting position is to temporarily fit the

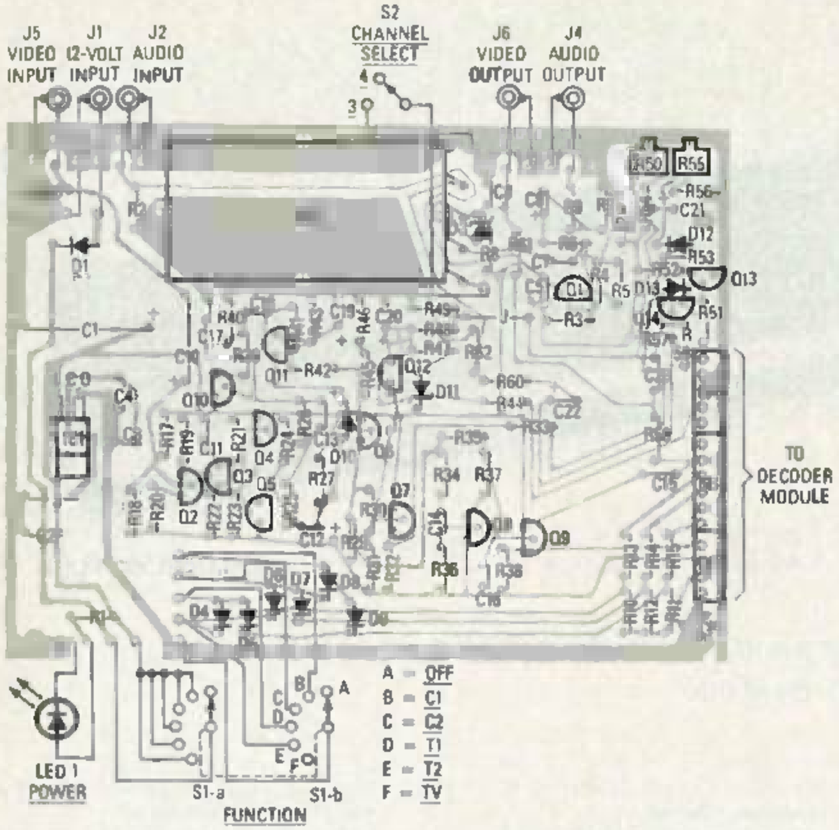


FIG. 7—MOST COMPONENTS EXCEPT THE SWITCHES AND J1 mount on the PC board. Use PC-board pins to connect the off-board components.

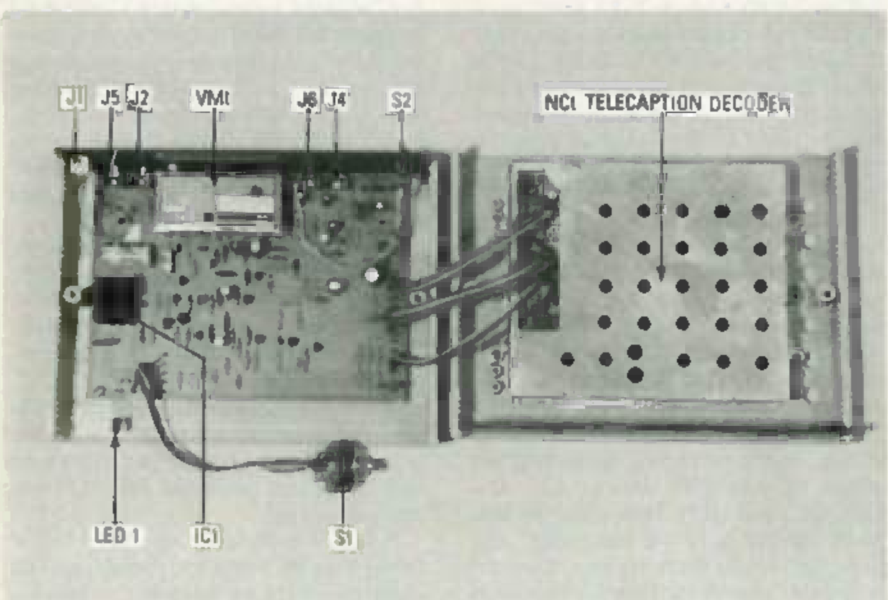


FIG. 8—THE PC BOARD MOUNTS IN THE BOTTOM of the case and the NCI decoder module mounts in the top. Make sure that the three jumper cables connecting the PC board and the module are oriented correctly.

PC-board and the front panel into the case. After the LED's leads are bent to fit, remove the board and solder the LED in place. Note that the lead next to the flat edge of the LED's case goes to the hole nearest the corner.

After all components have been mounted, inspect your work for incomplete joints and solder bridges, and correct any problems. Clean flux from the bottom of the board, and then spray it with an acrylic dielectric spray. Doing so will help the decoder to remain trouble-free in changing humidity conditions.

Interconnections

The connectors that couple our board to the NCI module are an unusual type with 0.1" spacing between adjacent pins. They are insulation-displacement types, so you need only press a strand of ribbon cable into each contact. We use three connectors of different sizes: four-, five-, and six-contact points. Each interconnecting cable has a connector only at the end that attaches to the NCI module; the other end is soldered to the PC board.

Cut three pieces of ribbon cable about six or seven inches long, one each with four, five, and six conductors, and separate the conductors about one inch at each end. Insert the unstripped wires into the "bays" of the appropriate connector and, holding them in place, pull the cable down across the terminals, but don't apply too much pressure. With the cable seated, use a small flat-blade screwdriver to push each wire into the notch of its terminal.

Strip about ¼-inch of insulation from the other end of each conductor of all three ribbon cables. Twist the strands together, and then solder the wires to the PC-board pins. Make sure that you solder those wires so that the connectors at the other end will be able to fit in the NCI module. Figure 8 shows how they should seat. The six-conductor cable should be split for an inch or so at the PC end between its second and third conductors in order to clear C15. Or you could push C15 so that it lies flat on the board. Don't break its ceramic coating or short any of the other connecting pins. After all of the wires are soldered in place, inspect your work and correct any errors.

Attach J1 and S2 to the rear panel, and insert the panel into the top half of the case. Install the PC board and secure it with four self-tapping screws. Make sure that the jacks line up with the holes in the panel.

Connect wires between J1's pins and the appropriate pins on the PC board. Then connect S2 to the channel-select pins, using segments of ribbon cable or other 20- to 24-gauge hookup wire. Keep the wires short and neat, but leave a small amount of slack to allow removal of the board or the panel.

Remove the anti-rotation lug from rotary switch S2 and mount the switch to the front panel, tightening its nut finger-tight. Fit the knob to the shaft and adjust the switch's position so that the knob's indicator lines up with the panel markings. Carefully remove the knob and tighten the nut. Then re-install the knob and make sure that the indicator still lines up.

Use bus wire to connect the five common terminals of S1-a together. Clip the terminals off just above the wire, and re-

PARTS LIST

All resistors are ¼-watt, 5% unless otherwise noted.
R1, R22, R23, R52, R53, R56, R60—1000 ohms
R2—15,000 ohms
R3—270,000 ohms
R4—100,000 ohms
R5—22,000 ohms
R6—390 ohms
R7, R40—4700 ohms
R8, R58—180 ohms
R9, R20, R21—560 ohms
R10–R12, R17, R28—47,000 ohms
R13–R15, R34—470 ohms
R16, R61—75 ohms
R18—18,000 ohms
R19, R24—680 ohms
R25, R47, R48, R57—220 ohms
R26—180,000 ohms
R27—68,000 ohms
R29, R32, R38—2200 ohms
R30—1500 ohms
R31, R37, R44—3300 ohms
R33, R43, R49—330 ohms
R35—2700 ohms
R36—3900 ohms
R39, R59—10,000 ohms
R41, R45—12,000 ohms
R42—1800 ohms
R46, R54, R62—6800 ohms
R50, R55—1000 ohms, PC-mount, trimmer potentiometer
R51—100 ohms
Capacitors
C1—1000 µF 16 volts, electrolytic
C2, C4, C6, C15, C24—0.1 µF, ceramic disk
C3—1 µF, 35 volts, tantalum
C5, C13—1 µF, 16 volts, electrolytic
C7, C8, C19—10 µF, 16 volts, electrolytic
C9, C21—22 µF, 16 volts, electrolytic
C10—47 µF, 16 volts, electrolytic
C11—39 pF, ceramic disk
C12—2.2 µF, 16 volts, electrolytic
C14—150 pF, ceramic disk
C16—100 pF, ceramic disk
C17—0.001 µF, ceramic disk
C18—220 pF, ceramic disk
C20, C22—100 µF, 16 volts, electrolytic
C23—470 µF, 16 volts, electrolytic
Semiconductors
IC1—LM7805T, 5-volt regulator
D1—1N4001, rectifier
D2—not used
D3—1N4735 6.2-volt, 1-watt Zener diode
D4–10, D12, D13—1N914 switching diode
D11—1N4738 8.2-volt, 1-watt Zener diode
LED1—standard red
Q1, Q2, Q4, Q6–Q9, Q11, Q12—2N2222A NPN
Q3, Q5, Q10, Q13, Q14—2N3906 PNP
Other components
J1—⅛-inch miniature phone jack
J2–J6—RCA phono jack
S1—2P6T miniature rotary switch
S2—SPST miniature slide switch
Miscellaneous: Astec UM1285-8 video modulator, NCI Telecaption Decoder Module, PC board, 12-volt 500-ma wall-mount transformer, case, panels, wire, solder, etc.
Note: A kit (no. K-6314) including PC board, case, and all parts except RF modulator and power transformer is available for $139 plus $7.55 shipping and handling from Dick Smith Electronics, Inc., P. O. Box 8021, Redwood City, CA 94063. The modulator (no. K-6040) is available for $9.95 and the power transformer (no. M-9526) is available for $6.95. Allow shipping of $1.50 plus 5% of order. California residents must add 6.5% sales tax. Orders outside the U. S. must include U. S. funds and add 20% of total for shipping.

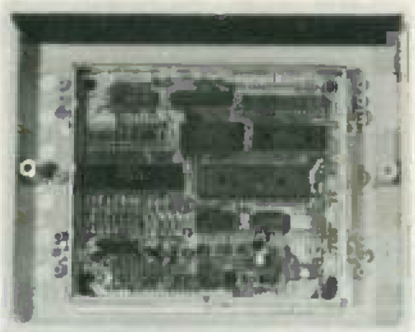


FIG. 9—THE NCI MODULE, shown here with its cover removed, mounts to the bottom of the case.

move the OFF terminal completely. The terminals must be removed in order for the switch to clear the edge of the PC board. To prevent possible wiring errors, remove the two terminals corresponding to the OFF and the TV positions of S1-b.

Solder a six- to seven-inch length of seven-conductor ribbon cable to the pins near the front of the PC board. Connect the other end to the appropriate points of S1. Insert the front panel into the top of the case.

Drill a row of ⅛-inch cooling holes along the bottom of the left half of the case. Those holes will let air get in to cool the heatsink; waste heat will pass by convection through the gaps around the rear-panel jacks.

Next mount the NCI module in the bottom half of the case. The module has four mounting lugs designed for attachment to a flat surface. To mount the module to the standoffs in the bottom of the case, bend the lugs so that they extend straight out from the module's shielding can; then make an additional horizontal bend about ¼ inch from the first bend. Press the module into place with the connectors on the opposite side of the cooling holes, and with the rear edge against the slot for the rear panel. The module must be all the way back to provide room for the rotary switch in front. Secure the module in place using self-tapping screws and washers. Do not connect the module to the PC board yet.

Testing and adjustment

Turn the rotary switch to OFF and plug the wall transformer's output plug into the power jack. Then plug the transformer into an AC socket and turn S1 to CI. LED1 should light up. Turn the knob through the other positions; the LED should remain lit.

Measure the voltage at the positive lead of C1. It should be no less than 12.5 and preferably no more than 16 volts. (That voltage will drop when the heavy load of the module is added.) Measure the 5-volt supply at either the +5 volt pin of S1-b or at module connector pin 5C4. It should be within 0.25 volt of 5 volts. Finally, measure the voltage at the cathode of D3; it should be between 5.8 and 6.2 volts. If all voltages are correct, turn the decoder off and attach the connectors to the NCI module. Turn the power back on.

Again measure the voltage at the positive end of capacitor C1. Ideally, it should be between 12 and 12.5 volts, but it may vary, depending on the wall trans-

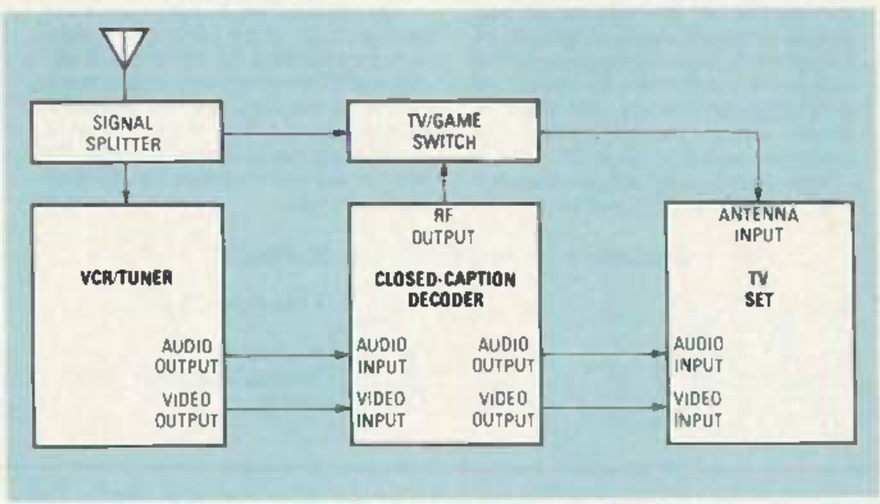
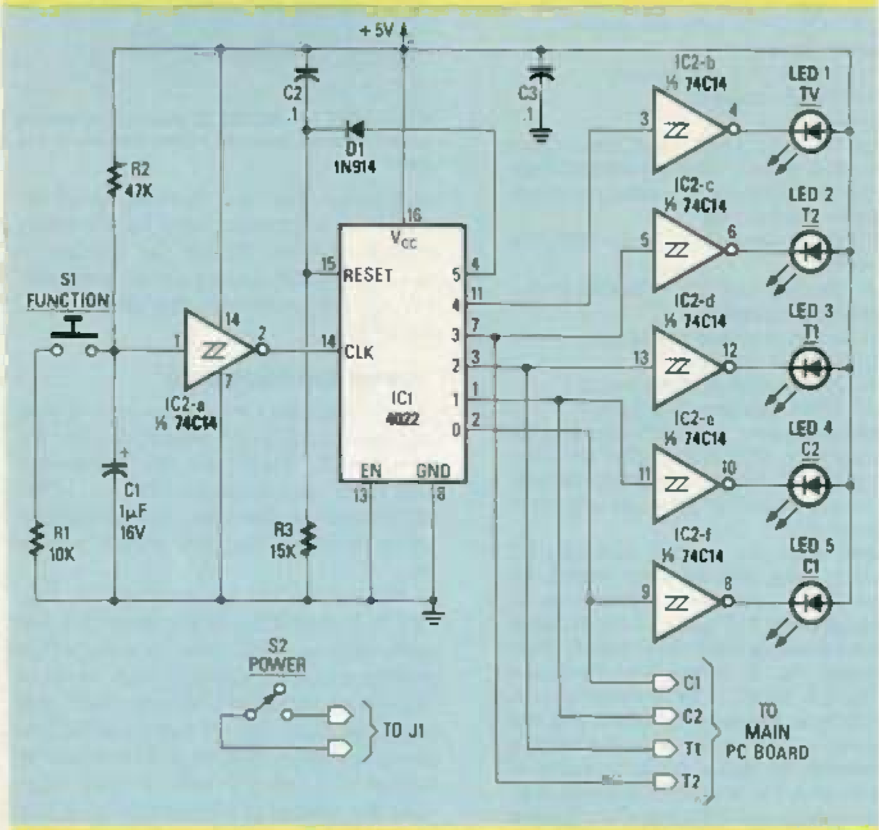


FIG. 10—SYSTEM WIRING DIAGRAM shows how the decoder should be connected to your video system. The signal splitter and TV/GAME switch are optional.

ELECTRONIC FUNCTION SELECTOR

As promised last month, we'll describe an all-electronic function-selector circuit that can be used to replace the rotary function selector, S1. The circuit is shown in Fig. 1.



clock input; that pulse advances the counter by one. The 0 output goes low and the 1 output (pin 1) goes high, so the C2 LED lights up, and caption channel C2 is selected. Successive presses of S1 cycle the 4022 through each of its states; a fifth press returns the decoder to the C1 mode, because the output 5 (pin 4) is coupled to the RESET input via diode D1.

The heart of the circuit is a 4022 8-stage ring counter. In a ring counter, one and only one output is high at any time. Each output of the 4022 drives an LED via an inverter. The first four outputs are also connected to the corresponding inputs on the main PC board. When power is first applied, C2 and R3 reset the counter, so the 0 output (pin 2) is high. Therefore, the decoder comes up tuned to the most popular closed-caption channel, C1.

When S1 is pressed, a pulse is applied (via Schmitt trigger IC2-a) to the counter's

You can build this circuit on a piece of perfboard and attach it to the front panel with spacers and screws. Note that a separate SPST switch will then be required to switch the decoder's power on and off; in addition, power-on indicator LED1 (on the main board) can be omitted, since one of the function LED's will light up whenever the power is on. **R-E**

PARTS LIST— ELECTRONIC FUNCTION SELECTOR

- R1—10,000 ohms
- R2—47,000 ohms
- R3—15,000 ohms
- C1—1 µF, 16 volts
- C2, C3—0.1 µF
- IC1—4022 ring counter
- IC2—74C14 hex Schmitt trigger
- D1—1N914
- LED1–LED5—Standard
- S1—SPST normally open pushbutton
- S2—SPST toggle

former used. To accommodate transformers with various output voltages, it may be necessary to alter the values of several resistors. We'll discuss those modifications in a moment.

Before closing up the case, temporarily connect the decoder to your video system as shown in Fig. 9. Note that a video switch is shown in that figure; it can be used to bypass the decoder when caption decoding is not needed. If captions will be desired most or all of the time, the switch, and the signal splitter, can be omitted and the decoder's TV mode can be used to bypass decoding, if necessary.

Select a strong station on the VCR or tuner, set your TV and S2 on the decoder to Channel 3 or 4. Now turn everything on. Place S1 in the TV position.

If the picture and sound on the TV are good, then no adjustments to the modulator are necessary. But if either picture or sound is faulty, use a 1/16-inch flat screwdriver to adjust the modulator's tuning coil (the one nearest the input leads) until the picture is good. Then adjust the other coil until the sound is clearest. You may have to adjust both coils several times to optimize both audio and video.

Set trimmer resistors R50 and R55 to the center of their travels, set S1 to C1, and tune in a captioned program. During the day, the best place to find one is on a PBS station. At night, try either a PBS or an ABC station. On satellite, tune in any of the ABC or PBS feed transponders.

If the captions appear with a dark background and bright, legible characters, no adjustments are necessary. But, if the boxes are too light, if the captions distort the picture, or if dark streaks appear in light scenes, adjust the BLACKNESS control (R50) until the boxes are as dark as they will get without streaks or distortion. If the characters are either too dim or smeared, adjust the CHARACTER control (R55) until they are clearly visible, but not smeared.

If proper adjustment cannot be obtained in the middle 1/3 of the trimmer's travel (or cannot be obtained at all), the problem is most likely the 12-volt supply. To compensate, one or two of the resistors in the blanking and Y level bias circuits will have to be changed. The resistors should be changed only if it is difficult to get clear captions and background.

If the background will not adjust properly, clip R47 from the board, leaving the lead stubs in place. Connect a 1K trimmer resistor to the stubs and, with the background trimmer set to the center of its travel, adjust the new resistor to obtain a dark background without streaks or distortion. Turn the decoder off, measure the value of the pot, and replace it with the closest standard resistor. If you're careful, you can solder the new resistor to the leads of the old one without having to remove the board from the case.

If it is the characters that will not adjust properly, perform the same procedure, but substitute a 2K trimmer resistor for R56.

After everything is working correctly, disconnect the decoder, assemble the case, and reconnect it to your video system. Now you're ready to enjoy the new world of closed-caption programming.

To conclude, it's our sincere hope that all of the hearing-impaired persons who are aided by this project enjoy using it as much as the author enjoyed designing and developing it and we enjoyed publishing it. It was truly our pleasure. **R-E**

DTMF Encoding and Decoding

Thanks to new low-cost DTMF encoders and decoders, the world of DTMF signalling now is available for use in your next project.

DALE NASSAR

DTMF (*DUAL-TONE MULTI-FREQUENCY*) signalling was developed about two decades ago by Bell Labs as a faster (by a factor of about 10), more versatile, and more reliable telephone-dialing scheme than the old pulse or rotary-dialing technique. The DTMF method is often referred to as tone dialing or *Touch-Tone* (note that *Touch-Tone* is a trademark of AT&T) and is used with push-button telephones and other equipment.

A standard DTMF signal consists of a pair of audio tones chosen from a group of eight standard frequencies. Those frequencies are divided into two groups: a low-tone group of four frequencies and a high-tone group of four frequencies. A valid DTMF signal consists of the algebraic sum of one tone from the low group and one tone from the high group. There are therefore 16 (4 low × 4 high) possible DTMF signals that can be encoded with the eight frequencies. The four standard low frequencies are 697, 770, 852, and 941 Hz, and are referred to as row frequencies R1, R2, R3, and R4, respectively. The four standard high frequencies are 1209, 1336, 1477, and 1633 Hz, and are referred to as column frequencies C1, C2, C3, and C4, respectively. Any combination of DTMF tone can be generated using a 4 × 4 keypad switch matrix as shown in Fig. 1. The DTMF frequencies and the keypad layout of Fig. 1 are international standards. The frequencies produced by DTMF generators are allowed a ±1.5% deviation from the listed standards. Note that all of those tones are well within the telephone system's voice band.

The choice of the standard DTMF frequencies was by no means an arbitrary one. The designers of the DTMF system used a great deal of care in selecting the particular frequencies. Other tones that may appear on the telephone line such as dial tones and power-line noise must not fall in the DTMF frequency band. Further, the standard frequencies must have no harmonic interaction, thus the highest standard frequency (1633 Hz) is lower than the third harmonic of the lowest standard frequency (697 Hz).

Conventional telephones that use DTMF signalling are usually equipped with a standard 3 × 4 keypad matrix for representing the digits 0–9, and two spare symbols, * (star or asterisk), and # (pound or octothorpe), which can be used for various purposes. That 3 × 4 matrix represents all four row frequencies (R1–R4), and the three lowest column frequencies (C1–C3). Some special-purpose

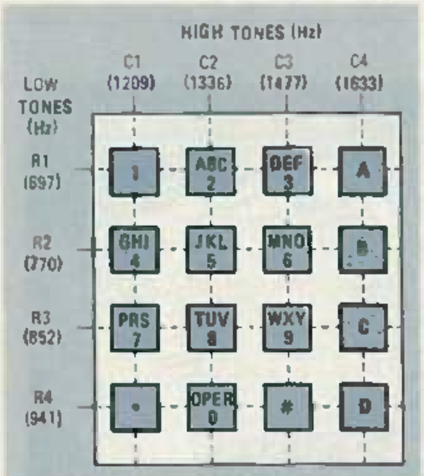


FIG. 1—STANDARD DTMF KEYPAD layout. The DTMF row and column frequencies are as shown.

telephones use the fourth column (C4) to represent four additional symbols (shown as A, B, C, and D in Fig. 1) in order to encode all of the sixteen possible DTMF signals.

If you have a tone-dial phone you can listen to a DTMF signal by simply picking up the telephone handset and pressing one of the buttons. For example, pressing the 8 key generates a 852-Hz tone (R3) and a 1336-Hz tone (C2) simultaneously. Those signals are processed and decoded by a DTMF receiver at the telephone company's central office.

The central office contains the switching equipment that provides local-exchange telephone service for a given geographical area. That area is designated by the first three digits of the telephone number. After the connection is established between the called and the calling parties, the DTMF receiver (at the central office) is no longer active and the connected parties are free to use the keypad-generated signals for station-to-station (end-to-end) signalling.

Until very recently, the DTMF encoders used by the telephone companies exclusively used large and bulky transistorized LC-tuned oscillator circuits to generate the tones. Many such LC circuits are still in use. Such rugged circuits were used by the telephone company because they were extremely dependable. They were designed to withstand the worst of operating conditions. For the hobbyist, limited parts availability makes building that type of circuit almost impractical. Fortunately it is also unnecessary, as DTMF generators are available in IC form.

Further, until just a few years ago the experimenter had to settle for a not-so-reliable IC decoding (receiving) system. The decoding circuitry had to be built up using a number of simple IC's. For instance, a separate 567 phase-locked-loop tone-detector IC was required for each frequency used, for a total of eight. Additionally, each tone detector had to be tuned by critical external timing components. Because each DTMF signal received activated two detector outputs (one for each frequency received), a logic circuit had to be added to convert those outputs into a usable format. The net result was a complex circuit that was time-consuming to build and difficult to align. Also, performance was often unsatisfactory. True, performance could be improved with the addition of pre-filtering at the inputs of each tone detector. But the active-filter circuitry required for that made an already complex circuit even more so.

Fortunately, those days are gone forever. With the new DTMF IC's available today, a complete and extremely reliable DTMF-encoding and -decoding system can be breadboarded in less than 10 minutes. Also, the built-in features of those decoding IC's usually include pre-filtering, complex processing, signal validation, etc., making possible a high degree of efficiency and reliability. In addition, no external tuning components are required, keeping the parts count minimal. DTMF IC's are manufactured by Nation-

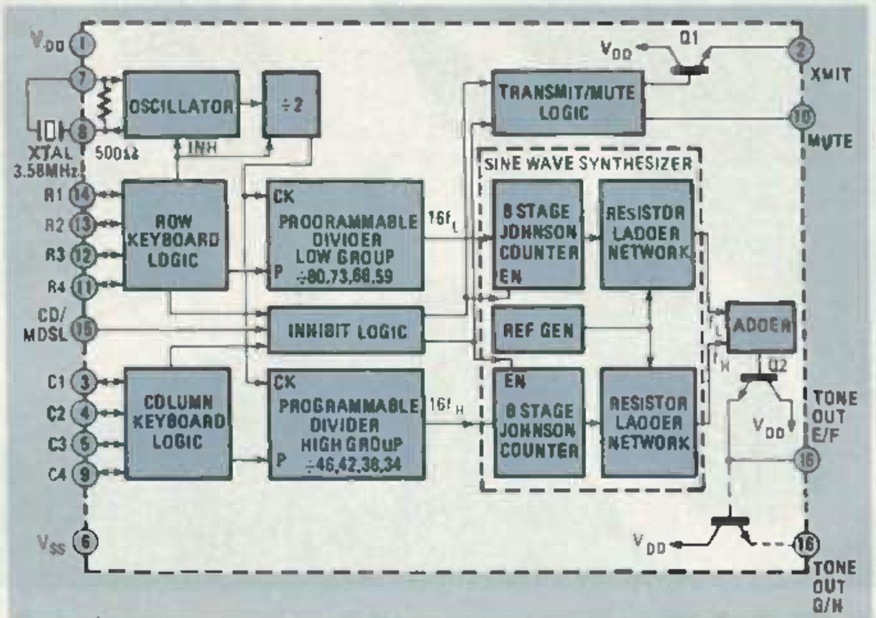


FIG. 2—INSIDE A DTMF ENCODER. The S2559E DTMF generator IC is shown here in block-diagram form.

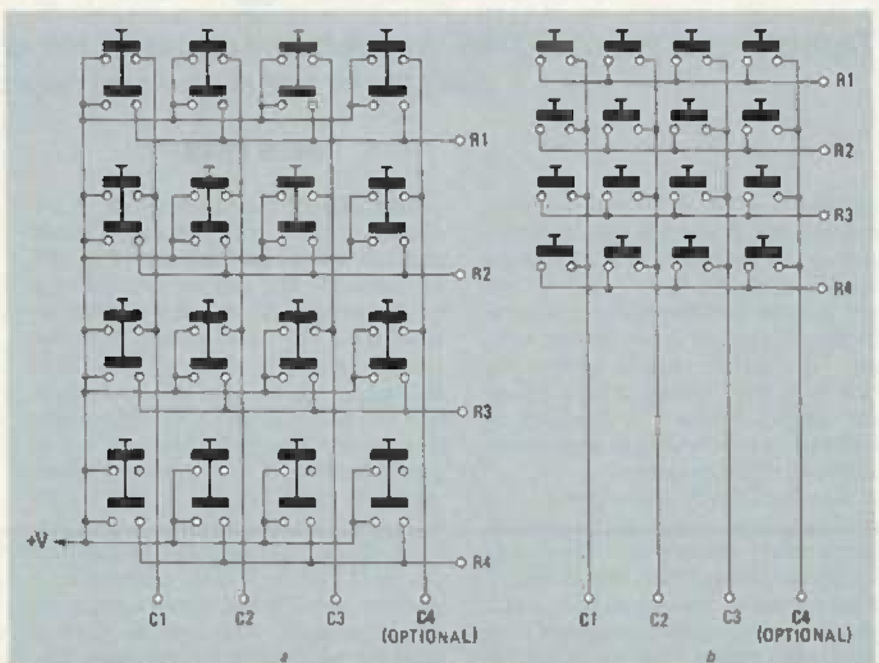


FIG. 3—TWO TYPES OF KEYPADS can be used with DTMF encoders. The one shown in a is a standard telephone tone-dialing keypad and uses DPST switches. The one shown in b is a calculator-type keypad and uses simple SPST switches, but it can not be used with all encoder IC's.

al. Silicon Systems. Mostek. Motorola. AMI, and Teltone.

Although the DTMF system was originally designed for telephone dialing, it is extremely useful as the basis for remote-control systems. In this article we'll describe some of the DTMF-encoding and -decoding IC's that are commercially available, and how they can be used in remote-control applications. After reading this article, you should have no trouble choosing and sucessfully using the DTMF IC's that best fit your needs.

DTMF encoding

The heart of a DTMF encoder is a a DTMF tone-generator IC. Those IC's are extremely easy to use and are very low in cost. Some DTMF tone generators are available for less than $2.00 in single quantities! They generate the desired DTMF signals by dividing a crystal-generated reference frequency. The oscillator is on-board the IC; the crystal is simply connected across two terminals of the IC. The most-common crystal frequency is 3.579545 MHz; that's the TV color-burst frequency, so those crystals are readily available and low in cost. However, as we will see shortly, other frequency references may be used for special purposes.

A block diagram of a typical tone-encoder IC is shown in Fig. 2. The IC illustrated there is a Gould AMI (3800 Homestead Rd., Santa Clara, CA 95051) S2559E. The desired DTMF signals are activated by a twelve-key (3 × 4) or sixteen-key (4 × 4) matrix keypad that is connected directly to the row- and column-input pins of the tone-generator IC. Two major types of keypads are used: One is the standard telephone pushbutton keypad. They are used with IC's that generate tones whenever the corresponding row and column pins are pulled high. As shown in Fig. 3-*a*, that keypad consists of a series of DPST momentary switches with a common line that simultaneously pulls the corresponding row and column outputs high when pressed. Note that some encoders are active low. For those, the keypad common line is connected to ground. Then, the appropriate row and common outputs are grounded when a key is pressed. The other, and simpler, keypad arrangement is shown in Fig. 3-*b*. Referred to as a calculator-type or X-Y keypad, it consists of SPST momentary switches and can be built easily. However, it can only be used with tone generators that use calculator-type scanning circuitry to detect switch closures. The S2559E contains such circuitry. Generally, the data sheet of a particular tone encoder will specify the type of keypad required.

A simple DTMF encoder is shown in Fig. 4. It mainly consists of a 16-key SPST keypad like the one shown in Fig. 3-*b*, and the S2559E tone-encoder IC. Power can be supplied by a small power supply or by a conventional 9-volt battery. Because the S2559E is a CMOS device, power consumption is low. Typically, the circuit shown will draw 5 mA during encoding and 7 μA when idle. Since the device is CMOS, be sure to observe all of the standard precautions when handling the IC.

TABLE 1—PIN FUNCTIONS

Pin	Function
SIGNAL IN	DTMF input. Internally biased so that the input signal may be AC coupled. SIGNAL IN also permits DC coupling as long as the input voltage does not exceed the positive supply.
12/$\overline{16}$	DTMF-signal detection control. When 12/$\overline{16}$ is at logic 1, the M-957 detects the 12 most commonly used DTMF signals (1 through #). When 12/$\overline{16}$ is at logic 0, the M-957 detects all 16 DTMF signals (1 through D).
A, B	Binary DTMF signal-sensitivity control inputs. A and B select the sensitivity of the SIGNAL IN input to a maximum of −31 dBm.
D3, D2, D1, D0	Data outputs. When enabled by the OE input, the data outputs provide the code corresponding to the detected digit in the format programmed by the HEX pin. The data outputs become valid after a tone pair has been detected and are cleared when a valid pause is timed.
OE	Output enable. When OE is at logic 1, the data outputs are in the CMOS push pull state and represent the contents of the output register. When OE is driven to logic 0, the data outputs are forced to the high-impedance or "third" state.
HEX	Binary output format control. When HEX is at logic 1, the output of the M-957 is full 4-bit binary. When HEX is at logic 0, the output is binary-coded 2-of-8.
STROBE	Valid data indication. STROBE goes to logic 1 after a valid tone pair is sensed and decoded at the data outputs. STROBE remains at logic 1 until a valid pause occurs or the CLEAR input is driven to logic 1, whichever is earlier.
CLEAR	STROBE control. Driving CLEAR to logic 1 forces the STROBE output to logic 0. When CLEAR is at logic 0, STROBE is forced to logic 0 only when a valid pause is detected. Tie to VNA or VND when not used.
ED	Early signal presence output. ED indicates that a possible signal has been detected and is being validated.
XIN, XOUT	Crystal connections. When an auxiliary clock is used, XIN should be tied to logic 1.
OSC/$\overline{CLK}$	Time base control. When OSC/$\overline{CLK}$ is at logic 1, the output of the M-957's internal oscillator is selected as the time base. When OSC/$\overline{CLK}$ is at logic 0 and XIN is at logic 1, the AUXCLK input is selected as the time base.
AUXCLK	Auxiliary clock input. When OSC/$\overline{CLK}$ is at logic 0 and XIN is at logic 1, the AUXCLK input is selected as the M-957's time base. The auxiliary input must be 3.58 MHz divided by 8 for the M-957 to operate to specifications. If unused, AUXCLK should be left open.
VNA, VND	Negative analog and digital power supply connections. Separated on the chip for greater system flexibility, VNA and VND should be at equal potentials.
VP	Positive power suppy connection.

Encoder output

The output of the encoder consists of two of the eight DTMF frequencies. Figure 5 shows an oscilloscope display of the row-3 signal (852 Hz) and Fig. 6 shows the column-2 signal (1336 Hz). The DTMF output is produced by adding the two signals together. The resulting signal,

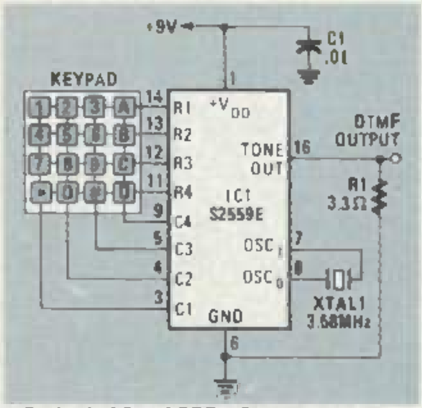


FIG. 4—A COMPLETE DTMF ENCODER requires just a keypad, an encoder IC, a crystal, and two additional components.

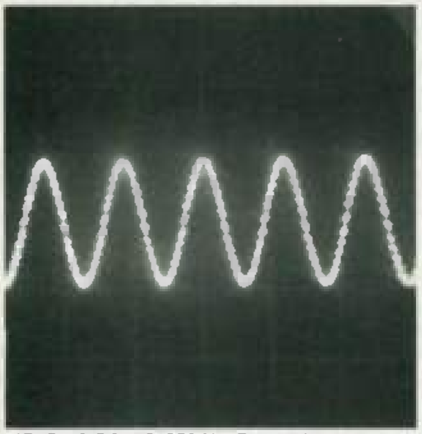


FIG. 5—A ROW 3, 852 Hz, DTMF signal.

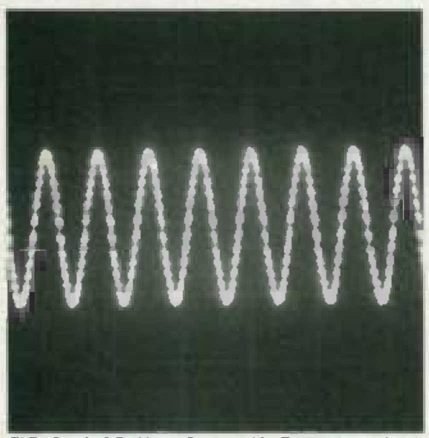


FIG. 6—A COLUMN 2, 1336 Hz DTMF signal.

which would be generated by pressing the "8" key, is shown in Fig. 7. Note that the output of the S2559E is not a pure sinewave. Instead the output is a digitally synthesized approximation, as shown in Fig. 8.

The S2559E also is capable of generating single-frequency tones. To place the IC in the single-frequency mode, pin 15, the mode-select pin (MDSL), is either tied high or left floating; for DTMF operation, that pin is grounded. Once in the single-frequency mode, a single frequency is output by pressing *two* keys in the appropriate row or column. For instance, simultaneously pressing the 4 and 5 keys (in row 2) will result in a 770-Hz output. The single-frequency mode is used primarily for testing.

The S2559E, as well as most other encoder IC's, have mute and transmit pins (MUTE and XMIT). In the S2559E, when no keys are pressed, the MUTE pin is low and the XMIT output is enabled and can source current to an external load. When a key is pressed, the XMIT output goes into a high-impedance state and the MUTE output goes high. Those pins are used in telephone applications. For instance, the MUTE pin is used to mute the telephone receiver during dialing so that the user does not hear the DTMF signals at full volume. The enterprising experimenter will doubtless find many other uses for those handy outputs.

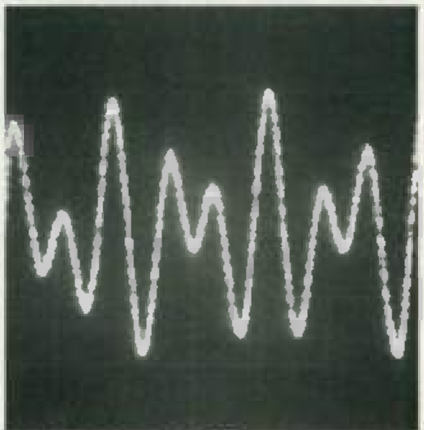


FIG. 7—WHEN THE DIGIT 8 is pressed on the keypad, the encoder generates the signal shown here. It consists of the sum of the row 3 (Fig. 5) and the column-2 (Fig. 6) signals.

To make the output of the encoder circuit audible, a speaker or some other transducer must be driven by the output signal. The S2559E output must be buffered to drive an 8-ohm speaker, but other high-impedance speakers can be driven by the IC directly. For example, the author has driven the earpiece from an old telephone headset by adding a 330-ohm resistor in series with the earpiece to prevent loading the encoder's output as well as to increase battery life.

We've been discussing the S2559E thus far, but there are three other members of that IC family. They are the S2559F, G, and H. Those four devices have replaced the earlier A, B, C, and D versions and feature extended operating voltage (2.5 to

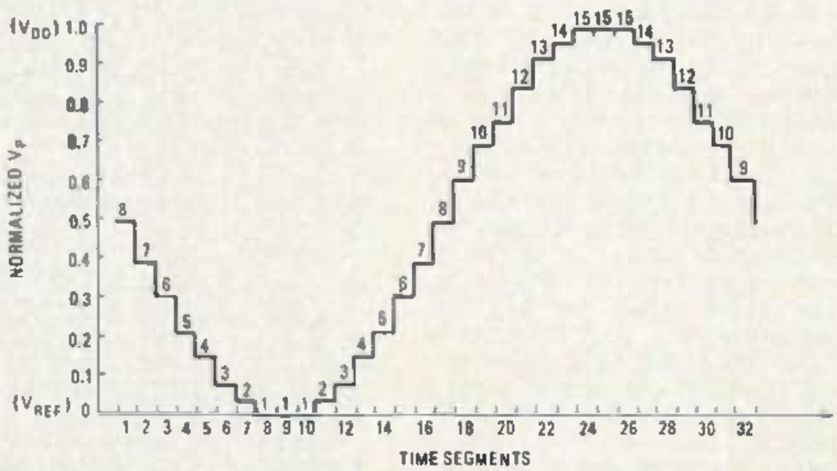


FIG. 8—THE OUTPUT OF THE S2559E is not a pure sinewave. Instead it is a digitally synthesized waveform. The stairstep-shape of such a waveform is shown here.

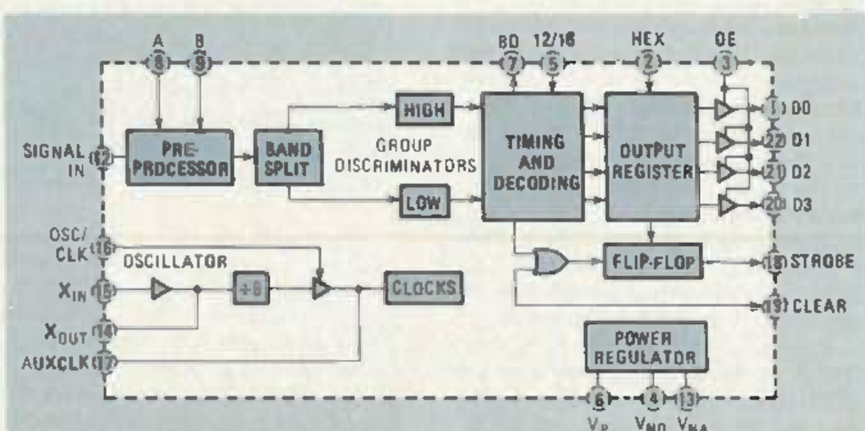


FIG. 9—INSIDE A DTMF DECODER. The M-957 DTMF decoder IC is shown here in block-diagram form.

TABLE 2—DTMF TO BINARY DECODING

Signal	Low-Frequency Component (Hz)	High-Frequency Component (Hz)	Hex Output Format 3210	2-Of-8 Output Format 3210
1	697	1209	0001	0000
2	697	1336	0010	0001
3	697	1477	0011	0010
4	770	1209	0100	0100
5	770	1336	0101	0101
6	770	1477	0110	0110
7	852	1209	0111	1000
8	852	1336	1000	1001
9	852	1477	1001	1010
0	941	1336	1010	1101
*	941	1209	1011	1100
#	941	1477	1100	1110
A	697	1633	1101	0011
B	770	1633	1110	0111
C	852	1633	1111	1011
D	941	1633	0000	1111

Note: The M-957 detects signals A through D only when the 12/16 input is at logic Ø.

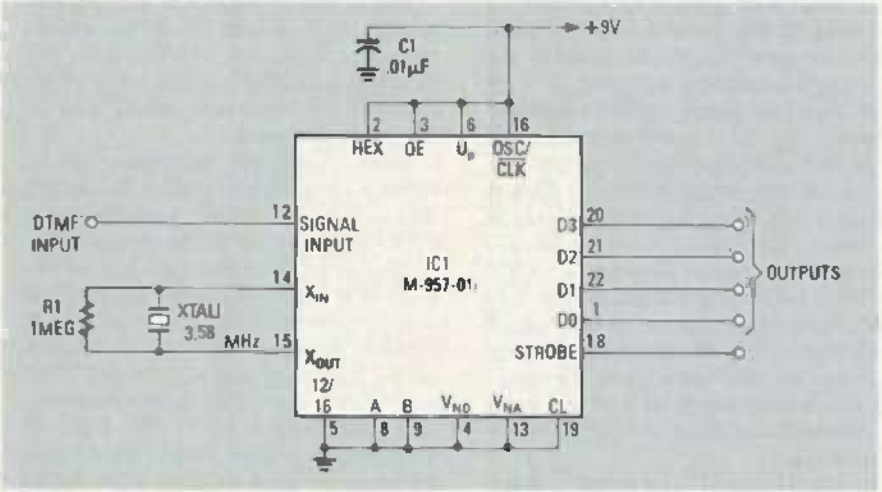


FIG. 10—USING THE M-957, building a DTMF decoder requires just the IC, a crystal, and a capacitor.

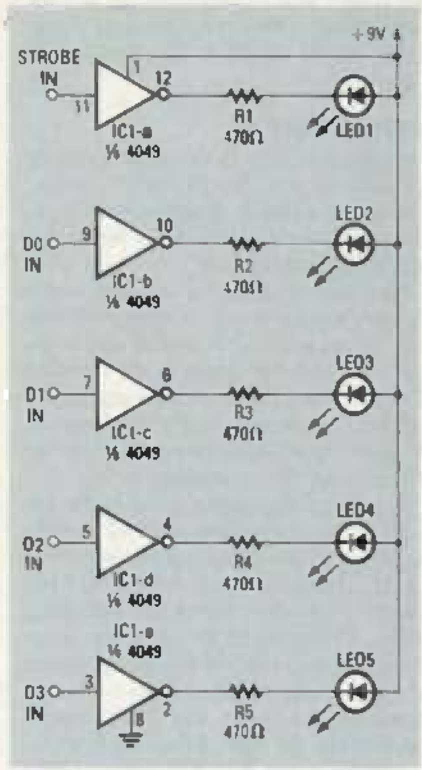


FIG. 11—USE THIS LED MONITOR CIRCUIT to verify that the encoder and decoder are operating correctly.

10 volts), improved tone fidelity, and an on-chip oscillator bias-resistor. In the S2995F, the MOST function of pin 15 is replaced by a chip disable (CD) function that is active high. When that pin is tied high, the row and column inputs are placed in a high-impedance state, the tone output is tied to ground, the oscillator is inhibited, the MUTE pin is tied high, and the XMIT pin is enabled. Essentially, the effect is that the IC is electronically disconnected from the keypad. That allows one keypad to be shared by several different devices.

The S2559G and H are identical to the S2559E and F, respectively, except that the output transistor has been replaced by a Darlington pair. In some applications that eliminates the need for an external transistor amplifier stage in the telephone circuit.

DTMF decoding

DTMF decoding is considerably more complex than DTMF encoding. The most involved function of the detector is to determine whether a received signal within the DTMF frequency band (697–1633 Hz) is a true DTMF signal or merely noise or speech. The detector must also be capable of detecting a DTMF signal that is combined with such noise. The DTMF detector should recognize any valid DTMF signal that is within ±2% of the standard value. The detector's job is made somewhat easier by the fact that a DTMF signal must have a minimum duration of 40 ms, and that each DTMF signal must be separated from others by at least 35 ms.

Somewhat surprisingly, most of the circuitry required to decode DTMF signals is now available in IC form. Therefore, despite its greater complexity, an entire 16-digit decoder can be built as easily and as simply as a 16-digit encoder.

DTMF decoders are often referred to by manufacturers as DTMF receivers. Those devices have only recently become commonly available at affordable prices. Some can be purchased for under $15.00 in single-unit quantities. Just a few years ago, when the first IC encoders became available, those devices cost about $100, and required external filters. The IC's on the market today are extremely sophisticated signal-processing devices with switched-capacitor filtering that use digital frequency-detection techniques. They can reliably detect DTMF signals with no need for pre-filtering.

The decoder that we'll use in our circuit is the M-957 from Teltone (P.O. Box 657, 10801-120th Ave. N.E., Kirkland, WA 98033). That CMOS device can be powered by a DC power supply or batteries. There are two versions of the M-957: the M-957-01, which can accept voltages of 5 to 12, and the M-957-02, which is designed for 5-volt operation only.

A block diagram of the M-957 is shown in Fig. 9. The function of each pin is outlined in Table 1. The pre-processing stages of the M-957 filter out noise and split the received DTMF signal into its high and low-frequency-group components, and limit each component to provide automatic gain control. The individual tones are then detected. The decoded output of the M-957-01 is a 4-bit binary code appearing at the DØ–D3 output. The output code format can be selected via pin 2, HEX. When that pin is high (logic 1), the output format is 4-bit hexadecimal; when the pin is low (logic 0), the output format is binary-coded 2-of-8.

Putting it together

It takes very little in the way of external circuitry to put the M-957 to work. Adding just a single capacitor and a crystal as shown in Fig. 10 yields a functional DTMF receiver/decoder.

Now that we have an encoder and a decoder, the next step is to verify that both work as intended. The easiest way to do that is to wire the output of the encoder (Fig. 4) to the input of the decoder. If you are using separate sources (batteries or DC power supplies) to power the circuits, be sure to tie their grounds together.

To monitor the output states of the encoder during testing you can build a simple monitor circuit like the one shown in Fig. 11. That circuit uses ⅚ of a 4049 hex inverter as a buffer to drive five indicating LED's. Those five LED's show the states of the four data outputs as well as state of the STROBE output. Table 2 shows the correspondence between the DTMF signal received and the state of the data outputs. The strobe output should be high, as indicated by a lighted LED, any time that a valid DTMF signal is received and decoded by the circuit.

Once you are sure that the decoder is operational it is time to think about adding to its usefulness and versatility. For one thing, the outputs could be further decoded to provide a 1-of-16 output. A circuit for doing that is shown in Fig. 12.

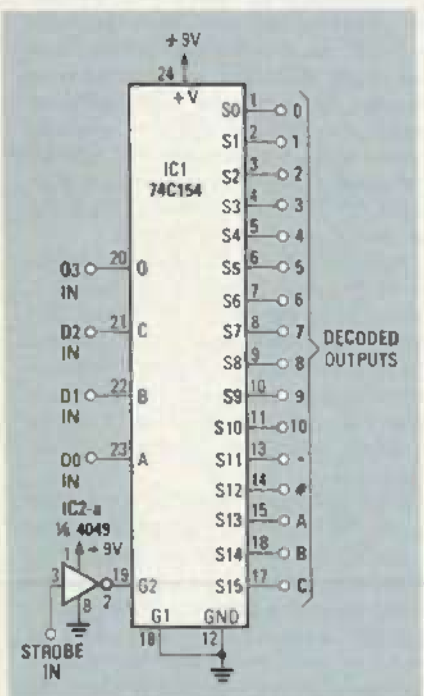


FIG. 12—THE FOUR-BIT OUTPUT of the M-957 is decoded using this circuit. With it, each DTMF code can be used to address one of the 16 outputs.

ORDERING INFORMATION

The following is available from High Technology Semiconductors, 2512 Chambers Road, Suite 204, Tustin, CA 92680, (714) 259-7733: Teltone M-957-N, $11.35; Stantel STC-5089-N (which is pin-for-pin compatible with the AMI S2559E), $2.10; 3.58-MHz crystal, $1.25. Also available is a kit of parts, TRK-957-N, which consists of the M-957, STC-5089, 3.58-MHz crystal, a 22-pin DIP socket, and a 1-megohm resistor for $14.95. Please add $2.30 shipping to all orders. MasterCard, Visa, and COD orders accepted.

Built around a 74C154 4-to-16 decoder/multiplexer, it provides 16 separate output lines. Each of the 16 DTMF signals will enable only one of the circuit's normally high outputs. For instance, if a DTMF 9 is received, only the S9 output, pin 10 of IC1, will go low. That output will remain low as long as a valid DTMF 9 is being received by the circuit.

Another useful enhancement would be to add some type of latched output. That means that once the appropriate DTMF signal is received, the output would remain either high or low until the next time the same DTMF signal is received. Such operation approximates the on/off action of a toggle or pushbutton switch.

A circuit for adding latched outputs is shown in Fig. 13. It is built around half of a 74C73 dual flip-flop that is configured to act as an edge-triggered binary divider (divide-by-2). When the circuit is used as shown, no external debounce circuitry is required. The input is shown as a DTMF D, but it could be any of the DTMF signals. Two complementary latched outputs are available. Use whichever output is appropriate for your application. Tie all of the IC's unused inputs (IC1-b) to ground to prevent oscillation and unnecessary current drain.

Switch S1 is used to clear both outputs to zero. That switch is not needed for all applications and can be eliminated if desired. Conversely, the circuit can be set up

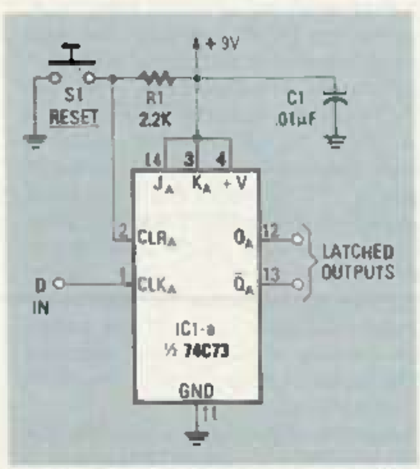


FIG. 13—LATCHED OUTPUTS can be provided using this circuit.

for remote reset. That is done by eliminating the switch and the 2.2K resistor (R1) and tying one of the momentary outputs of the 74C154 to the $\overline{CLR_A}$ pin of the 74C73. For example, if pin 17 of the 74C154 is connected to pin 2 of the 74C73, the latch will be reset anytime a DTMF C is received. If no reset function is desired, the $\overline{CLR}$ pin must be tied high.

Up to sixteen devices may be independently controlled by the outputs of the circuit in Fig. 12. If the controlled device is digital and if it is voltage-compatible with the decoder output, direct connection to that device is possible. If heavy driving currents are required, that current can be supplied by transistor switches located at the decoder outputs. If the voltages are not directly compatible, matching can be done using optocouplers or power-driver IC's. Also solid-state relays may be used to interface the digital signals with high-voltage, high-current loads, such as 117-volt AC household appliances, or even industrial devices with larger power requirements.

Going farther

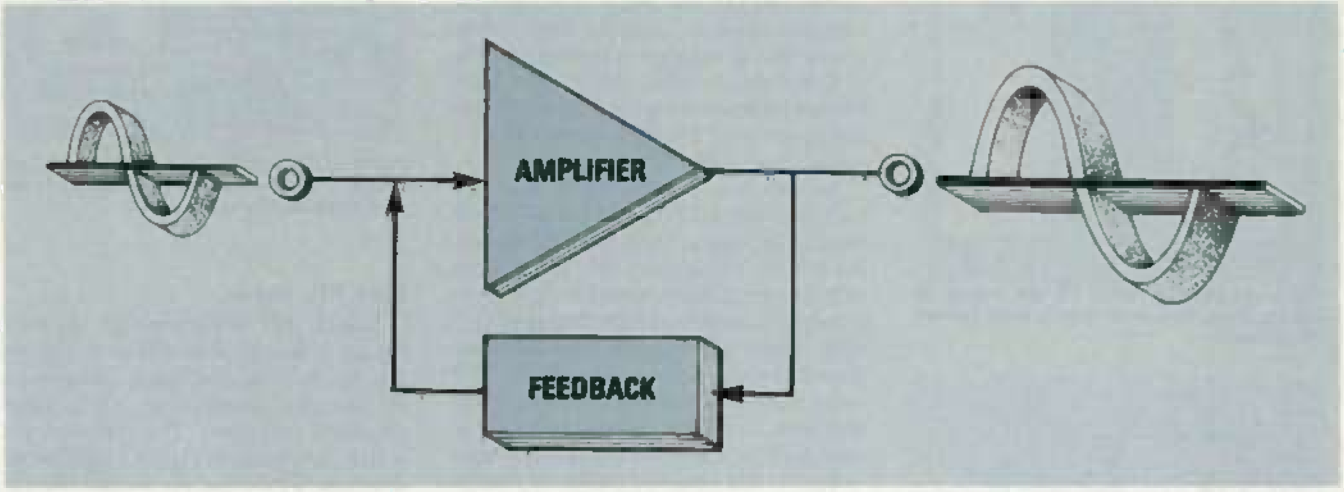
If a wireless data link is desired, any simple, single-channel radio or infrared communications link may be used. For example, a toy walkie-talkie set or a low-cost FM wireless-microphone/FM radio system may be used.

Many DTMF tone generators can be driven by logic-level signals. That allows direct control of DTMF signalling by a microprocessor or ROM circuit. The S2559E requires active high logic-levels at all of its row and column inputs. That means that an 8-bit signal or some type of external driving circuitry is required for digital control of the IC. Other DTMF devices are better suited to digital control. One such device is AMI's S2579 DTMF tone generator with binary input. That device is designed so that a 4-bit digital signal can be used to encode all 16 DTMF signals.

The DTMF IC's will function with crystal frequencies other than those specified for DTMF operation. However, the frequencies that will be generated or decoded will differ from the standard DTMF ones. If a higher crystal frequency is used, all tones will be correspondingly higher in frequency; if a lower crystal frequency is used, all tones will be lower in frequency. That effect can be useful for applications such as when a private communications code is desired.

In this article we've presented some of the basics of DTMF communications. We've also presented some possible applications of that technology. For the enterprising experimenter there are countless more. Now that the cost of the required encoding and decoding IC's is so low, the only limit to their use is your own imagination. R-E

How to Design OSCILLATOR Circuits



Digital clock circuits using TTL IC's.

Part 6 THIS TIME WE'LL DIScuss digital clocks. We don't mean time-of-day clocks, but circuits that create pulse trains for synchronizing digital circuits. Digital clocks usually produce either a squarewave or a trapezoidal wave. In this article we'll discuss digital-clock circuits based on TTL IC's.

TTL basics

The TTL logic family was probably the first really successful family of integrated digital devices. Previous families (e.g., RTL and DTL) never really attained the widespread popularity enjoyed by TTL devices. One reason for TTL's popularity is that it uses standard input and output circuits, and standard logic levels.

A digital circuit is binary in nature; that is, it permits only two possible states. Those states, 1 and 0, can be represented by the digits of the binary (base 2) number system. Those two states are often called high and low (respectively).

Figure 1 shows the standard logic levels for TTL devices. The high condition is attained when the input or output voltage is greater than +2.4, but less than +5. The low condition is represented by any voltage between 0.0 and 0.8. Voltages above +5 (the groan zone) and below ground (the zap zone) must be avoided. In addition, an inappropriately connected capacitor or inductor can also feed too much (or incorrectly polarized) voltage to TTL devices.

The members of any logic family work together because inputs and outputs can be interconnected with only a conductor—no impedance-matching or other devices are necessary. Figure 2-*a* shows a standard TTL output, and Fig. 2-*b* shows a standard TTL input. The TTL input acts as a 1.6-mA current source, and the TTL output acts as a 16-mA current sink.

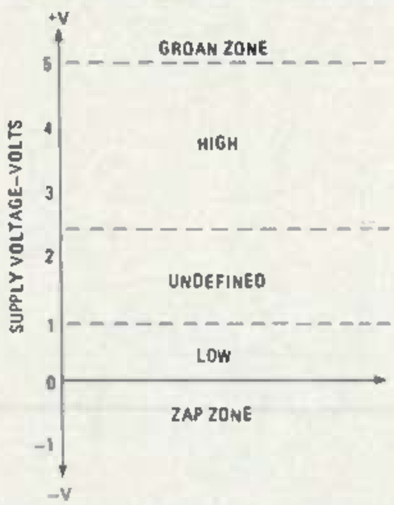


FIG. 1—VOLTAGE LEVELS OF A TTL IC determine logic state. Any voltage below 0.8 is a logical low; any voltage above 2.4 is a logical high. Signals in the groan and zap zones may destroy a TTL device.

To interface TTL devices, all we must do is make sure that current-drive requirements are met. Those requirements are simple to calculate because of standardization. A single 1.6-mA input is said to have a "fan-in" of 1. A single 16-mA output has a fan-out of 10. In other words, a standard TTL output can drive 10 standard (fan-in-of-1) devices.

There are several sub-families of TTL devices. For example, low-power TTL devices are signified by an "L" in the part number (e. g., 74L00). L-type devices have lower drive capacity than regular TTL. There is also high-speed TTL, which contains an "H" in the part number (e.g., 74H00). There is also low-power Schottky. That is probably the most commonly used type of TTL IC; it contains "LS" in the part number (e. g., 74LS00).

The LS type of TTL device has Schottky diodes at its inputs; those diodes are somewhat sensitive to static electricity. Therefore, it is recommended that you handle LS-series TTL devices almost as gingerly as you would handle CMOS devices. The various sub-families have differing drive capacities; consult a data book for details.

Using TTL

Figure 3 shows a circuit that converts

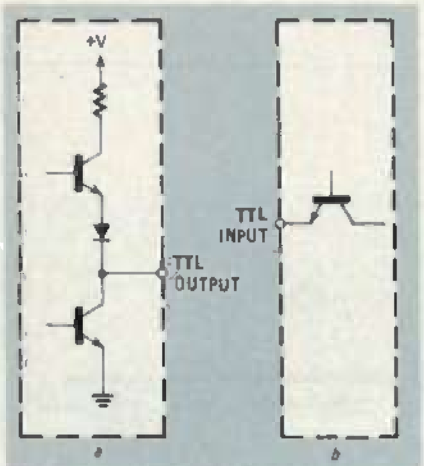


FIG. 2—STANDARD INPUT (a) and output (b) circuits make it easy to interconnect various TTL devices.

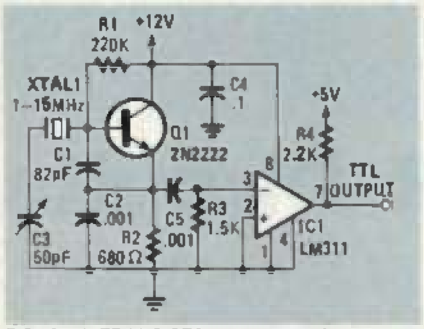


FIG. 3—A TRANSISTOR OSCILLATOR may be made TTL-compatible by following the output with a comparator.

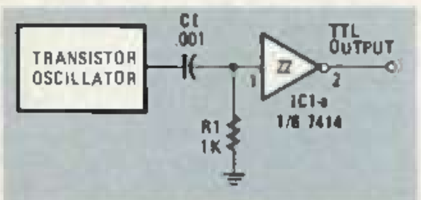


FIG. 4—A SCHMITT TRIGGER may also be used to make a transistor oscillator TTL-compatible.

the output of a transistor-based Colpitts oscillator circuit to TTL levels. As we saw in Part 5, which appeared in the November issue, the feedback level in a Colpitts oscillator is set by the capacitive voltage divider composed of C1 and C2. The oscillator's frequency is set by XTAL1, a piezoelectric crystal. Variable capacitor C3 allows fine control of frequency.

The output stage is an LM311 comparator. A comparator is basically a differential amplifier with too much gain. In any differential amplifier, the output voltage is a function of the difference between the two input voltages. When the input voltages are equal, the difference is zero, so the output voltage will be zero. But when those voltages differ by even a few millivolts, the output voltage will be non-zero. The gain of a typical comparator is 10,000 to 100,000, so the output will saturate any time that the differential input voltage is non-zero.

In Fig. 3, the non-inverting input is grounded, so it sees a zero potential. Hence, whenever the signal applied to the inverting input (pin 3) exceeds zero volts, the output will go low.

The LM311 has what is called an "open-collector" output stage. That means that it requires a pull-up resistor (R4) in order to supply current. The 2.2K resistor shown can supply only about two mA of current at five volts, so the LM311's output is not truly TTL-compatible.

Another way to accomplish the same trick is to use a TTL IC called a Schmitt trigger. The operation of the Schmitt trigger follows this simple rule: The output will snap high when a positive-going input signal crosses a certain threshold (1.7 volts), and it will snap low when the input signal crosses a lower threshold (0.9 volts) in a negative-going direction. If the transistor oscillator shown in Fig. 3 is used to drive a Schmitt trigger, as shown in Fig. 4, the sinewave output of the oscillator will produce a train of squarewaves at the output of the Schmitt trigger.

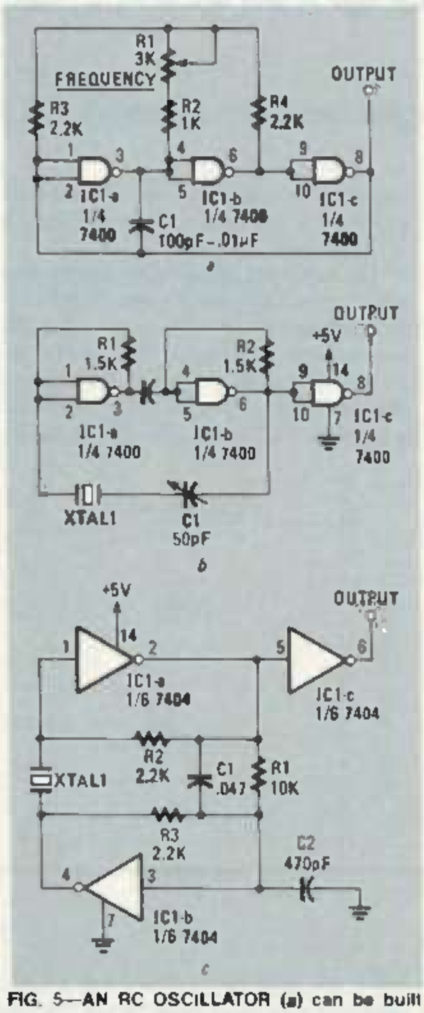


FIG. 5—AN RC OSCILLATOR (a) can be built with three gates and several discrete components. For better stability and accuracy a crystal oscillator may be used. Two popular configurations are shown in (b) and (c).

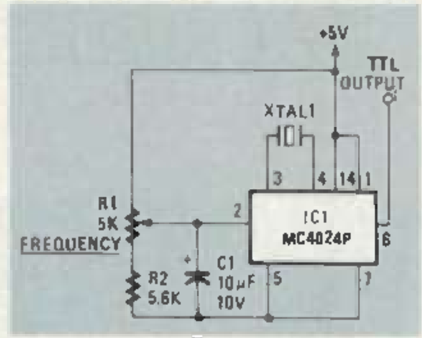


FIG. 6—A TTL-COMPATIBLE VCO requires just a crystal and a few discrete components to be a very stable oscillator.

Pure TTL clocks

Several TTL oscillators are shown in Figure 5. The circuits shown in Fig. 5-*a* and Fig. 5-*b* use NAND gates configured as inverters; the circuit in Fig. 5-*c* uses three standard inverters. The frequency at which the circuit in Fig. 5-*a* oscillates is determined by capacitor C1 and resistors R1 and R2. Potentiometer R1 allows you to vary the operating frequency over a small range. If only a single fixed frequency is needed for your application, replace R1 and R2 with a single fixed resistor.

One disadvantage of any RC oscillator is that its operating frequency is neither stable nor accurate. The effects of both problems can be reduced by using a piezoelectric crystal, as in Fig. 5-*b* and Fig. 5-*c*. Two of the NAND gates are used for the oscillator (IC1-a and IC1-b); the third functions as a buffer stage. Operating frequency is set by crystal XTAL1, and may be varied with capacitor C1.

The circuit shown in Fig. 5-*c* is similar to the one shown in Fig. 5-*b*, and is based on TTL inverters. Again, one stage (IC1-c) is used as an output buffer, and the oscillating stages are self-biased.

Special TTL oscillators

There are several all-in-one TTL oscillators on the market; Fig. 6 shows the diagram of a circuit based on the MC4024P dual voltage-controlled oscillator. Only one oscillator is used in that circuit. By the way, don't confuse the MC4024P with the 4000-series CMOS device called the 4024.

The center frequency of oscillation can be controlled in two ways: with a capacitor or with a crystal. For non-critical applications, a capacitor is used; it will have a value of approximately 300/*f* (Hz) picofarads. Potentiometer R1 gives you some control over the circuit's frequency.

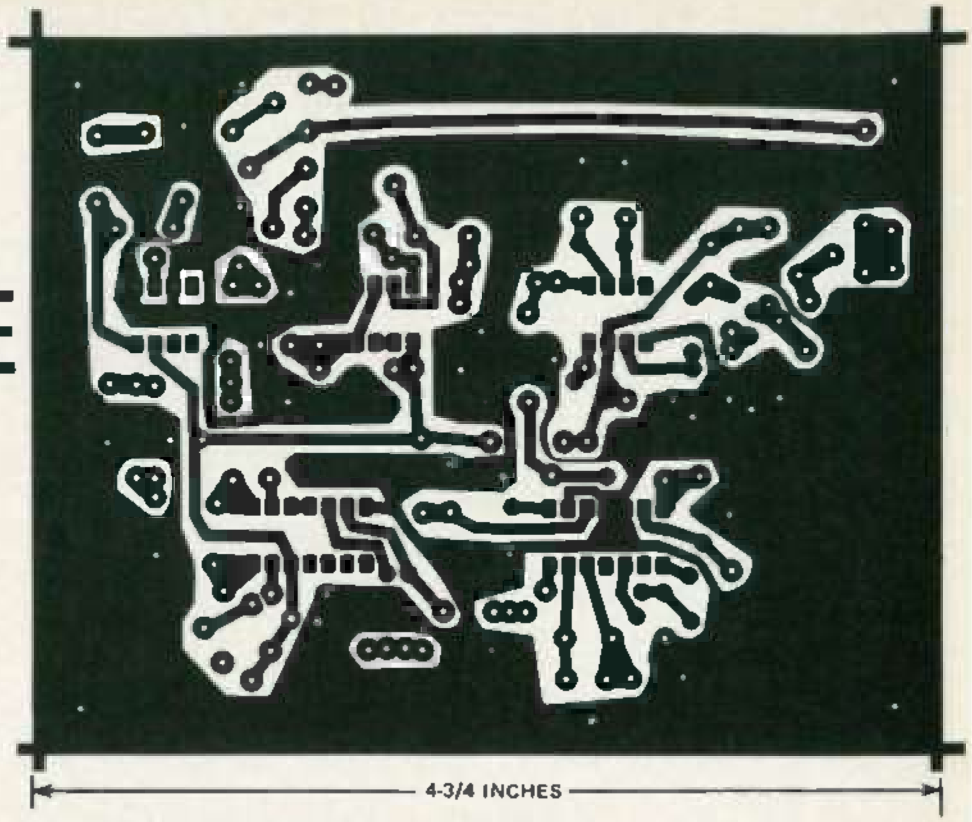
TTL clocks are easy to build and to operate, especially in applications where a great deal of frequency stability is unnecessary. In the next and final installment of this series we will examine clock circuits made from CMOS IC's. R-E

PC SERVICE

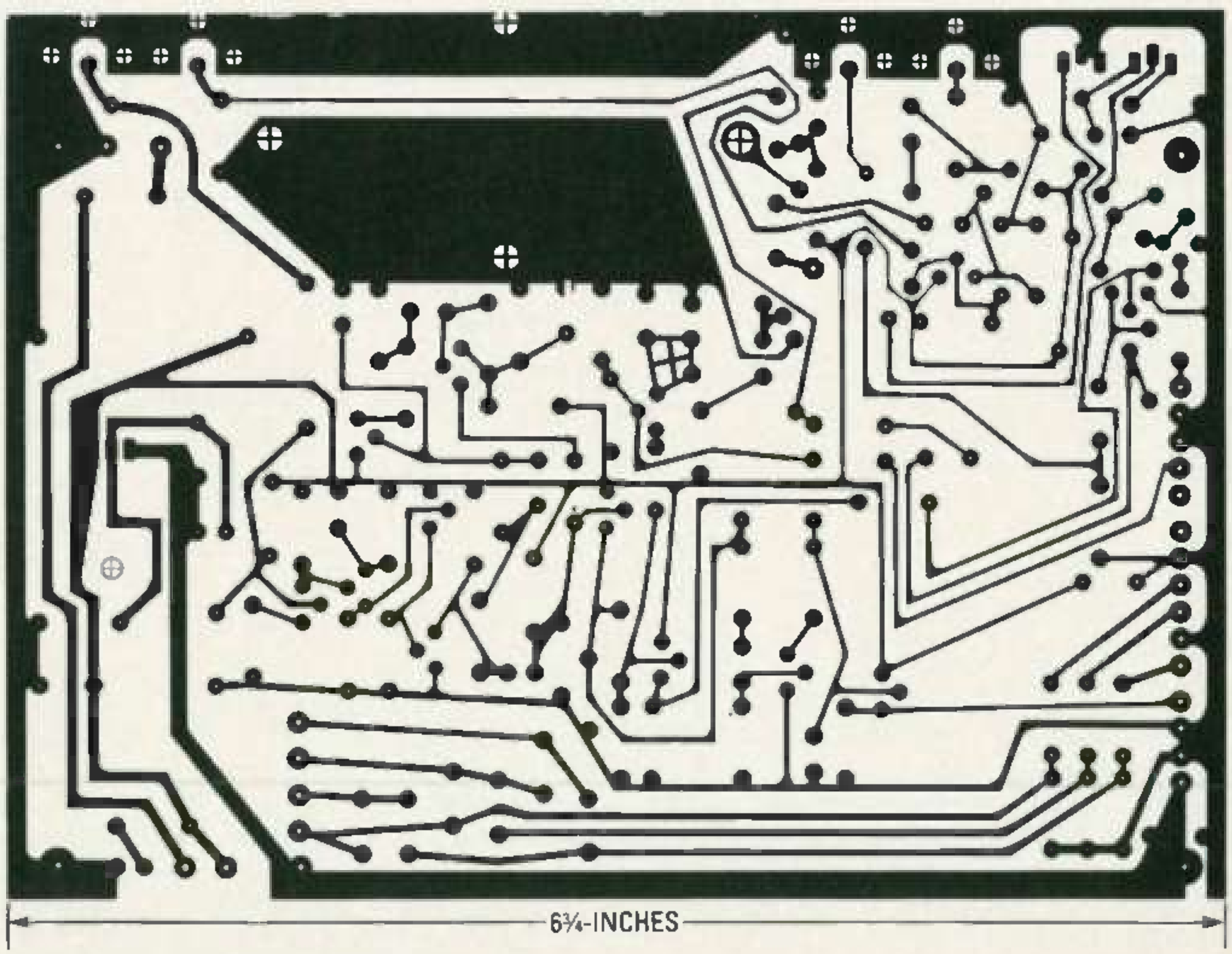
One of the most difficult tasks in building any construction project featured in **Radio-Electronics** is making the PC board using just the foil pattern provided with the article. Well, we're doing something about it.

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

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



BUILD THE SINEWAVE DESCRAMBLER using this PC pattern.



THE CLOSED CAPTION DECODER'S PC board is shown here.

VOL. 3 NO. 12 DEC. 1986

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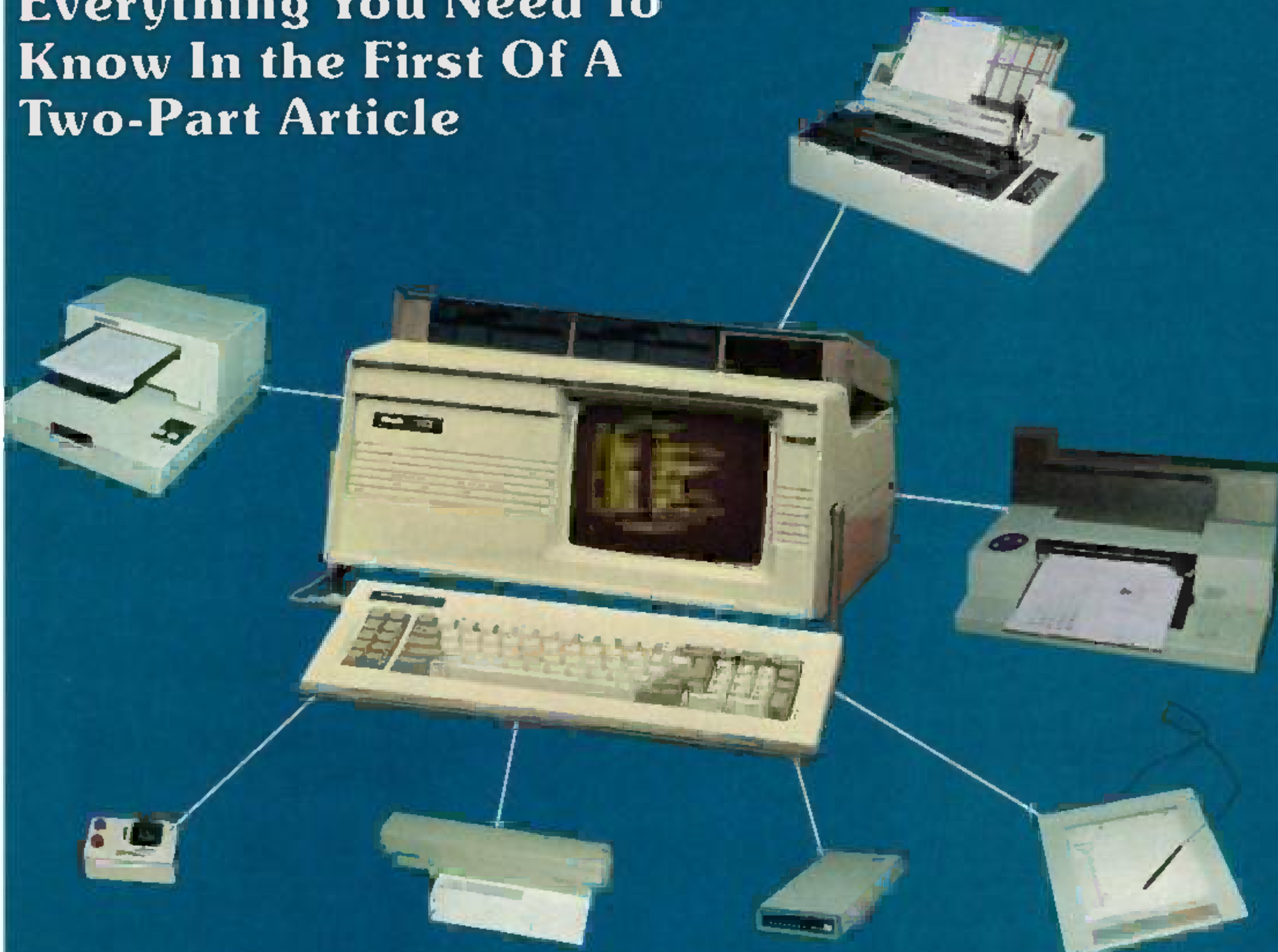
ALL ABOUT INTERFACING

Everything You Need To Know In the First Of A Two-Part Article



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A New Battle Is Shaping Up

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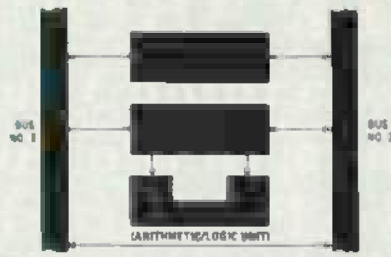

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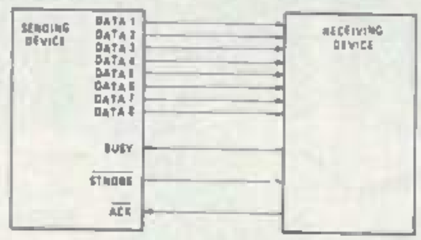

See Page 9

ON THE COVER

If you're going to be doing ANY interfacing, you'd better start by reading the story beginning on Page 9 of this issue. Admittedly, it's a bit more involved than laying out photos and drawing the connecting lines! Most of the photos of assorted equipment around our office, were taken by Herb Friedman.

COMING NEXT MONTH

Naturally, we try to pack all the information that we can into each issue. But in the January, 1987 issue, we've really outdone ourselves. You won't want to miss the conclusion of our two-part article on interfacing, and we've got an important how-to on TVRO antenna pointing. We're finishing up with a fine piece on a five-volt RS-232. Don't miss it.

EDITORIAL

Let's standardize the "standards."

■Henry Ford has to be the father of mass production, and he built this scheme on totally-interchangeable parts. The carburetor of one car could easily be switched with the carburetor of another car. And the need for standards extends well-into electronics. Every young electronics devotee knows the standard for the resistor color code. You can see them counting on their fingers, as they recite, "Bad boys..."

But something began to go awry when it came to stadardizing capacitor color codes. There were decimals to be considered, and multipliers, and the result was utter confusion.

Today, in the computer field, we have the so-called "RS-232" standard. But the manufacturers do not cleave to the standard, using their own variations for their own convenience. The result is a non-standard standard, and when you say "We're using RS-232," you find people asking just *which* "RS-232?"

It goes even beyond that. We have assorted operating systems, beginning with MS-DOS and CP/M and a host of other proprietary systems produced by various manufacturers, that prevent a software package that works on one, from working with another. The standard that seems to be emerging, is the IBM system, for almost every software manufacturer talks about "IBM compatibility."

Even the simple blank disk cries for standardization. You now have a choice of "hard sectored disks," or "soft sectored disks."

Wouldn't it be nice to be able to buy a computer without having to trace down the standards to make sure that they were indeed standard? Or that your projected computer purchase would operate *all* the disks you now have? Sure it would.

Now I'm shopping for a videocassette recorder. Top loading? Front loading? VHS? Beta? Programmable? Fast scan?

Decisions! All day long, decisions!

Byron G. Wels
Editor

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LETTERS

Too Long

I submitted an article to your magazine, and got paid for it. Thank you. That was several months ago, and it still hasn't appeared in print. What's the delay?—S.T., Orlando, FL.

Have a heart! First of all, things just take time. For example, this column will actually appear in the December Issue, but as I write these words, it's really August. The 17th, to be exact. And yes, if you look it up on a calander, it's a Sunday. And right now, the magazine is all set through February. So maybe the next time we need a three-pager, and yours fits, you might get lucky.

Warranty

I'm confused about my computer warranty. It runs for a full year, *unless* I open the case! Now (a) how can I add a board or do some construction if I don't open the case, and (b) how are they going to know whether or not I did?—J.T., Fresno, CA.

You pays yer money and takes yer cherce. Open it up, and you automatically void the warranty. And yes, they will know, for the manufacturers usually put a dab of paint on a cover-mounting screw, or paste on a small paper patch. Break the paint or paper and you kiss your warranty goodbye. We usually suggest waiting until the warranty expires before experimenting.

Budding Editor?

I'm fascinated with the publishing business and would (I think) like to get into it when I get older. What would you recommend?—A. L., Memphis, TN.

It's been extremely kind to me, and I'd suggest you start preparing the publishing business as well as yourself, by submitting articles on a freelance basis. This will help you learn to write, and will start getting your name around.

Expensive?

I've been pricing furniture (desks/tables) for my computer equipment. Now why is that stuff so expensive?—S.K., Reno, NV.

It doesn't have to be. Your local lumber yard can sell you a sheet of 4 × 8 plywood, finished one side and ¾-inch thick at a very low price. For another couple of bucks they'll cut 30-inches off one end and run another cut 30-inches down the length of the remainder. That will give you two handsome table tops, ready-to-finish and enough wood to make legs with!

COMPUTER PRODUCTS

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

VOICE-RECOGNITION SYSTEM, the *Voice Master,* is a half-card expansion board with resident program that recognizes hundreds of words. It is designed for the IBM-PC, XT, AT and compatible

CIRCLE 27 ON FREE INFORMATION CARD

personal computers. Versions are currently available for Commodore, Apple II series, and Atari 8-bit microcomputers.

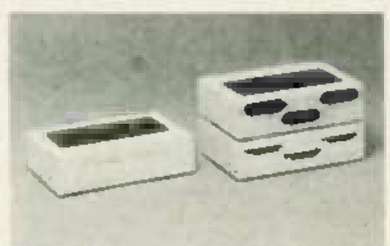
The *Voice Master* has a suggested retail price of $129.95, which includes half-card circuit board, microphone headset, and resident system software.—**Covox, Inc.,** 675-D Conger St., Eugene, OR 97402.

SYNCHRONOUS MODEM

The model *91* is designed to function point-to-point or in a multi-polled network. Multi-dropped operation is achieved by using a daisy-chained approach to system wiring, in which each model *91* regenerates each signal before passing it on in the link. That process of incorporating signal repeaters results in extremely-high data reliability, especially at long distances. At 19,200 baud, the model *91* will support link distances of one mile.

The opto-isolation feature assures that devices connected to the model *91* are electrically isolated from each other, thereby eliminating problems associated with potential differences between grounds.

The model *91* provides full duplex synchronous serial data communication from 150 to 19,200 baud using frequency modulation. Transmission of a self-clocking FM signal on a balanced



CIRCLE 28 ON FREE INFORMATION CARD

opto-isolated current-loop allows transfer of clocking information as well as data. The model *91* can also be linked to establish a full-duplex bus network between host and a number of remote terminals. It is priced at $250.00.—**Telebyte Technology, Inc.,** 270 Pulaski Road, Greenlawn, NY 11740.

SOFTWARE REVIEW

That's right! A print shop in your computer.

■Judging by its use, The Print Shop is probably the best-selling program. The program is used by schools, supermarkets, shops, even used-car dealers (and you know they're fussy about advertising).

For all its popularity, The Print Shop isn't a word processor, a spread sheet, time-manager or CAD/CAM. It's a signmaker. Using pin-feed paper it makes 8½ × 11 inch signs, greeting cards from folded 8-1/2 × 11 inch paper, letterheads, and banners; which can be used as advertising flyers, bookplates, report covers, award certificates, even abstract printed designs.

The program has an assortment of type styles in three formats (solid, outline and three-dimensional), borders, graphic characters and symbols, even abstract patterns. Each type style is its own size, each can be stretched to a proportional GIANT size. (The Commodore version has eight upper case fonts, nine border styles, and 60 graphics. The IBM version has twelve type styles in upper and lower case, sixteen borders, and 119 graphics.)

The user can integrate any type style with any border and any graphic, or any print function can be left out so the paper can be run through for a second or third printing, or run through to add conventional text from a word processor. When set to print greeting cards, all type, graphics and borders are reduced to the appropriate size and the printing is automatically rotated 180° so that everything comes out right side up when the paper is folded into a card.

Because the program was intended for children (if adults ever give them a chance to use it), it is menu-driven by cursor movement: the user steps the cursor to the desired mode and then hits RETURN. Each menu, except for graphics selection, shows the available and selected border and type styles. (The IBM version also shows the available and selected graphics.)

Special screens let the user select a small, medium or large graphic, built-in or custom graphic layouts, and line and page type-setting. The screen shows the possible graphic locations depending on the user's size selection (the graphics cannot overlap), and the allowable characters per line for each type and size type. If you select GIANT size and the characters won't fit the available space the screen shows what will fit, along with left, center or right positioning normal, reverse or 3-D type on a per line basis, and automatic top-to-bottom centering, if desired.

The program is goof-proof, and you can step back through each function one at a time and change only

what you want to change without losing all your work. For example, if after completing a sign you decide to change the border, say from *stars* to *hearts*, you step back through the composing, type selection, and graphics until you come to the border menu. You then change the border and step forward through graphics and type without affecting anything other than the border selection. You can even step back and change the position of a single line of type, or its outline, or even erase a line or characters (there is a built-in editor). What you can't do is mix type styles or graphics. The only variation on this rule is the IBM version, which permits the type to be upper or lower case on a per-line basis; that is, the line must be all upper case or all lower case.

The Print Shop has a graphics editor that lets you create your own graphics. In the Commodore version, the user-generated graphics can be saved to disk, but that's all that can be saved. In the IBM version the graphics and any sign, card, stationary or banner design can be saved to disk.

Each version supports a selection of printers, which is listed on the back of the box. If your printer isn't listed assume the program will not work.

The Print Shop is supplied on disk and requires at least one disk drive. It comes with a supply of heavyweight pinfeed paper and greeting card envelopes. Additional multi-color supplies and disk volumes of additional graphics characters are available. The Print Shop is heavily discounted: It sells for $19.95 to $59.95 depending on the version and the dealer.—Broderbund Software, 17 Paul Drive, San Rafael, CA. 94903-2101.

V-20 VS 8088

Is there a direction change in the offing?

MARC STERN

■The way to stay afloat in the microcomputer world is IBM emulation, as it is accepted by big business, professionals, and home users.

Many manufacturers, having first tried to go their own ways found that crowds weren't flocking to their doors for solutions. The crowds were still heading toward IBM. Those firms that were able to switch have survived, while those that haven't are no longer active in the microcomputer market.

The ultimate in emulation would be a microprocessor that not only emulates, but surpasses that used in the IBM Personal Computer series.

Such a microprocessor is the Nippon Electric Co.'s (NEC) V20/30 series. It not only emulates the 40 pin Intel 8086/8088 series, used in the IBM PC and close compatibles, but it betters that series by using less power (300 mW versus 1.7 W) and operates about 20 percent faster than the IBM version.

The only way you can differentiate between the two, is the NEC stamp on the microprocessor chip, and the "V" designation.

The V20/30 series has an added mode, 8080 emulation. This gives CP/M users an out because CP/M was written to work in a Z80/8080 environment. With an emulator the V-20 will function effectively as an 8080. So those CP/M programs which may have been threatened with obsolesence by the 8086/8088 series and PC/MS-DOS will gain a new life and users will be able to retain their investment in software.

A closer look

The V20 and V30 are equivalent to the 8088 and 8086, respectively. Like the 8088, the V20 is an 8/16 microprocessor. It has an 8-bit data bus, but a 16-bit internal architecture. The marketing departments of various microcomputer manufacturers like to call this type of microprocessor a 16-bit device, but, it really isn't.

The true 16-bit device is the 8086. It has a 16-bit architecture, and also a 16-bit data bus. It is faster than the 8088 in realtime number crunching. The V30 is the

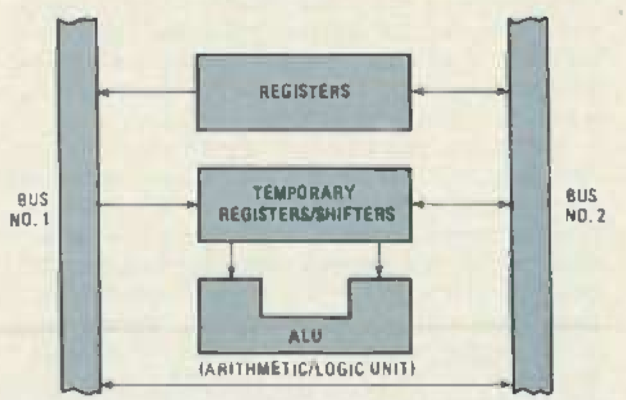


Fig. 1: A DUAL INTERNAL BUS helps increase the performance level of the V20/V30 series. The 8086/8088 family has a single internal bus and must suspend information processing as it moves source and destination data back and forth. The V20/V30 can move this data simultaneously.

functional equivalent to this device.

Both microprocessors are available in 5 and 8 MHz versions and they are CMOS devices. While both microprocessor series are functionally equivalent, the V20/30 series uses 600 percent less power to handle the same jobs. For a system that is struggling at the razor edge of its power supply the lower demands of the NEC device can make a difference.

Not only are the V20/30 chips power misers in their active mode, they offer a standby mode where their power consumption drops from 300 mW to 30 mW which means these devices can be used in standard desktop machines, and they can be used in briefcase or lap-top microcomputers.

The advantages seem to be with the V20/30, because the V20/30 series is much newer than the 8086/8088 family. Because it was designed recently, NEC has taken advantage of Very Large-Scale Integration and gate array technology, as well as advances in CMOS technology to produce this capable chip. The 8086/8088 series was designed in the mid-1970s and its age is beginning to show.

Another result of the age difference is the V20/30's dual internal bus (See Fig. 1), which compares with the single internal bus of the 8086/8088 family. This can effectively increase the speed specifications of the V20/V30 because destination and source data can move along the data bus at the same time in two directions.

Data are taken into the registers in preparation for processing and the data are sent to the temporary storage registers and shifters. At this point, the data goes to the arithmetic-logic unit (ALU) for processing and then to either bus, depending on whether the information is source or destination. Data can pass from the registers back to the second bus.

Moving in parallel, the microprocessor is freed of of wait states generated by having to free alternate cycles on the data bus for 16- bit source data and then destination data. Picture a single freeway lane trying to accommodate traffic in both directions during rush hour. This applies to the execution time of the 80886/8088 family. (We're talking about a difference of microseconds and the user won't notice the difference in speedup unless the application crunches a lot of numbers and must constantly fetch and latch the numeric data.)

Another change in the architecture of the V20/V30 is the substitution of hardware address calculations for the software (microcode) and hardware address calculation of the 8086/8088 series. The V20/30 series includes a hardware section which performs address calculations from 2.6 to 6 times faster than the 8086/8088. Where it takes the 8086/8088 from five to 12 clock cycles to perform address calculations, the V20/V30 performs them in two. Address calculation, then, is also transparent to applications, which means that a developer only has to be concerned with a standard set of addresses for a particular device, rather than having to worry about both hardware and software addressing.

Another performance enhancement that is unique to the V20/V30 is its prefetch pointer. (See Fig. 2)

Working with the instruction pointer, the prefetch pointer speeds things by moving to the next instruction and points to it as the microprocessor works through a program. A movable pointer, the prefetch jumps to the next instruction no matter how far it is from the instruction pointer. This enhances performance because the next Instruction is always available for the micro.

The V20/V30 begins with performance advantages that the 8086/8088 series doesn't have. These advantages wouldn't make much difference if the V20/V30 wasn't compatible with the 8086/8088 family, which it is.

When it was developed, this series was modeled on and implemented the instruction set of the 80186/80188, a more powerful and later version of the 8086/8088 family. The differences were in the level of integration of such functions as the timer and interrupt controller, which are on-chip functions on the 80186/80188 series. The instruction set is enhanced with new instructions which add power and flexibility, but without sacrificing compatibility. There's no loss of compatibility as the complete instruction set of the 8086/8088 series is supported, as well as the additional code.

Speed improvement

While the specifications indicate a potential speed increase, it doesn't work out that way in practice. The V20/V30 series gives a user about a 20 percent increase in performance. Independent testing has confirmed this. The increase in speed is noticeable in processor-intensive applications where the microprocessor must constantly issue fetch commands for new instructions. The same testing has confirmed that input-output intensive applications, such as word-processing or telecommunications won't benefit that much from the new microprocessor because the system is constantly waiting for keyboard or communications port input.

You might be wondering why the speed differential exists. The microprocessor is busy doing other things—adding, subtracting, looping—while it is handling specific data addressing and calculation. Because it is, its resources are being spread through the system and they can't all be brought to bear for the ultimate speed increase.

Clock speed also seems to enter the picture. Running

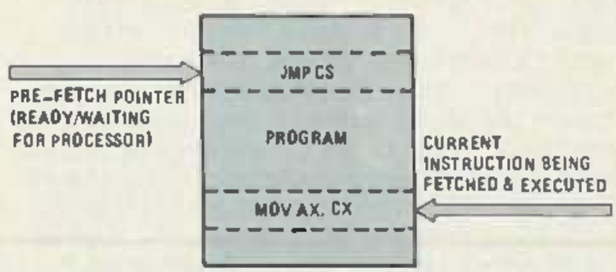


FIG. 2: THE PREFETCH POINTER speeds up processing in the V20/V30 series by moving directly to the next instruction to be executed by the microprocessor. This speeds things up because the micro always has the next instruction ready for its instruction pointer, which doesn't have to move around as much.

a standard IBM Personal Computer or close compatible at its standard 4.7 MHz imposes timing and performance constraints on its 8088 processor. Reports circulated in the IBM user community for years of hyper-speed functionality brought about simply by changing the clock chip from 4.7 MHz to 8 MHz, at which the 8088 is easily capable of operating.

Although the V20 is a capable performer, when you run standard IBM applications or languages that are meant to operate at 4.7 MHz, you're imposing the same fetters on microprocessor performance that you have on the IBM's 8088 and performance of the system will be degraded, even though you are using the V20/V30. The 20 percent speed increase seems reasonable in light of this input.

Some users have complained about the speed shortfall and have questioned the capability of the V20/V30. But, those users have come to expect too much. It's one of the oldest marketing ploys in the microcomputer world, the specifications game, where the specifications are fantastic, but the performance doesn't match.

The solution, if you're considering the V20/V30, is knowledge. If you realize that the speeds won't be superfast, but will be modestly improved, then you'll get what you expect from the $25 to $30 V20/V30 chip.

Even a 20 percent performance increase is welcomed in some applications.

Finally, temperature and power usage are also important considerations and this is an area where the V20/V30 shines. It generates a lot less heat and uses manifestly less power than the 8088 and because it does it proves a blessing for a system overtaxed by the number of add-in cards and devices that may be on the motherboard because there's less heat and power consumption for the system box to contend with.

ALL ABOUT INTERFACING PART I

All you need to know about microcomputer interfacing

Jeff Holtzman

Connecting peripheral devices such as printers, modems, and plotters to personal computers can be confusing. Many books dealing with the subject concentrate on connecting specific computers to specific peripherals.

We cannot guarantee that by absorbing the information presented here you will able to connect any computer to any peripheral device. Designers and manufacturers in the microcomputer world do their best to avoid any efforts at following standards.

What you will learn are the basic principles of both parallel and series interfaces, with hints on how to get two pieces of equipment talking to each other. As Count Basie used to say, let's try it "just one more once."

Serial versus parallel

Most microcomputers move data to and from peripheral devices in eight-bit bytes. There are two methods of moving a byte from one location to another. We can send all eight bits at once, or we can send one bit at a time. The one-bit-at-a-time approach is called serial data transmission, and the all-at-once approach is called parallel data transmission. Neither is better; each has advantages and disadvantages that must be weighed for each application.

If we send one bit at a time, we can get by with as few as two lines (signal and ground) if we only need one way communication, or three lines, if we need communications to and from a peripheral device. We'll talk about that later. But now, consider that for parallel transmission, we're going to need eight separate signal lines, plus a ground, and another one or two for synchronizing things so data won't be lost.

One advantage of parallel transmission is, since all bits are sent at once, transmission may occur at a higher speed than serial transmission. Also, the parallel circuitry is simpler and less expensive than serial circuitry. But the connecting cables are more expensive than serial cables, and there is less standardization of parallel connectors than serial connectors.

In another example, disk drives have (special) parallel interfaces that let them to take advantage of the speed advantage of the parallel approach. Some laboratory equipment and some low cost personal computers communicate with disk drives over (special) serial interfaces, but that is the exception.

Plotters and graphics printers usually operate with parallel interfaces. The time to send—serially—the large amounts of data they require would be excessive.

Parallel transmission

The minimum parallel interface consists of ten signal lines and a ground. Frequently each active (non-ground) line of a parallel interface is twisted together with—or run close by—a ground line. That provides immunity to electrical interference, and is one reason parallel cables often have so many leads.

Of the active lines, eight are for data, one is a STROBE line, which indicates to the receiving device that it should take the data present on the data lines, one is a BUSY signal, which goes high to indicate that the receiving device is busy, and not to transmit any more data until it goes low, and the final signal is called $\overline{ACK}$, which is (usually) a short, negative-going pulse from the receiving device that indicates the data has been accepted properly. A simple parallel interface might be wired as shown in Fig. 1. Note that the twisted-pair grounds are not shown. Note also that the Busy and $\overline{ACK}$ lines come from the peripheral device, and that the STROBE line goes to it.

The normal sequence for sending a byte of data over such an interface is as follows. Refer to the timing diagram in Fig. 2. The character in that figure is the letter "U," which has an ASCII value of 55.

The computer monitors the BUSY line, waiting for the peripheral device to OK sending data. After the BUSY lines goes low, the computer places its data on the eight data lines and pulses the STROBE line. That informs the peripheral device to grab the data. After it has taken the data, it pulses the $\overline{ACK}$ line, and tums the BUSY

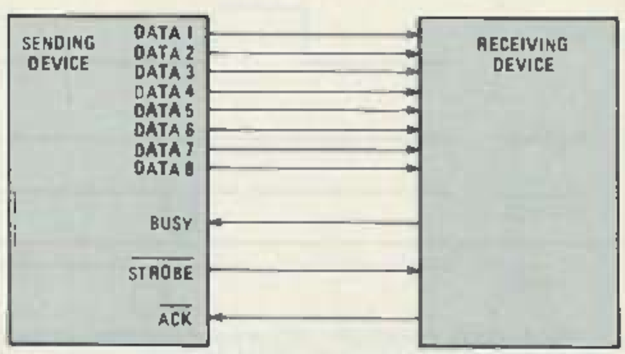


FIG. 1—EACH ACTIVE SIGNAL may have a ground, implemented as a twisted pair, as a shield, or as a nearby wire in a multi-conductor ribbon cable.

line on, if necessary, while processing that byte of data. When it finishes doing that, the BUSY line goes low, and the process may be repeated. If you are interested in how fast a parallel device can accept data, try connecting an oscilloscope to the STROBE line of your computer.

The highest bit, bit 8, is low. ASCII encoded data requires seven bits, so the eighth bit may be ignored or used for other purposes. Some word processing programs use the eighth bit to mark end of words, and in data communications, the eighth bit is often used to indicate the parity of a character.

Parity indicates how many of the lower seven bits of a character are "on" (high). Our "U" has four "on" bits, and four is an even number. If our transmitting device were set up for even parity, bit eight of the "U" would be low, since the character already has four bits. If our transmitter were set up for odd parity, bit eight of the "U" would be high, in order to make a total of 5 "on" bits. A transmitted "V" (ASCII 56, decimal 96) would cause the opposite parity values.

Parity is used for error checking. When a device using parity checking receives a character with incorrect parity, it signals the driving software that an error has occurred, which might then cause a request for the data to be re-transmitted. The most common circuitry allows parity to be set for odd, even, mark, space, or no parity. We have discussed the first two; mark and space simply force bit 8 high or low, respectively; and no parity simply ignores bit 8. Unless you have a specific reason not to do so, choose the latter when setting up your equipment. Otherwise only seven bits of each byte will carry useful data.

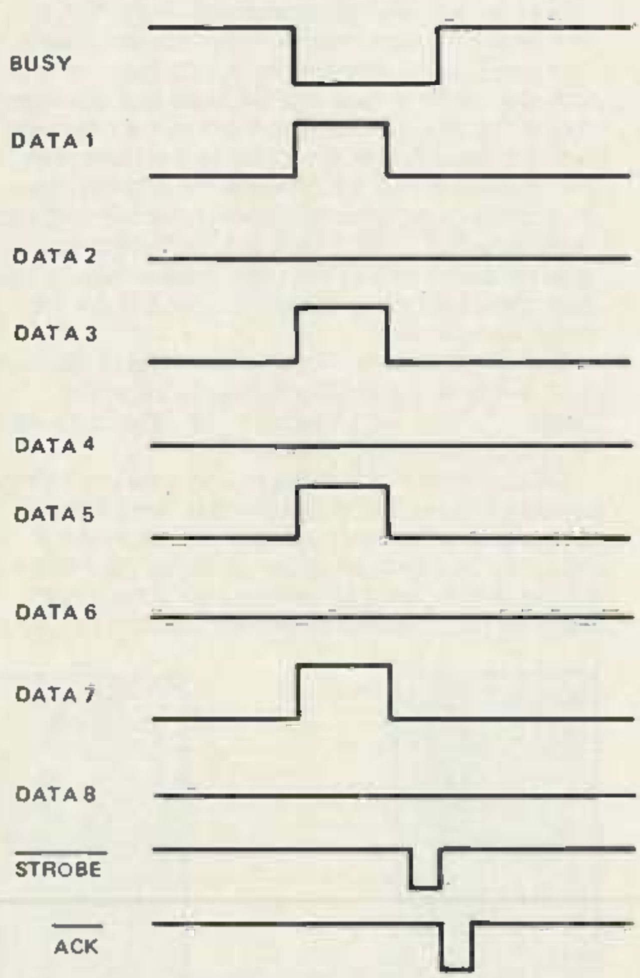


FIG. 2—DATA TRANSMISSION in a parallel interface begins with the BUSY line going low. Data bits may be sent, followed by a STROBE signal. Receipt of the character is acknowledged by sending the ACK line low. The character "U" is shown here.

The transmission process outlined could be applied to any parallel interface: one linking a computer and a printer, a computer and a laboratory instrument, a computer and another computer, etc. However, a typical parallel printer interface will have a number of additional signal lines, as shown in Fig. 3.

The PAPER END signal indicates when the printer is out of paper. The SELECT line is generally high when the printer is "on-line"—that is, ready to receive data, and low when the ON-LINE switch has been pressed by the operator. The I-PRIME signal is a reset line that will force the printer into some well-defined (by each particular printer manufacturer!) state. Finally, the FAULT line goes high when the printer is off-line, when it is out of paper or ribbon, or if some sort of transmission error has occurred.

It is important to understand that not every printer will have all of those signals, and some printers may have additional signals (such as a low-current +5-volt source for powering peripheral devices such as a serial to parallel interface). It is also important to understand that little—if any—microcomputer software makes much use of any of the warning signals shown in Fig. 3. Usually, a printer suffering from a paper-out condition will cause the computer to lock up because the printer sends both the Busy and Paper End signals low, but software usually pays attention only to the Busy line. So your word-processing program might know that the printer is "busy" but not the reason for it.

A serial interface transmits bits of data one after the other. But not at random. When data is transmitted over a line conforming to the RS-232 standard, there are no timing restrictions on when individual bytes of data may be sent. However, each bit of a particular byte must be transmitted with strict attention to timing. Baud Rate refers to the speed at which transmission occurs, but not in a glib way.

Baud rate

First, let's define Baud Rate as the number of bits that may be transmitted per second. A Baud Rate of 300 means that 300 bits may be transmitted per second. That doesn't mean that 300 bits will necessarily be transmitted every second, though that's possible.

The term baud rate refers to the spacing between each bit of a single character, not the speed at which complete characters are transmitted. The way to find the time between each bit is take the inverse of the Baud Rate:

TC (sec) = 1 / Baud Rate

To find the time it takes to transmit a complete character, multiply TC by the number of bits per character.

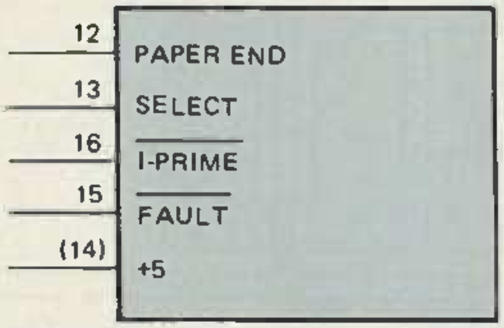


FIG. 3—ADDITIONAL SIGNALS in a parallel interface. These signals are frequently unused by software.

In a 300 baud system, the amount of time from the start of one bit to the start of the next is 1/300, or 3.33 msec. To determine the amount of time a character takes, multiply the number of bits per character by 3.33. How many bits does a character have? In the microcomputer world of the 1980s, the correct answer is usually eight. There are exceptions.

An 8-bit character is going to be 10 or 11 bits long! Every character has a start bit, and one or more stop bits. Most equipment operates with one stop bit; older equipment used two stop bits to give slow machines a little bit (no pun intended) of "recovery" time.

Transmission of a character begins with a start bit. The data bits follow (usually eight, but not always), and then one or two stop bits. Figure 4 shows the transmission of the "U" character with 1 start bit, 1 stop bit and 8 data bits. Note the time "t" between each bit; that is the value 1/Baud rate.

If our 8-bit character has one start and one stop bit, that is a total of 10 bits. So the time to transmit one character at 300 baud is 10 * 3.33 = 33.3 msec.

How many characters can be transmitted in one second, if it takes 33.3 msec to transmit one character? Using a little algebra, we see that

$$\frac{1\text{char}}{0.0333\text{sec}} = \frac{X\text{chars}}{1.0\text{sec}}$$

So X = 1*1/.0333 = 30 chars/sec. We could have arrived at the same answer without the algebra—but doing it the hard way taught us something. Divide the baud rate by the number of bits per character. In our case, and in most you're likely to encounter, just divide the baud rate by ten.

300 / 10 = 30 chars/sec.

What is the character/second rate of a 110-baud transmission?

If you came up with 11, you jumped the gun. You can't really answer the question without knowing the number of bits per character. We picked 110 baud because the old Teletype machines used that as their baud rate. And they used two stop bits—so the TTY has 11 bits/char, and 110/11 = 10 chars/sec.

Here's another trick question: If characters are coming over a transmission line at 300 baud, does that mean that 30 characters come through every second? It doesn't, and that brings us to our next topic.

Transmission rate

Transmission rate may be defined as the number of characters flowing over a communications line per unit of time. The most important thing to realize is that there is no relationship between baud rate and transmission rate! You might have one computer dumping data at 300 Baud and another at 9600 Baud, and the latter might have a lower transmission rate than the former. How could that happen?

The 300 baud machine might be dumping 30 characters every second, the 9600 baud machine might only send a character once every 30 minutes. Remember a transmission rate of 300 Baud guarantees only that there will be a delay of 3.33 msec between each bit of a character.

That example illustrates the point. Higher baud rates aren't necessarily better. You could attach circuitry (such as a "printer buffer") to a 110-baud Teletype machine that would enable your computer to dump characters at 9600 baud. The TTY will be unable to print at the rate of 960 characters/second, so as soon as the buffer memory inside your interface filled up, your effective transmission rate would fall from the baud rate to near the actual printing speed of the TTY.

Adding a high-speed interface to a slow piece of equipment may still be an advantage. If the buffer memory could hold a fairly large number of characters, your computer might dump an entire document at high speed and go on to do something else while the buffer outputs data at a rate the printer can handle.

If you attach a buffer memory to your printer (or MODEM, for that matter), make sure you get a buffer with enough memory to make it cost effective. If you mostly print double-spaced documents under about 25 pages, a 64K buffer should suffice. But with documents much longer than that, or with graphics dumps, you'll run up against the same problem. Once the buffer's memory is filled, transmission rate will

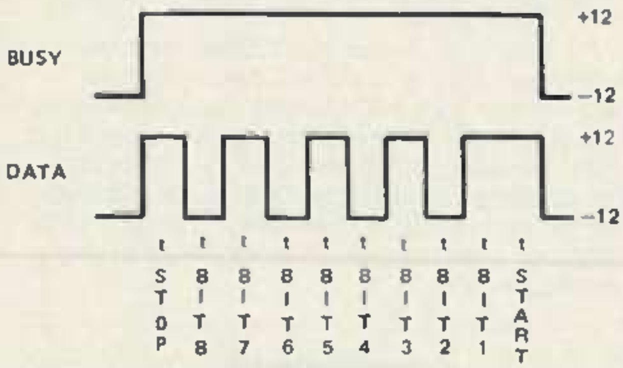


FIG. 4—SERIAL TRANSMISSION of data also begins with the busy line going low. A "U" is being transmitted here. Note the time "t" between each bit.

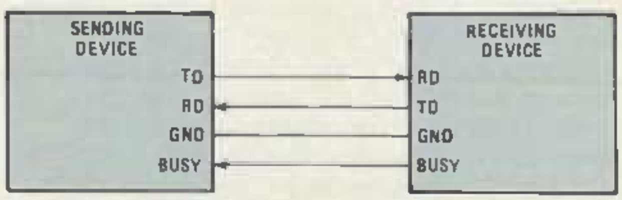


FIG. 5—RS-232 INTERFACES are commonly wired with only the signals shown here.

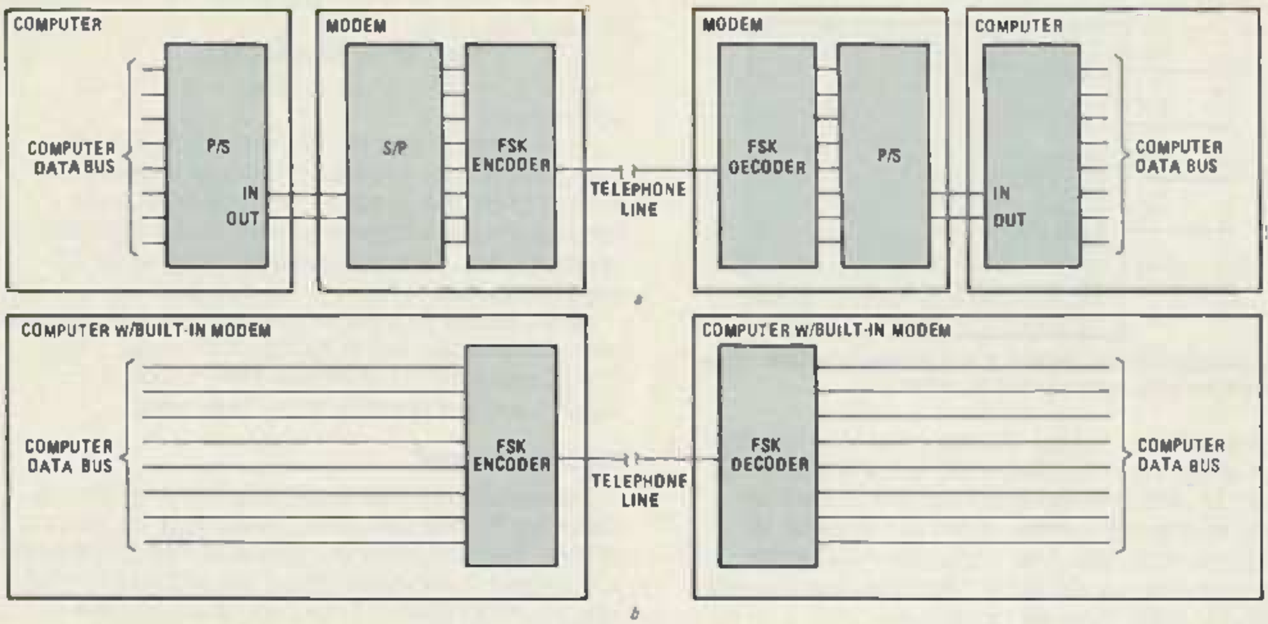


FIG. 6—TWO COMPUTERS connected via external MODEM's over the telephone lines are shown at *a*, and at *b* the computers are linked by internal MODEMs.

decrease drastically.

A practical RS-232 interface would appear as in Fig. 5. There are two data lines, a ground, and, like the parallel interface shown in Fig. 1, a BUSY line. There is no strobe line, as the start bit informs the receiving device that more is on the way. Neither is there an ACK. The BUSY line may perform the same function as in a parallel interface, as shwon in fig. 4, but there are other ways of indicating a busy condition.

Controlling transmission rate

Often we are unable to allow a computer to spew forth data at a transmission rate equal (or close to) the maximum value allowed by the baud rate—30 chars/sec, in the 300-baud system discussed here. The hardware on the receiving end must have a way of telling the transmitter "Hey—wait! I can't accept any more data right now."

There are two ways of doing that: With hardware and with software. With software we require two communication lines: One allowing data to flow from the transmitter to the receiver, and another allowing data to flow from the receiver to the transmitter.

What happens is that the transmitter sends data as fast as it can, while monitoring the line from the receiver for a special "wait" character that tells the transmitter not to send any more data. After receiving the "wait" character, the transmitter stops until it receives a "continue" character from the receiver. There are several such "protocols" in common use; you may have heard of ETX/ACK or X-OFF/X-ON. The first member of each pair simply represents the "wait" character, and the other, the "continue" character.

With hardware, a busy condition can be shown simply by the polarity of a signal line (high or low); the opposite polarity represents the "continue"condition. For example, low represents "Busy," high represents "continue."

Note that neither the hardware nor the software method is better than the other; each was developed to solve different problems. The software protocols for use with MODEMs and remotely operated printers where single-line-communication links are a part of the system. A seismographic sensing unit might be located in a remote location, would be linked to a printer in a geological survey office by MODEM. A signal in addition to the transmit data and receive data lines that would distinguish between "wait" and "continue" conditions is hard to implement. Modem printers let you choose between software and hardware solutions, or both.

Historically, MODEMs were serial-in serial-out devices, as shown in Fig. 6a. There we see two computers connected through MODEMs via telephone lines. Each computer has a device labeled "P/S Converter," and each MODEM has a device labeled "S/P Converter." That is the same device, and is called a UART (Universal Asynchronous Receiver Transmitter). Another device inside the MODEM (called an FSK, for Frequency Shift Keying encoder) converts the parallel binary data into audio tones that can be transmitted over telephone lines.

It is becoming common for MODEMs to be built right in the computer; some MODEMs are built on plug-in cards. Such MODEMs give cost advantages, as shown in Fig. 6b: external packaging can be eliminated, as can the power supply, two UARTs, and associated circuitry. But a stand-alone MODEM can be used with any computer, printer or other device with appropriate interfaces, whereas plug-in cards are limited to one specific machine.

To be continued in next month's issue

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and

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Abbreviations: (AR)Antique Radio; (ARE) Ask Radio-Electronics; (C)Construction; (CD)ComputerDigest; (COMC)Communications Corner; (COMPC)Computer Corner; (D)Department; (DB)Drawing Board; (DN)Designers Notebook; (E)Editorial; (ER)Equipment Report; (LTR)Letter; (NI)New Ideas; (R)Robotics; (SC)Service Clinic; (SQ)Service Questions; (SDSS)State Of Solid State; (STV)Satellite TV

COMPUTERDIGEST Volume 3

January 1986 — December 1986

Abbreviations: (C)Construction; (D)Department; (E) Editorial; (L)Letter; (ER)Equipment Review; (SR)Software Review

Satellite TV

BOB COOPER, JR.,
SATELLITE-TV EDITOR

Hacking *Videocipher*

PARDON ME IF I'M REPEATING OLD news, but most of the major satellite signals are being broadcast in scrambled form. That scrambling has caused significant problems in the TVRO industry. For example, sales are off by more than half, and everyone from OEM to dealer is hurting. Some people are hurting badly enough that they are attempting to do something about scrambling—they're trying to beat it.

Black-box solutions abound already, and there is an active underground (and middleground) in which descrambling devices and information are being distributed. However, until quite recently, most claims about successful descrambling were fanciful flights of creative copywriting. But no more.

Oak and M/A-Com

Two unrelated scrambling systems are being used in the U.S. and Canada this year. One is the product of Oak Industries; they call their system the ORION (*O*ak *R*estricted *I*nformation and *O*peration *N*etwork). Two versions of their decoders are available; one is for cable-systems operators and one is for the home market. The home-style decoder for that system is called the ORION *P*; the *P* stands for Personal.

In the U.S., we have the M/A-Com *Videocipher* system, which has been widely adopted by cable programmers such as HBO, CNN, and more than a dozen others. (Even The Disney Channel is scrambling now.) There are also two versions of Videocipher; the *VC-2*, which is for the cable people, and the *VC-2000*, which is for home use.

FIG. 1

Descrambling both Oak's and M/A-Com's *video* signals was child's play. In fact, at least one home-style receiver manufactured by Arunta Engineering (3111 E. Thomas Rd., Phoenix, AZ 85016) decodes that type of video straight out of the box. It may be coincidental, but Arunta's receiver was designed and marketed before *Videocipher* took off. But the fact is that it does produce perfect pictures from both types of signals.

The audio has been a greater challenge. The first breakthrough comes from the Canadian firm Westar Technologies (2 Bloor Street West, Suite 100, Toronto, Ontario, Canada M4W 3E2). Westar has introduced an IC, shown in Fig. 1, that contains complete descrambling circuitry for the Oak system—both video and audio—on a 40-pin carrier.

In mid August that IC costs about $250, and the ORION *P* decoders are selling for approximately the same price. So, for $500 or so, you can have access to everything scrambled by the Oak system.

Needless to say, there are several legal problems here, because neither U.S. nor Canadian authorities condone descrambling signals that are intended only for authorized use.

The next breakthrough is imminent, if it has not been attained by the time this column reaches print. It involves the Videocipher system, which until now has been invincible to hacking attempts.

The Oak system converts audio to digital form and then hides it in the video signal. The M/A-Com system uses a similar technology, but it also encrypts the audio according to a Governmental security standard called DES (*D*igital *E*ncryption *S*andard). To recover the Videocipher audio, one must first extract the digital data and then decrypt it according to a key.

The M/A-Com system might have been invincible were it not for design "features" of the *Videocipher* system. What really compromises the system is that a master decoding key is transmitted along with the encoded audio.

Interested In TVRO?

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

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

Therefore the key to unlock scrambling the system is actually there in the data stream. The key itself is also encrypted, but it is nonetheless present.

Finding a way to decode that key is a considerable challenge, and it has attracted some of the most talented engineers, software hackers, and cryptanalysts in the world. Like Mount Everest, it is there; and, for the same reason that some climb the mountain, others are slowly revealing the secrets of *Videocipher.* There has been significant progress to date; much more will have been accomplished by the time you read this report.

For example, it was determined at an early stage that integrated circuit U7 in the *Videocipher* unit holds some of the decrypting keys. Getting inside that IC to recover the data hidden there was a trick, since removing it from the circuit killed it. To get inside, researchers used a microscopic drill to enter the IC and reach a special location where the silicon chip is bonded to the carrier. A small drop of mercury was then placed in the microscopic hole to allow an electrical connection to that point. Signals within the IC could then be analyzed. All of that was accomplished while the chip was fired up and operating! Needless to say, several of the IC's were destroyed during that process.

Data was extracted and delivered to software analysts who were assigned the task of descrambling the programming secrets. Once the program is deciphered, the next trick is to write a new program that gets around M/A-Com's program.

The upshot of this is that we expect to see *Videocipher* clones soon. And since the hackers also expect that some of their clones will ultimately end up at M/A-Com, a clever "auto-cloning" technique is being studied; it will allow the clone IC's to "refresh" their decoding keys by continually analyzing the data stream fed via satellite that we now know is present.

Legalities

It is not illegal to take *Videocipher* apart to learn how it works. However, distributing hardware that does so, or even information describing how to do so may be illegal.

Many of those working on cracking *Videocipher* have no commercial interest in selling or in profiting in any way from cracking *Videocipher;* when the task is accomplished they will simply back out and leave any possible commercial exploitation and distribution to others. Rest assured that such exploitation will take place.

Needless to say, the people at Oak and M/A-Com are unhappy about any unauthorized descrambling. So lawsuits are probable. Even those who provide detailed decoder/hacking information in print run the risk of being sued. As in many other facets of American life, the lawyers will make lots of bucks while the public struggles to understand the how's and why's of what is happening, and tries to figure out how to react to the underground distribution of information and hardware. **R-E**

ROBOTICS

MARK J. ROBILLARD,
ROBOTICS EDITOR

Experimental robot vision

LAST TIME WE PRESENTED THE CONSTRUCTION details of a simple photocell-based vision sensor. To conclude the presentation, this time we'll show you how to connect it to a microcomputer, and then we'll discuss a few software algorithms that demonstrate how to use it.

The sensor consists of nine photocells. For a computer to be able to read the analog resistance of each photocell, that resistance must be converted into the digital language the computer understands. So we must use an ADC (*A*nalog-to-*D*igital *C*onverter). When a photocell is connected between the positive supply voltage and a resistor that is grounded on the opposite end, the pair acts as a variable voltage divider. The divider is variable because the resistance of the photocell changes depending on the amount of light that reaches its active surface. When you connect the output of the divider circuit to the input of an ADC, a digital representation of the voltage dropped by the photocell may be read.

It would be inconvenient and expensive to connect a single ADC to each of the nine sensors in our vision unit. Fortunately, however, National Semiconductor has an IC (the ADC0816) that includes not only an ADC, but also a 16-channel analog multiplexer that allows us to monitor all nine photocells (and seven other analog inputs, if desired) without multiplying costs nine times.

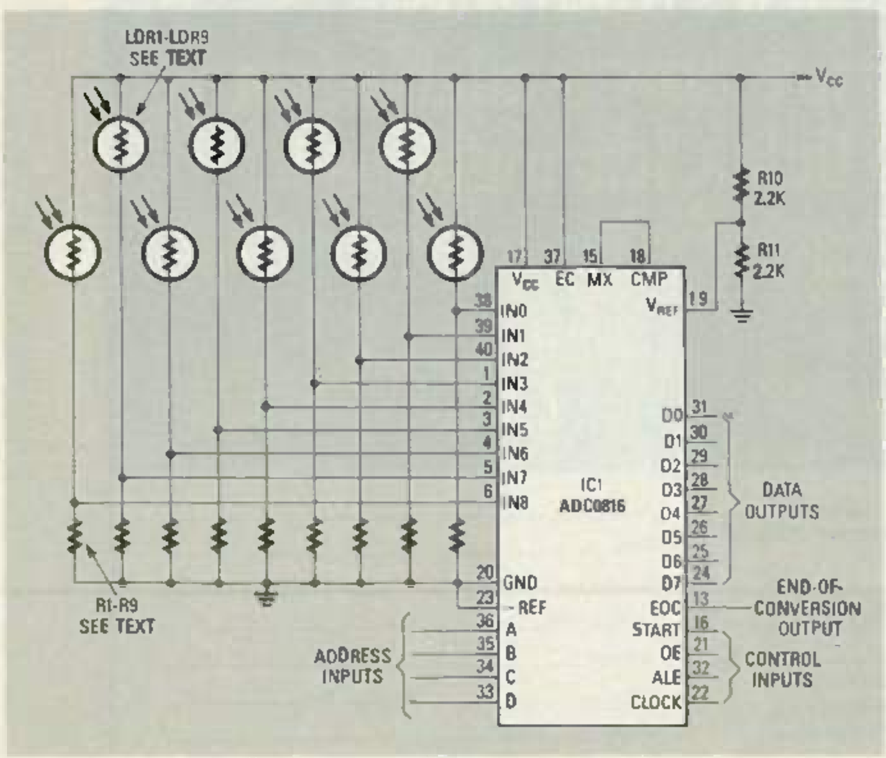

FIG. 1

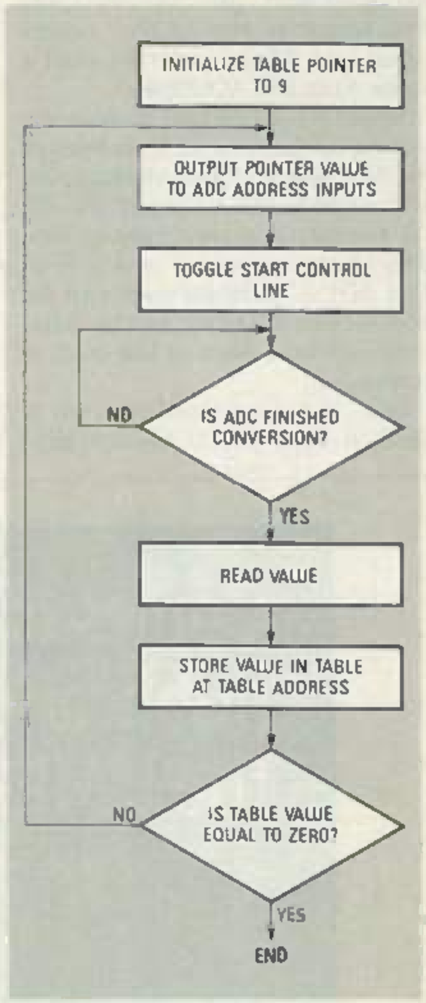

FIG. 2

Figure 1 shows the circuit details of the sensor interface. In addition to the sixteen analog inputs, the ADC0816 has four address inputs that allow you to select which of the sixteen inputs you want to read. Further, the circuit has several control lines that are used to select various operations. We'll discuss each of the control lines below.

If your computer has a built-in eight-bit parallel interface, you can probably use the circuit directly as shown. Otherwise, you'll have to add some external circuitry. One way of connecting the ADC0816 to an 8-bit computer system is as follows.

The computer's data bus (or eight-bit I/O bus) is connected directly to the IC's 3-state data outputs (pins 24–31). You could AND the computer's READ signal with a decoded port address and apply that signal to the OUTPUT ENABLE input (pin 21) in order to read a value from the ADC0816.

Selecting a channel is done by setting up the four address lines of the ADC0816 and then strobing the address into the ALE input (pin 32) via another decoded output AND-ed with the computer's WRITE line. The ADC's address lines can be connected directly to the low-order address lines of the control computer.

Last, the START input (pin 16) is used to start the conversion process. You could drive that input with another decoded output port AND-ed with the computer's WRITE line.

AN ENDING, A BEGINNING

This marks the 19th and final installment of Mr. Robillard's Robotics column. We'll miss Mark (who will contribute an occasional feature article), but we're happy to announce a new series of articles that includes complete details for building, operating, and experimenting with a personal robot. The new series begins in this issue and will continue for many months, as we continue keeping you up to date on the latest developments in the fascinating field of personal robotics. R-E

Because the ADC works much slower than your computer, you cannot simply select a channel, send a "start" command, and then read the data. The ADC must sample the input and then convert it to digital form. The ADC0816 can take as long as 116 µs to complete the conversion. To alert the computer when the conversion is done, the IC has a special END-OF-CONVERSION output (pin 13) that goes high when a digital representation of the analog input may be read. You can monitor pin 13 by AND-ing a decoded I/O port address with your computer's READ line. Alternatively, you may want to connect pin 13 to an interrupt input; doing so would allow your computer to do other things while the ADC is working.

Figure 2 outlines the basic algorithm for scanning the nine-element sensor. First we select analog channel one. Then the START signal is activated. Then the computer goes into a loop and monitors the END-OF-CONVERSION output. When that signal goes high, the output buffer is read, and its value is stored in a nine-byte table for analysis later. The program loops to select the next channel (i.e., the next sensor element) and executes the same sequence of operations. When all sensors have been read, the algorithm is finished.

After reading in the data, it must be analyzed. It would simplify analysis if each sensor returned a value of 1 for light areas and a value of 0 for dark areas. Then the table of bytes could be compared with a set of previously-stored templates. The program would interpret the object as being the one with the closest match.

However, things don't work quite so simply in the real world. In fact, the circuit shown here is so sensitive that, instead of getting two distinct values that represent light and dark, you'll be getting readings with 256 distinct values. Areas of your target that appear to be the same will actually register tremendous differences.

In order to eliminate most of that "clutter," an auto-sensitization adjustment must be made. What we must do is to trick the circuit into being less sensitive. One way of doing so is with a threshold adjustment. Looking back at the circuit in Fig. 1, notice the resistive voltage divider connected to pin 19 (V_{REF}) of the ADC. All converted values are compared to the value at that pin. By varying the reference, you can adjust the sensitivity of the circuit.

You could use a DAC (*D*igital-to-*A*nalog *C*onverter) to perform the auto-focus. Connect the digital inputs of the DAC to a separate output port, and the analog output of the DAC to the reference input of the ADC. Then, by placing a black and white cross (or some other shape) under the sensor, have the computer read the ADC. If the sensors under the black areas don't read similarly, have the computer change the reference voltage via the DAC converter. Adjust the reference until the output reads the way you want it to.

Also, you could calibrate the sensor manually using a potentiometer and some sort of program that outputs the values to the screen. The value of the automatic circuit, though, is that the computer can calibrate itself at any time.

I have found the sensor to be great at picking out brightly colored symbols on a dark block. In addition, the sensor reads well at a distance of one inch above the target object. As discussed last time, use a flash from an old camera to illuminate the area evenly. And be sure that the duration of the flash is at least 200 µs to compensate for the conversion time. R-E

ANTIQUE RADIOS

RICHARD D. FITCH,
CONTRIBUTING EDITOR

Reader letters, filament checker

DURING THE PAST TWO YEARS I HAVE made many references to reader correspondence. It is gratifying to know that so many are interested in the history of radio, which is probably the most important scientific discovery of all time. At least it's the most fascinating, especially to readers of this column.

Writing this column has taught me a lot. Much of my knowledge comes out of the research I must do to get the column out, but more comes from information contained in readers' letters. I have heard from some very knowledgeable readers who have first-hand information on radio history. In fact, many have personal recollections of the developing days of radio. First broadcasts, home-made equipment, and early receivers are still fresh in the minds of many readers of this column.

While many letters share information, many others contain questions. Many of the latter cause me to do considerable research. Often readers ask about sets of which only a few were manufactured, and which have long been forgotten. Sometimes it's hard to believe that a reader actually has one. Of course, I'd like to shows photos of all those forgotten radios, but there simply isn't room to do so.

Letters

Now let's get to the letters. Maybe we can all learn something from the problems experienced by these readers. Or perhaps readers can help each other.

Daniel Nevels (11836 Alamo, Baton Rouge, LA 70818) needs the glass dial cover for a Zenith Model *6S556* radio. Dan mentioned that he could get the set repaired for $300.00, and that it is similar to the Zenith pictured in the June 1985 column. Dan, if you're referring to the Zenith console with the veneer problem, that's not the only thing wrong with it. There is also the matter of a burnt-out power transformer. You can have the whole thing for $300.00. Actually, if you didn't live so far from me, you could get the whole set for $30.00. If anyone in Dan's area can help, drop him a line.

Many antique-radio restorers find their sets complete except for one small but hard-to-locate part. Usually it's an accessory like an escutcheon, a knob, a cabinet, or a piece of curved glass. Often, if you have patience, you can fabricate a missing part from commonly available materials. For example, you can turn (or carve) a piece of dowel rod to simulate a knob. Other materials that come in handy include veneer, masonite, and stiff, clear plastic such as toys are packaged in. The plastic can be used to replace missing glass. Sometimes it's even worthwhile to buy an item just for the packaging.

Cliff Priddle, (P. O. Box 725, North Bend, OR 97459) is interested in crystal sets. He would like to obtain old parts. Cliff, my old tube sets keep me so busy I haven't had time to get into crystal sets. However, one company advises me that they can supply crystal-radio parts and information. Send an SASE to MIDCO (P.O. Box 2288, Hollywood, FL 33022). *(Also check the Classified Advertisements in the back of the magazine.—Editor)*

Here's an interesting letter for antique collectors who haven't located a suitable set yet, or for those who would like to add to their collection. Victor Jackman (230 April Court, North Huntington, PA 15642) has a fine collectable to sell. It was made by International Radio Inc., of Ann Arbor, MI and has serial No. 2914. I have some information on International Radio, but their sets are listed by model number. If anyone wants more information about this collectable, drop Vic a line.

Another interesting collectable is an Ultradyne Model *L-2*. It's a TRF with tubes, circuit, and cabinet. For more info contact Herb Henry (331 Elliot Road, Ft. Walton Beach, FL 32542.)

I have searched my files but am unable to help Eugene K. Warner (522 Weiman Street, Ridgecrest, CA 93555.) He has a small radio with no tubes. Also, no tube diagram or manufacturer's name or model number. It appears to use both a line-cord resistor and a ballast tube. The only clues are on the dial, which contains the image of a four-engine prop transport airplane and the name Clipper. The radio may be from the thirties.

I wish I could share the set of color photos sent in by Allie C. Lingo of Pierks, Arkansas. They show a classic southwestern tester and some equally classic radios.

While discussing photos, I have to mention the photo of a World War 1 military receiver sent in by Charles W. Dold of New Smyrna Beach, FL. Mr. Dold responded to my promise to discuss WW 1 equipment in a future issue. However, my visits to military mu-

BUILD YOUR OWN ANTIQUE-RADIO TUBE-FILAMENT CHECKER

This month, I am going to show you how to build a simple but useful piece of test equipment. That is a tube-filament tester. I've always found such a device very valuable in troubleshooting old radios.

While the much-altered filament tester shown in Fig. 1 is about 40 years old, I didn't invent it. Commercial versions were available for years before I built mine. Besides testing tube filaments you can also use it to test light bulbs, home and auto fuses, etc.

Even if you already own an emission-type tube tester, there is an advantage to having a simple filament checker: it's

FIG. 1

much easier to use because you don't have to set nine switches, three dials, and several pushbuttons, not to mention tube warm-up time. Besides, many late-model tube testers don't have sockets for the antique tubes we are interested in.

As shown in Fig. 2, the filament checker has sockets that are pre-wired to accept the most popular types of tubes, and a pair of test leads that allow you to check any tube with non-standard filament connections or a non-standard base. The box has special clamps to hold that type of tube in place while you connect the test leads.

The circuit works like this. The battery, lamp and the tube under test are all connected in series through the on/off switch. When you close the switch, the lamp will light if the filament is good. Otherwise it's bad.

The box shown in the photo measures 9" × 12" × 4". The two plastic boxes affixed to the sides of the checker can serve as "in" and "out" boxes when you're testing a batch of tubes. Place tested-good tubes in the out box, and simply discard any bad tubes.

You can use any low-voltage low-current lightbulb for LMP1, such as a number 48 or 49, or even a number 14, which is rated at 2.47 volts at 300 mA. The toggle switch isn't really necessary. I just like to have a switch on all electrical equipment to make sure that it is off when I'm not using it. R-E

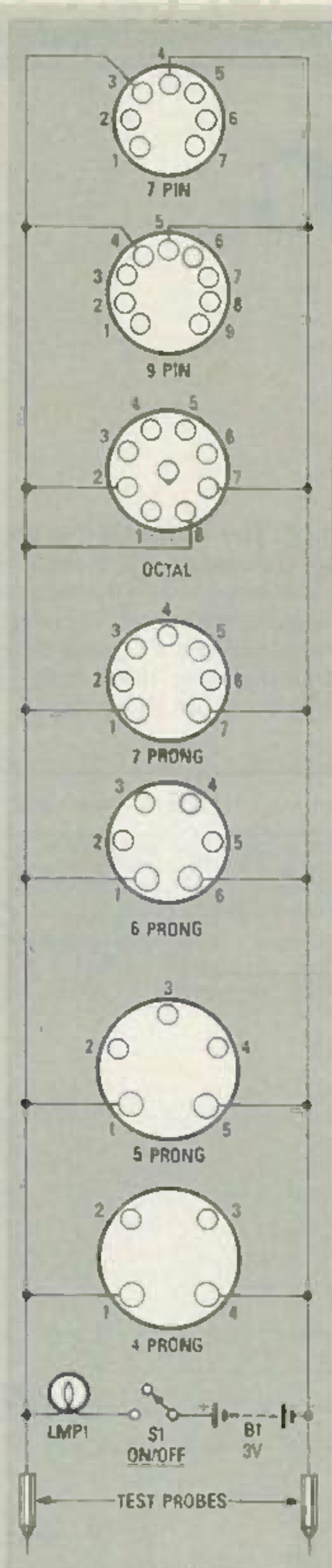

FIG. 2

seums failed to give me enough material for a complete column. But if I can obtain enough information, I will include it in a column.

Haves and needs

A. B. Nacy (1421 Retallack Street, Regina, Canada S4T 2J3) has an antique Arvin for sale. James Lindsay (85 Circuit Avenue, Weymouth, MA 02188) needs a complete speaker for a RCA Victor Model 87T. And David Fentem (704 Emerald Forrest Circle, Lawrence, GA 30245) needs all major parts for an old Silvertone console. R-E

DRAWING BOARD

ROBERT GROSSBLATT,
CIRCUITS EDITOR

A remote-control system

IF YOU'RE A REGULAR READER OF THIS column, there's one thing you should realize by now—I'm a firm believer in a systematic approach to design. A sure road to brain damage is trying to design something without analyzing the problem first. The subject we're going to start discussing this month—remote control—is one that requires a systematic approach. There's just no way of doing a sucessful design without planning the whole system out on paper beforehand.

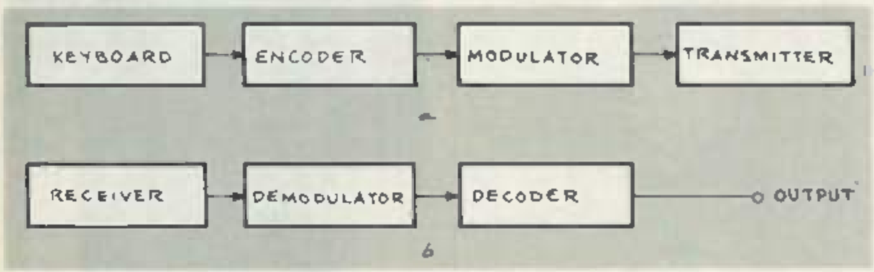

FIG. 1

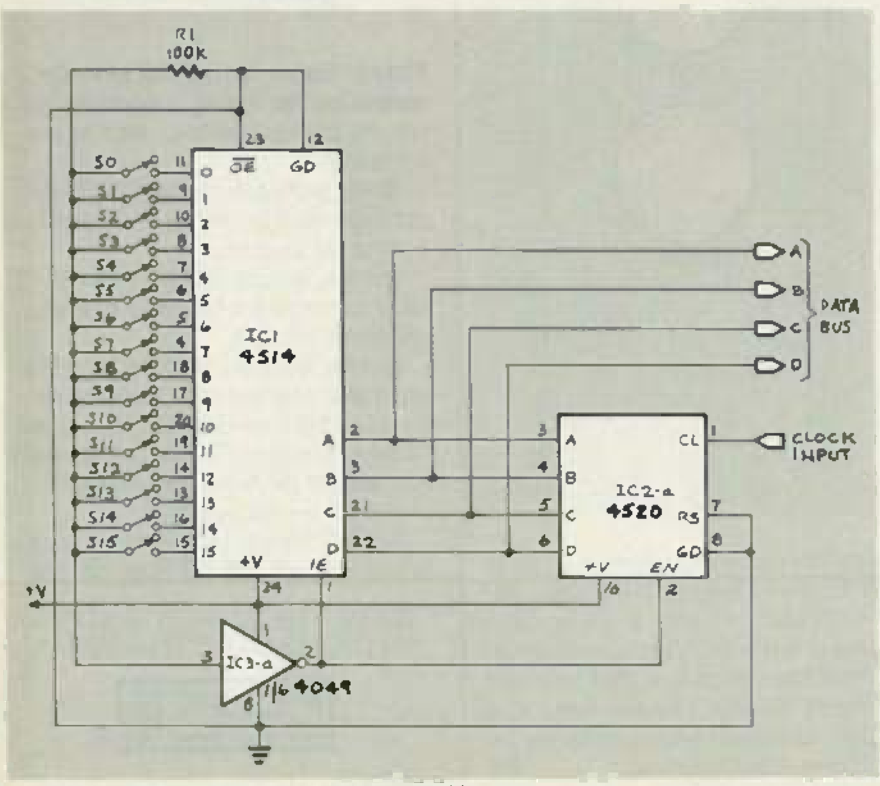

FIG. 2

A remote-control system is more complex than many of the other circuits we've looked at in this column. The degree of complexity is, of course, directly related to how much you want the circuit to do for you. But even if you only want your remote controller to switch your TV on and off from your armchair, the first step is to list the overall specifications of your control system. Our system's specifications are as follows:

1. The transmitter will be battery powered.
2. The transmission medium will be infrared light.
3. The circuit will be able to control at least 10 devices.
4. Standard parts will be used wherever possible.
5. The receiver will be as noise-immune as possible.

If you think about those specifications for a moment, you'll see that the remote-control system is really a combination of two different circuits, each of which has several subsections. The two main sections are the transmitter, shown in Fig. 1-*a*, and the receiver, shown in Fig. 1-*b*. Each of the main sections is a complete circuit in itself, and each must be designed separately before the whole thing can be assembled. But before we can even start thinking about putting the electronics together, we must get an overview of the system's operation.

Keyboard and encoder circuits are nothing new. We've designed them several times in past columns. Basically, we're looking for something that will translate a keypress into a unique binary code and place that code on a data bus.

After the code has been generated, we must modulate it before we send it on to the transmitter. The modulator (and the corresponding demodulator in the receiver) are both new circuits in this column.

The modulator must take the data from the keyboard and convert it to whatever is needed by our transmission circuitry. There are many schemes for accomplishing that. For example, the data can be encoded as FSK (*F*requency-*S*hift *K*eying), AM (*A*mplitude *M*odulation), or DTMF (*D*ual *T*one *M*ulti-*F*requency). We all know the latter from its use in *Touch-Tone* dialing.

After the data has been converted by the modulator, it is passed on to the transmitter. For a transmission medium we could use anything from a pair of twisted wires to ultrasonic sound, but we'll use infrared light. When we begin that part of the design, you'll see that it's very easy to change from one transmission medium to another. I'm using infrared because ultrasonic waves make my teeth hurt.

At the receiving end, the signal is detected, conditioned, and then passed on to the demodulator where it is converted back to its original binary form. Then the decoder turns on the selected output.

Now that we have an overall idea of how the circuit works, let's get started by looking at the transmitter's keyboard encoder.

From keypress to code

Figure 2 shows the schematic of the keyboard encoder we'll use for our remote-control system. The 4514 is a 4- to 16-line decoder with normally low outputs. When a 4-bit binary word is presented at its A–D inputs, the corresponding decoded 0–15 output goes high. Pin 1 is an active-high input enable (IE), and pin 23 is an active-low output enable ($\overline{OE}$) control. In normal operation, pin 1 must be high and pin 23 must be low. The 4520 is a dual synchronous 4-bit binary counter. We've used it so often that you should be able to recite its pinout in your sleep.

The operation of the keyboard circuit is straightforward. One of the 4520's counters is fed with a clock that causes the counter to cycle through its full 4-bit count (0 to 15) repetitively. The binary inputs of the 4514 are tied to the 4520's outputs, thereby causing its 16 outputs to go high one at a time in turn. Because $\overline{OE}$ (pin 23) is tied to ground, the 4514's outputs are always enabled. The INPUT ENABLE (pin 1), however, is connected to the common terminal of switches S1–S16 through an inverter. As long as no key is pressed, resistor R1 holds that point low, so the output of the inverter is high, so the 4514 continues to cycle through its various states.

When a key is pressed, however, the outputs continue to cycle until the output corresponding to that key goes high. When that happens, the inverter's input goes high, so its output goes low. That disables the 4514 and the 4520. Therefore, the binary output of the 4520 is frozen on the data bus.

There is one special feature of the circuit that's not immediately apparent. You'll notice that nothing is done to debounce the switches. If you trace through the operation of the circuit carefully, you'll see that it's not necessary—the circuit is inherently bounce-free. If we happen to produce a bounce when the switch is closed, all that happens is that the inputs stay enabled and the 4514 continues to cycle through another full count. But by using the output of the inverter to strobe data into the following stage (which is what we'll do next time), we can ignore the additional pulses.

To see how the circuit works, breadboard it and feed it a clock of some sort—a 555 circuit will do just fine for test purposes. If you slow the clock down to a few Hertz, you'll be able to watch the circuit operate. Slowing the clock and watching the outputs will do more to help you understand how the circuit works than ten pages of written explanations.

The next thing we must do is take the 4-bit binary code from the keyboard and encode it for transmission. But that is a subject for next time. In case you're interested we'll be using the S2579 DTMF Generator from American Microsystems Inc. **R-E**

SERVICE CLINIC

Oughta be ain't is!

JACK DARR,
SERVICE EDITOR

THE FIRST THING THING TO DO WITH any set that looks totally dead is to start measuring DC voltages. When you find one that looks incorrect, try to find a logical reason for it: look at nearby components that may be bad (open or shorted) and at other sections of the circuit that could affect the one with problems.

An incorrect or missing DC voltage is often the best clue we have to a bad stage. Always check DC signals first: No volts, no work! However, you can't use DC levels as your only source of troubleshooting information; some parts can stop an audio or video signal cold without having much effect on the DC voltages. If you find no odd-looking DC levels, you'll have to try another technique—signal tracing, for example.

If you've got decent service literature, most likely it has scope photos illustrating the shape and amplitude of signals at various points in the circuit. Try feeding a test signal (that approximates what you see in the literature) into the input of the circuit, and see if the output looks anything at all like what it should.

For example, take a look at the horizontal output stage in Fig. 1. You might try feeding a 10-volt p-p sinewave into D1. Then look at the collector of Q1. If you don't see something that resembles the 170-volt p-p signal shown in the schematic, Q1 may be bad. On the other hand, if the test signal gets through, that part of the circuit probably works correctly, so you can go on and test other stages.

By following that process in a logical manner, you'll eliminate possible sources of trouble one by one and eventually arrive at the real source of trouble.

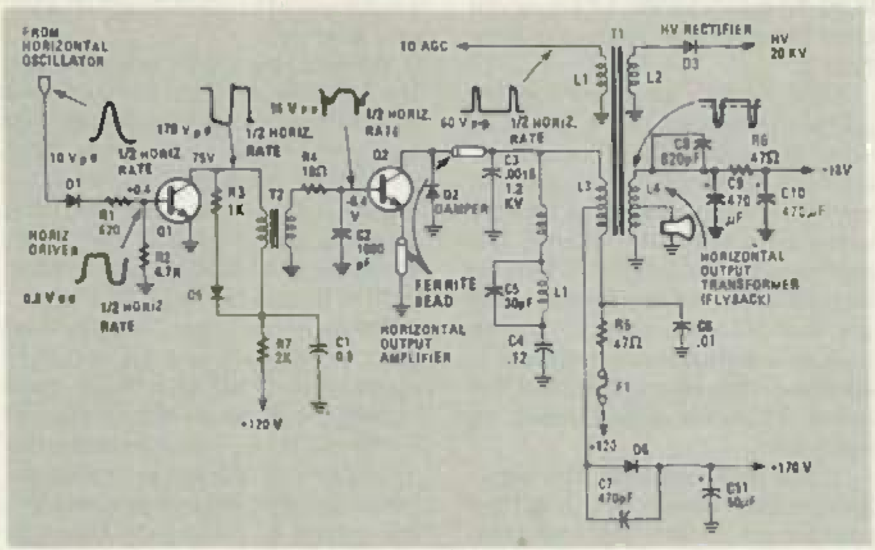

FIG. 1

Of course there are special things to look out for: coupling capacitors, for example. If one develops an open, it can stop the signal dead in its tracks, but the DC voltages will often be affected little, if at all. And that's when we've got to resort to signal tracing.

Always be careful with little things like coupling capacitors that *look* good. Don't assume that those capacitors never go bad. I used to have a bad habit of doing just that. That is, until the day I found one that had developed an open!

So never get into the bad habit of assuming any part is good without thoroughly checking it; always test everything. I used to make assumptions until one day I had a lot of trouble figuring out what was wrong with several different sets. So always keep that most valuable asset of a service technician: the completely open mind! In other words, suspect everything in a circuit until you find out who the real culprit is! And don't be too sure then!

Here's an example of how making assumptions can lead you astray. I had a set that was completely dead: no video, no audio, not even any noise. There was one big solder joint on a terminal right in the middle of the chassis. It had a large blob of solder on it, and it looked like a perfectly good joint. I thrashed around in that circuit until I finally got a hold of myself, started signal-tracing, and, behold, the signal came right up to that "perfect" solder joint where it stopped!

I melted the joint, and the moment my iron touched it, it went up in a little puff of smoke! It wasn't solder at all, but a big blob of what is called "liquid solder." Obviously there wasn't much continuity in that joint. Hardened acetate cement doesn't conduct electricity very well. So I soldered that joint in the usual way, and the set began working right away.

The moral is that, if you never take anything for granted, you'll have fewer servicing headaches. Never assume that a solder joint is good. Check the dad-burned thing with an ohmmeter just to make sure. You'll find many pitfalls of that sort; don't let 'em throw you. When tracing a signal that suddenly stops, check everything in the immediate vicinity and you'll often find something that will surprise you.

Shop bookkeeping

One thing we seldom talk about is how to keep track of the amount of work that has been done for each customer, and which parts went into his set. One way to keep track of things is by keeping the parts we've pulled out for replacement in a separate pile for each customer. That way, when the job is over, we can just go through the pile and charge the customer accordingly. That makes bookkeeping (one of our favorite tasks!) much easier. And if you're your own bookkeeper, as most of us are, it's well worth spending a little time getting and staying organized; you could lose a lot of money if you're not careful.

Another thing that can help, when making out the bill, is to write down each part you installed, and its function (for example, 0.01 µF, "2nd IF screen-bypass capacitor"). Keep a copy of the bill, and the next time the customer comes in, you'll quickly be able to see what you've already done to that set. And you'll want to know the date of installation for parts that are covered by warranty—yours or the manufacturer's.

And be sure to write clearly! If you can't read your own writing, get someone else to do it for you! That way, if you get a callback on a job, you'll have some idea of where to begin troubleshooting. If you can pull the original bill, you'll be able to tell just which parts you installed, and, more importantly, which you didn't.

That's about all for now. I got a card from an old friend, Bill Eslick, 2607 E. 12th Street, Wichita, KS 67214. He wants to buy old issues of Radio-Electronics, *Radio-Craft*, etc. Drop Bill a line if you have any back issues for sale. R-E

SERVICE QUESTIONS

BLOOMIN' PROBLEMS

I've got a problem in my own set! It's blooming with visible retrace lines, and the contrast control won't darken the screen. The brightness increases until the HV shuts off. I've checked all voltages, and they seem normal. The PC board is so delicate that I don't want to do a lot of desoldering without a good idea of where to begin. I hope you can help.—R. D. W., Bergen, NJ.

So do I! I think you'll find a leaky transistor somewhere. Check all DC voltages carefully and see if one is a good bit off. If so, that will change the bias on the CRT, and make it draw more current until the set shuts off. Start by measuring the CRT grid and cathode voltages very carefully, and then trace the circuit back until you come to the stage that controls it. There you will find the the trouble.

RED-HOT 6KD6 TUBE

I've got a Philco CT7340AWA. It uses a 6KD6 horizontal output tube. The problem is that the 6KD6 plate gets red hot and there is no HV. The sound also gets distorted. Any ideas?—M. R., Flushing, NY.

Several, and all boil down to one thing; you have lost the grid drive on the 6KD6 tube. That drive normally generates a high negative voltage to bias the tube. If you lose grid drive, the tube will draw a very high current, perhaps as much as 400–500 mA. That's normal. The fact that the tube will take that much current shows that it is still good, but don't allow high current to flow through the tube for too long, or it might be damaged.

Normal bias on the 6KD6 should be at least −60 volts. Check your schematic for the exact value, because sometimes it's even more. You may also want to check the horizontal oscillator. R-E

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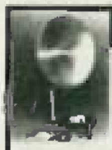

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R-E ROBOT

continued from page 56

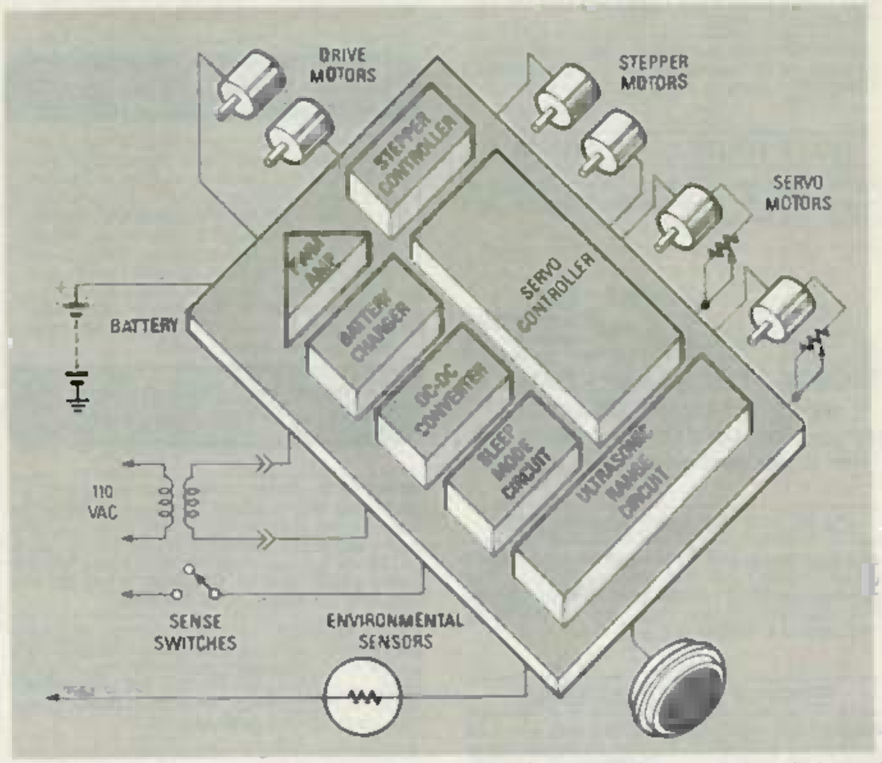

FIG. 2—MOST OF THE BASIC CONTROL CIRCUITS are located on a single custom board, designated Board 1. That board is shown here in block-diagram form.

of FORTH is written in FORTH, the internal routines are available to the programmer, and we can use parts of the FORTH interpreter in the RCL interpreter. The end result is an interactive RCL that can be modified by the user, and that can be used without a disk drive. We will be looking at RCL in depth in a future installment.

Operator interface

Most applications of robots are limited not by the ability of the hardware to perform a given task, but by the amount of time it takes to "teach" the robot. RCL significantly improves programming productivity.

Several methods of operator interface were considered. One was the "teach pendant" approach wherein motion sequences are learned and stored for recall and execution at a later time. However, after both utility and expense were considered, all other methods of interface were abandoned in favor of using a serial terminal. The reason is that almost everyone who considers building a robot has a terminal or a personal computer that can emulate a terminal. And if a more sophisticated method of control is desired, the required modifications are easy to perform. However, modifications of that sort are left to the ingenuity of the reader.

It is important to be able to operate the robot from a remote location. What we need is a way to transport our commands from the control terminal to the robot. That is done using an RF link. The link interfaces to the terminal via the terminal's serial port.

Table 1 shows how our robot stacks up against several of the leaders in the personal-robot market: the *RB-5X* from RB Robots (14618 W. Sixth St., Golden, CO 80401) and the Heath (Benton Harbor, MI 49022) *HERO 2000*. When you compare the capabilities of those robots to ours, we think you'll find that our inexpensive, build-it-yourself robot more than holds its own against the competition.

That concludes our overview of the R-E robot. In the coming months we will analyze each of the robot's subsystems in detail and show you how you can adapt our design to your applications.

As part of the design process, a special section of RE-BBS, **Radio-Electronics'** new computer bulletin-board service, will be dedicated for use by robot builders. We invite readers who devise interesting applications, programs, and experiments, or who discover sources of parts, or who have questions, answers, or any other information of general interest to share that information with others by posting it on the bulletin board. In addition, the author and the editors will be posting circuit modifications, design updates, and supplier information there for your convenience. By sharing information in that way, we hope to develop the kind of personal robot that has long been promised but never produced. R-E

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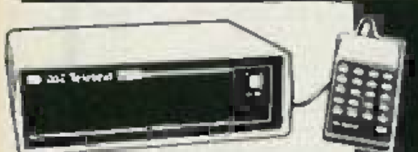

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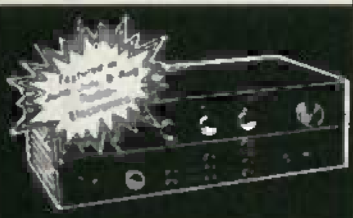

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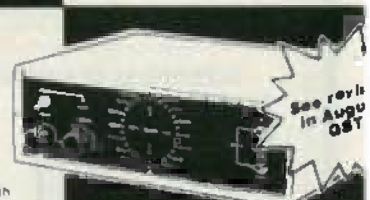

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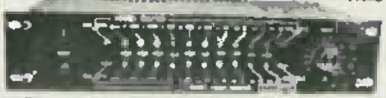
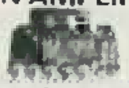


Kit $50.00
Ass. with tested $60.00

80W + 80W DC LOW TIM PRE-MAIN AMPLIFIER

TA-800



Kit $49.05
Metal Cabinet/X'Former (Optional) .... $23.90/$22.00

COLOR LIGHT CONTROLLER

TY-238

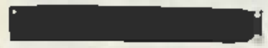
Best for Party!

As a result of the advanced technology, this unit can control various colorful light bulbs, the visual effect of which is most suitable in places like party, disco, electronic game centre and also in lightings for advertisement. Total output power is 3000W (1000W Ch.) which means that it can control 30 pieces of 100W or 600 pieces of 5W color light which is enough for most usages.

Kit $65.00
Ass. with tested $75.00

TA-2400A ELECTRONIC ECHO AND REVERBERATION AMPLIFIER

REMIX records yourself!



This unit combines the most advanced B.B.D. technique with high quality Japan made components. It has the following FEATURES:
It can generate various reflection and reverberation effects. It has 3 special effect controls which include reverberation control, delay control and depth control. Special effect can be made in your record tape by using this model. All kinds of [illegible] sound effect can be obtained by skillful use of this control. It has LED display to show reflection and reverberation.

Ass. with tested $99.85

CORDLESS SOLDERING IRON RECHARGEABLE

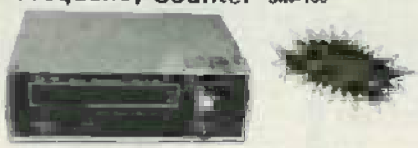
No. 620

New

The most perfect handy, lightweight soldering iron for Work shop, Home, Hobby & Outdoor work.
Includes UL approval charger & cleaning sponge.
With build in solder point illumination.

Each set $22.80

150MC Universal Digital Frequency Counter SM-100



Frequency Range: 10Hz – 150MHz
Event Counter: 0 to 99999999 counts (8 Digit)
Input sensitivity: KHz range 10Hz – 10MHz 50mVrms,
MHz range 1MHz – 150MHz 40mVrms
Response time: 0.2 second
Hold Function: Hold the last input signal
Power Supply: DC9V Battery or DC9V 250MA Adaptor
Dimension: 9⅛" x 6 7/16" x 2¾"

Assembled with tested $99.00

TALKING CLOCK

AMAZING VALUE!

GOLDEN & BLACK ARE AVAILABLE!

1. Tap push button for voice announcement of time
2. Read out: twelve hours system display for hour, minute, second (by color flash) AM & PM
3. Display: three display modes of time, alarm time & date
4. Alarm: on off switch with thirty seconds voice alarm
5. Snooze: reminder voice alarm of thirty seconds after 4 minutes of first voice alarm
6. Volume: two level of voice output
7. Language available: English, Mandarin

PARROT 8801 .... $17.75 NOT a KIT!
MYNAH 8804 .... $18.90

HIGH QUALITY MULTIPURPOSE PRE-AMPLIFIER

TA-2500

GREAT VALUE

This specially designed pre-amplifier includes a professional GRAPHIC EQUALIZER TONE control system and has a gain of ±12dB. Frequency response extends from 5Hz to 20KHz, so as to ensure best performance in whatever adverse condition. It can accept input from various magnetic cartridge record deck, CD player and tuner; its output can be connected to all kinds of power amplifier!

Assembled with tested $82.00

NF-CR BI-FET IC PRE-AMPLIFIER WITH 3 WAY TONE CONTROL!

TA-2800

Kit $36.80

100W DYNAMIC CLASS "A" MAIN POWER AMPLIFIER

TA-1000A

NOW PAY LESS!

This powerful dynamic bias class "A" circuit makes this unit unique in its class. Crystal clear 100W R.M.S. POWER output will satisfy the most picky Hi-Fi fans. This is a single channel amplifier. If you need a stereo effect you can buy two to make a total of 200W DYNAMIC POWER!
Over 3000 KITS ARE SOLD IN THE STATE!

Kit $45.50

STEREO SIMULATOR

TA-3000

SPECIAL KITS OFFER!

KIT ONLY $25.00

You can own a stereo TV from today! This simulator is a special design of using the most advanceable monopolized L.S.I. It produced a superior analog stereo effect since the L.S.I. is equalled so pre. of LOW NOISE FET & TRANSISTOR. The simulator can even help you to promote your television from a normal one to a special one with a Hi-Fi STEREO function. Our simulator is also applicable to any other 'mono sources' in covering it to ANALOG STEREO. Undoubtedly, it is the most advanced equipment for every family, while it should contribute to your listening pleasure.

Ass. with tested $30.00

120W MOSFET POWER AMPLIFIER

TA-477

This amplifier consists of three super low TIM differential stages, and Hitachi 2SJ49/2SK 134 match pair "MOSFET" as output component whose frequency response and transient response is superior to the other power transistor. Therefore this amplifier has high-fidelity and superior analytic power over the entire Audio Spectrum. It is suitable for reproducing classic and modern music. Heavy Duty Heat Sink with 29 radial fins is included!

Kit $66.00
Metal Cabinet/X'Former (Optional) .... $23.90/$19.80

Model No	Description	Kit/Assembled	Unit Price
TA-001	1W Mini Amplifier	Kit	$3.90
TA-006	8W Mini Amplifier	Kit	$4.92
TA-007	12W Stereo Power Booster	Kit	$8.00
TA-008	AC/DC SHOULDER AMPLIFIER	Ass	$48.00
TA-10	STEREO PRE AMPLIFIER WITH MAGNETIC MIC AMP	Kit	$6.00
TA-50 A, B	MULTI PURPOSE MELODY GENERATOR	Kit	$10.78
TA-120	PURE CLASS "A" MAIN POWER AMPLIFIER	Kit	$25.00
TA-207	20W AC/DC STEREO AMPLIFIER	Ass	$60.00
TA-300	30W Multi Purpose Single Channel Amp	Kit	$11.07
TA-302	60W Stereo Power Booster	Kit	$50.00
		Ass	$60.00
TA-323A	High Quality 30W+30W Stereo Amplifier	Kit	$24.60
TA-322	60W IC Stereo Pre Amplifier & Power Amplifier	Kit	$29.50
TA-400	40W TRANSISTORIZED MONO AMPLIFIER	Kit	$17.84
TA-477	120W MOSFET POWER AMPLIFIER	Kit	$55.00
TA-800	160W DC LOW TIM PRE AMPLIFIER & POWER AMP	Kit	$49.05
TA-802	160W PURE DC ST. POWER AMP. W SPK. PROTECTOR	Kit	$39.95
TA-820A	120W OCL DC PRE MAIN & STEREO AMPLIFIER	Kit	$43.00
TA-1000A	100W DYNAMIC CLASS "A" MAIN POWER AMP (MONO)	Kit	$45.50
TA-1500	200W NEW CLASS "A" DC STEREO PRE MAIN AMP	Kit	$67.00
TA-2400A	ELECTRONIC ECHO AND REVERBERATION AMP	Ass	$99.85
TA-2500	HIGH QUALITY MULTI-PURPOSE PRE AMPLIFIER	Ass	$82.00
TA-2200	DC FET SUPER CLASS "A" PRE AMPLIFIER	Kit	$38.00
TA-2800	NF-CR BI-FET PRE AMP WITH 3WAY TONE CONTROL	Kit	$36.80
TA-3000	STEREO SIMULATOR	Ass	$30.00
		Kit	$25.00
SM-43	3 1/2 MULTI FUNCTIONAL LED D.P.M.	Kit	$29.23
		Ass	$35.00
SM-48	4 1/2 HI PRECISION D.P.M.	Kit	$38.00
		Ass	$43.00
SM-100	150MC UNIVERSAL DIGITAL FREQUENCY COUNTER	Ass	$99.00
TY-43	3 1/2 DIGITAL PANEL METER	Kit	$26.00

Model No	Description	Kit/Assembled	Unit Price
TR-355 A, B	3-5A REGULATED DC POWER SUPPLY	Kit	$10.60
TR-503	0-50V 3A POWER SUPPLY WITH SHORT CIRCUIT BREAK & OVERLOAD PROTECTOR	Kit	$12.30
TR-100	0-15V 2A REGULATED DC POWER SUPPLY	Ass	$69.50
		Kit	$59.50
TY-1A MK II	BATTERY FLUORESCENT LIGHT	Kit	$3.99
TY-7	ELECTRONIC TOUCH SWITCH	Kit	$5.50
TY-11A	MULTI FUNCTIONAL CONTROL RELAY	Kit	$3.99
TY-12A	DIGITAL CLOCK WITH TWO TIMER	Kit	$13.80
TY-13	COLOR LED VU METER	Kit	$17.50
TY-14	ELECTRONIC SHOCK	Kit	$3.00
TY-18	HIGH PRECISION SOUND CONTROL SWITCH	Kit	$7.68
TY-20	SUPER SENSITIVE AUDIO LEVEL INDICATOR	Kit	$19.50
TY-238	COLOR LIGHT CONTROLLER	Kit	$65.00
		Ass	$75.00
TY-25	SPEAKER PROTECTOR	Kit	$9.50
TY-36	FM WIRELESS MICROPHONE	Kit	$7.68
TY-38	AC/DC QUARTZ DIGITAL CLOCK	Kit	$18.92
TY-38	SOUND OR TOUCH CONTROL SWITCH	Kit	$10.00
TY-41 MK II	INFRARED REMOTE CONTROL UNIT	Kit	$26.00
		Ass	$30.00
TY-42	BAR/DOT LEVEL METER	Kit	$21.00
TY-45	BAR/DOT AUDIO LEVEL DISPLAY	Kit	$34.95
TY-47	SUPERIOR ELECTRONIC ROULETTE	Kit	$18.92
YAMATO 4001	3½ DIGITAL MULTIMETER	SET	$33.80
T1	LCD THERMOMETER CLOCK WITH & OUT DOOR SENSOR	SET	$20.00
T2	LCD THERMOMETER CLOCK W/F & C MEASURING	SET	$18.00
8504	TALKING CLOCK MYNAH (GOLDEN OR BLACK)	SET	$25.00
NO. 620	CORDLESS SOLDERING IRON RECHARGEABLE	SET	$22.80

Ass = Assembled form, it is fully checked and tested

TERMS: Minimum order: $10.00. Charge card order $20.00. No C.O.D.! Check & Money order, phone order accept. CA. residents must include 6.5% sales tax. Prices are subject to change without notice. All merchandise subject to prior sale. Shipping & handling: Inside L.A. 5% of total order (Min. $1.50). Outside L.A. 10% of total orde (Min. $2.50). Outside U.S.A. 20% of total order (Min. $5.00). Shipped by UPS ground.
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NATION-WIDE DISTRIBUTORS WANTED FOR OUR PRODUCTS, QUANTITY DISCOUNTS AVAILABLE!

CIRCLE 93 ON FREE INFORMATION CARD

20MB HARD DISK SYSTEM ONLY $389.95!

STATIC RAMS

2101	256x4	(450ns)	1.95
5101	256x4	(450ns)(CMOS)	3.95
2102L-4	1024x1	(450ns)(LP)	.99
2112	256x4	(450ns)	2.99
2114	1024x4	(450ns)	.99
2114L-4	1024x4	(450ns)(LP)	1.09
2114L-2	1024x4	(200ns)(LP)	1.49
2114L-15	1024x4	(150ns)(LP)	1.95
TMS4044-4	4096x1	(450ns)	1.95
TMM2016-150	2048x8	(150ns)	1.49
TMM2016-100	2048x8	(100ns)	1.99
HM6116-4	2048x8	(200ns)(CMOS)	1.89
HM6116-3	2048x8	(150ns)(CMOS)	1.95
HM6116LP-4	2048x8	(200ns)(CMOS)(LP)	1.85
HM6116LP-3	2048x8	(150ns)(CMOS)(LP)	2.05
HM6116LP-2	2048x8	(120ns)(CMOS)(LP)	2.95
HM6264P-15	8192x8	(150ns)(CMOS)	3.89
HM6264LP-15	8192x8	(150ns)(CMOS)(LP)	3.95
HM6264LP-12	8192x8	(120ns)(CMOS)(LP)	4.49

LP=Low power

DYNAMIC RAMS

4116-250	16384x1	(250ns)	.49
4116-200	16384x1	(200ns)	.89
4116-150	16384x1	(150ns)	.99
4116-120	16384x1	(120ns)	1.49
MK4332	32768x1	(200ns)	6.95
4164-200	65536x1	(200ns)(5v)	1.19
4164-150	65536x1	(150ns)(5v)	1.29
4164-120	65536x1	(120ns)(5v)	1.95
MCM6665	65536x1	(200ns)(5v)	1.95
TMS4164	65536x1	(150ns)(5v)	1.95
4164 REFRESH	65536x1	(150ns)(5V)(REFRESH)	2.95
TMS4416	16384x4	(150ns)(5v)	4.95
41128-150	131072x1	(150ns)(5v)	5.95
TMS4464-15	65536x4	(150ns)(5v)	6.95
41256-200	262144x1	(200ns)(5v)	2.95
41256-150	262144x1	(150ns)(5v)	2.95

5v=Single 5 Volt Supply REFRESH=Pin 1 refresh

★★★★HIGH-TECH★★★★

NEC V20 UPD70108 $11.95

REPLACES 8088 TO SPEED UP IBM PC 10-40%

- HIGH-SPEED ADDRESS CALCULATION IN HARDWARE
- PIN COMPATIBLE WITH 8088
- SUPERSET OF 8088 INSTRUCTION SET
- LOW POWER CMOS

8MHz	V20	UPD70108-8	$13.95
8MHz	V30	UPD70116-8	$19.95

★★★★SPOTLIGHT★★★★

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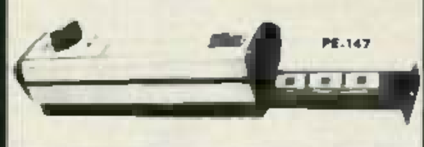
VISA MasterCard

EPROMS

2708	1024x8	(450ns)	4.95
2716	2048x8	(450ns)(5V)	3.49
2716-1	2048x8	(350ns)(5V)	3.95
TMS2532	4096x8	(450ns)(5V)	5.95
2732	4096x8	(450ns)(5V)	3.95
2732A	4096x8	(250ns)(5V)(21V PGM)	3.95
2732A-2	4096x8	(200ns)(5V)(21V PGM)	4.25
27C64	8192x8	(250ns)(5V)(CMOS)	5.95
2764	8192x8	(450ns)(5V)	3.49
2764-250	8192x8	(250ns)(5V)	3.95
2764-200	8192x8	(200ns)(5V)	4.25
MCM68766	8192x8	(350ns)(5V)(24 PIN)	17.95
27128	16384x8	(250ns)(5V)	4.25
27C256	32768x8	(250ns)(5V)(CMOS)	10.95
27256	32768x8	(250ns)(5V)	7.49

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

SPECTRONICS CORPORATION EPROM ERASERS



Model	Timer	Capacity Chip	Intensity (uW/Cm²)	Unit Price
PE-14	NO	6	8,000	$83.00
PE-14T	YES	6	8,000	$119.00
PE-24T	YES	12	9,600	$175.00

8000

8035	1.49
8039	1.95
8080	2.95
8085	2.49
8087-2	169.95
8087	129.00
8088	6.95
8088-2	9.95
8155	2.49
8155-2	3.95
8748	7.95
8755	14.95
80286	129.95
80287	199.95

8200

8203	24.95
8205	3.29
8212	1.49
8216	1.49
8224	2.25
8237	4.95
8237-5	5.49
8250	6.95
8251	1.69
8251A	1.69
8253	1.49
8253-5	1.95
8255	1.69
8255-5	1.89
8259	1.95
8259-5	2.29
8272	4.95
8279	2.49
8279-5	2.95
8282	3.95
8284	2.95
8286	3.95
8288	4.95

Z-80

Z80-CPU 2.5 MHz	1.69
4.0 MHz	
Z80A-CPU	1.79
Z80A-CTC	1.69
Z80A-DART	5.95
Z80A-DMA	5.95
Z80A-PIO	1.89
Z80A-SIO/0	5.95
Z80A-SIO/1	5.95
Z80A-SIO/2	5.95
6.0 MHz	
Z80B-CPU	3.75
Z80B-CTC	4.25
Z80B-PIO	4.25
Z80B DART	14.95
Z80B SIO/0	12.95
Z80B-SIO/2	12.95
Z8671 ZILOG	19.95

6500

1.0 MHz	
6502	2.69
65C02 (CMOS)	12.95
6507	9.95
6520	1.95
6522	4.95
6526	26.95
6532	6.95
6545	8.95
6551	5.95
6561	19.95
6581	34.95
2.0 MHz	
6502A	2.95
6520A	2.95
6522A	5.95
6532A	11.95
6545A	7.95
6551A	6.95
3.0 MHz	
6502B	6.95

6800

1.0 MHz	
6800	1.95
6802	4.95
6803	9.95
6809	5.95
6809E	6.95
6810	1.98
6820	2.95
6821	1.95
6840	6.95
6843	19.95
6844	12.95
6845	4.95
6847	11.95
6850	1.98
6883	22.95
2.0 MHz	
68B00	4.95
68B02	5.95
68B09E	6.95
68B09	6.95
68B21	3.95
68B45	6.95
68B50	2.95
68B54	7.95

CLOCK CIRCUITS

MM5369	1.95
MM5369-EST	1.95
MM58167	12.95
MM58174	11.95
MSM5832	2.95

CRT CONTROLLERS

6845	4.95
68B45	8.95
6847	11.95
HD46505SP	6.95
MC1372	2.95
8275	26.95
7220	19.95
CRT5027	12.95
CRT5037	9.95
TMS9918A	19.95

DISK CONTROLLERS

1771	4.95
1791	9.95
1793	9.95
1795	12.95
1797	12.95
2791	19.95
2793	19.95
2797	29.95
6843	19.95
8272	4.95
UPD765	4.95
MB8876	12.95
MB8877	12.95
1691	6.95
2143	6.95

BIT RATE GENERATORS

MC14411	9.95
BR1941	4.95
4702	9.95
COM8116	8.95
MM5307	4.95

UARTS

AY5-1013	3.95
AY3-1015	4.95
TR1602	3.95
2651	4.95
IM6402	6.95
IM6403	9.95
INS8250	6.95

SOUND CHIPS

76477	5.95
76489	8.95
SSI-263	39.95
AY3-8910	12.95
AY3-8912	12.95
SP1000	39.00

CRYSTALS

32.768 KHz	.95
1.0 MHz	2.95
1.8432	2.95
2.0	1.95
2.097152	1.95
2.4576	1.95
3.2768	1.95
3.579545	1.95
4.0	1.95
4.032	1.95
5.0	1.95
5.0688	1.95
6.0	1.95
6.144	1.95
6.5536	1.95
8.0	1.95
10.0	1.95
10.738635	1.95
12.0	1.95
14.31818	1.95
15.0	1.95
16.0	1.95
17.430	1.95
18.0	1.95
18.432	1.95
20.0	1.95
22.1184	1.95
24.0	1.95
32.0	1.95

CRYSTAL OSCILLATORS

1.0MHz	5.95
1.8432	5.95
2.0	5.95
2.4576	5.95
2.5	4.95
4.0	4.95
5.0688	4.95
6.0	4.95
6.144	4.95
8.0	4.95
10.0	4.95
12.0	4.95
12.480	4.95
15.0	4.95
16.0	4.95
18.432	4.95
20.0	4.95
24.0	4.95

MISC.

TMS99531	9.95
TMS99532	19.95
ULN2003	.79
3242	7.95
3341	4.95
MC3470	1.95
MC3480	8.95
MC3487	2.95
11C90	19.95
2513-001 UP	6.95
AY5-2376	11.95
AY5-3600 PRO	11.95

74LS00

74LS00	.16	74LS165	.65
74LS01	.18	74LS166	.95
74LS02	.17	74LS169	.95
74LS03	.18	74LS173	.49
74LS04	.16	74LS174	.39
74LS05	.18	74LS175	.39
74LS08	.18	74LS191	.49
74LS09	.18	74LS192	.69
74LS10	.16	74LS193	.69
74LS11	.22	74LS194	.69
74LS12	.22	74LS195	.69
74LS13	.26	74LS196	.59
74LS14	.39	74LS197	.59
74LS15	.26	74LS221	.59
74LS20	.17	74LS240	.69
74LS21	.22	74LS241	.69
74LS22	.22	74LS242	.69
74LS27	.23	74LS243	.69
74LS28	.26	74LS244	.69
74LS30	.17	74LS245	.79
74LS32	.18	74LS251	.49
74LS33	.28	74LS253	.49
74LS37	.26	74LS254	1.79
74LS38	.26	74LS257	.39
74LS42	.39	74LS258	.49
74LS47	.79	74LS259	1.29
74LS48	.65	74LS260	.49
74LS51	.17	74LS266	.39
74LS73	.29	74LS273	.79
74LS74	.24	74LS279	.39
74LS75	.29	74LS280	1.98
74LS76	.29	74LS283	.59
74LS83	.49	74LS290	.89
74LS85	.49	74LS293	.89
74LS86	.22	74LS299	1.49
74LS90	.39	74LS322	3.95
74LS92	.49	74LS323	2.49
74LS93	.39	74LS364	1.95
74LS95	.49	74LS365	.39
74LS107	.34	74LS367	.39
74LS109	.36	74LS368	.39
74LS112	.29	74LS373	.79
74LS122	.45	74LS374	.79
74LS123	.49	74LS375	.95
74LS124	2.75	74LS377	.79
74LS125	.39	74LS378	1.18
74LS126	.39	74LS390	1.19
74LS132	.39	74LS393	.79
74LS133	.49	74LS541	1.49
74LS136	.39	74LS624	1.95
74LS138	.39	74LS640	.99
74LS139	.39	74LS645	.99
74LS145	.99	74LS669	1.29
74LS147	.99	74LS670	.89
74LS148	.99	74LS682	3.20
74LS151	.39	74LS683	3.20
74LS153	.39	74LS684	3.20
74LS154	1.49	74LS688	2.40
74LS155	.59	74LS783	22.95
74LS156	.49	81LS95	1.49
74LS157	.35	81LS96	1.49
74LS158	.29	81LS97	1.49
74LS160	.29	81LS98	1.49
74LS161	.39	25LS2521	2.80
74LS162	.49	25LS2569	2.80
74LS163	.39	26LS31	1.95
74LS164	.49	26LS32	1.95

HIGH SPEED CMOS

A new family of high speed CMOS logic featuring the speed of low power Schottky (8ns typical gate propagation delay), combined with the advantages of CMOS: very low power consumption, superior noise immunity, and improved output drive.

74HC00

74HC: Operate at CMOS logic levels and are ideal for new, all CMOS designs

74HC00	.59	74HC148	1.19
74HC02	.59	74HC161	.89
74HC04	.59	74HC154	2.49
74HC08	.59	74HC157	.49
74HC10	.59	74HC158	.95
74HC14	.79	74HC163	1.15
74HC20	.59	74HC175	.99
74HC27	.59	74HC240	1.89
74HC30	.59	74HC244	1.89
74HC32	.69	74HC245	1.89
74HC51	.59	74HC257	.85
74HC74	.75	74HC259	1.39
74HC85	1.35	74HC273	1.89
74HC86	.69	74HC299	4.99
74HC93	1.19	74HC368	.99
74HC107	.79	74HC373	2.29
74HC109	.79	74HC374	2.29
74HC112	.79	74HC390	1.39
74HC125	1.19	74HC393	1.39
74HC132	1.19	74HC4017	1.99
74HC133	.69	74HC4020	1.39
74HC138	.99	74HC4049	.69
74HC139	.99	74HC4050	.69

74HCT00

74HCT: Direct, drop in replacements for LS TTL and can be intermixed with 74LS in the same circuit.

74HCT00	.69	74HCT166	3.05
74HCT02	.69	74HCT174	1.09
74HCT04	.69	74HCT193	1.29
74HCT08	.69	74HCT194	1.19
74HCT10	.69	74HCT240	2.19
74HCT11	.69	74HCT241	2.19
74HCT27	.69	74HCT244	2.19
74HCT30	.69	74HCT245	2.19
74HCT32	.79	74HCT257	.99
74HCT74	.85	74HCT259	1.69
74HCT75	.95	74HCT273	2.09
74HCT138	1.19	74HCT367	1.09
74HCT139	1.19	74HCT373	2.49
74HCT154	2.99	74HCT374	2.49
74HCT157	.99	74HCT393	1.89
74HCT158	.99	74HCT4017	2.19
74HCT161	1.29	74HCT4040	1.69
74HCT164	1.39	74HCT4060	1.49

74F00

74F00	.69	74F74	.79	74F251	1.69
74F02	.69	74F86	.99	74F253	1.69
74F04	.79	74F138	1.69	74F257	1.69
74F08	.69	74F139	1.69	74F280	1.79
74F10	.69	74F157	1.69	74F283	3.19
74F32	.69	74F240	3.29	74F373	4.29
74F64	.69	74F244	3.29	74F374	4.29

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4001	.19	14419	4.95
4011	.19	14433	14.95
4012	.25	4503	.49
4013	.35	4511	.89
4019	.29	4516	.79
4016	.29	4518	.85
4017	.49	4522	.79
4018	.85	4526	.79
4020	.59	4527	1.95
4021	.69	4528	.79
4024	.49	4529	2.95
4025	.29	4532	1.95
4027	.39	4538	.95
4028	.65	4541	1.29
4035	.69	4553	5.79
4040	.69	4585	.79
4041	.75	4702	12.95
4042	.59	74C00	.29
4043	.85	74C14	.59
4044	.69	74C74	.59
4045	1.98	74C83	1.99
4046	.69	74C85	1.49
4047	.69	74C95	.99
4049	.29	74C150	5.75
4050	.29	74C151	2.29
4051	.69	74C161	.99
4052	.69	74C163	.99
4053	.69	74C164	1.39
4056	2.19	74C192	1.49
4060	.69	74C193	1.49
4066	.29	74C221	2.49
4069	.15	74C240	1.89
4076	.59	74C244	1.89
4077	.29	74C374	1.99
4081	.22	74C905	10.95
4085	.79	74C911	8.95
4086	.89	74C917	12.95
4093	.49	74C922	4.49
4094	2.49	74C923	4.95
14411	9.95	74C926	7.95
14412	6.95	80C97	.95

7400/9000

7400	.19	74147	2.49
7402	.19	74148	1.20
7404	.19	74150	1.35
7406	.29	74151	.55
7407	.29	74153	.55
7408	.24	74154	1.49
7410	.19	74155	.75
7411	.25	74157	.55
7414	.49	74159	1.65
7416	.25	74161	.69
7417	.25	74163	.69
7420	.19	74164	.85
7423	.29	74165	.85
7430	.19	74166	1.00
7432	.29	74175	.89
7438	.29	74177	.75
7442	.49	74178	1.19
7445	.69	74181	2.25
7447	.89	74182	.79
7470	.35	74184	2.00
7473	.34	74191	1.19
7474	.33	74192	.79
7475	.45	74194	.85
7476	.35	74196	.79
7483	.50	74197	.75
7485	.59	74199	1.35
7486	.35	74221	1.35
7489	2.15	74246	1.35
7490	.39	74247	1.25
7492	.50	74248	1.85
7493	.35	74249	1.95
7495	.55	74251	.75
7497	2.75	74265	1.35
74100	2.29	74273	1.95
74121	.29	74276	3.11
74123	.49	74367	.65
74125	.45	74368	.65
74141	.65	9368	3.95
74143	5.95	9602	1.50
74144	2.95	9637	2.95
74145	.60	96S02	1.95

74S00

74S00	.29	74S163	1.29
74S02	.29	74S169	3.95
74S03	.29	74S174	.79
74S04	.29	74S175	.79
74S05	.29	74S188	1.95
74S08	.35	74S189	1.95
74S10	.29	74S195	1.49
74S19	.49	74S196	2.49
74S30	.29	74S157	2.55
74S32	.35	74S226	3.99
74S37	.69	74S240	1.49
74S38	.69	74S241	1.49
74S74	.49	74S244	1.49
74S85	.95	74S257	.79
74S86	.35	74S253	.79
74S112	.50	74S258	.95
74S124	2.75	74S280	1.95
74S138	.79	74S287	1.69
74S140	.55	74S288	1.65
74S151	.79	74S299	2.95
74S153	.79	74S373	1.85
74S157	.79	74S274	1.89
74S158	.95	74S471	4.95
74S161	1.29	74S571	2.95

DATA ACQ / INTERFACE

ADC0800	15.55	8T26	1.29
ADC0804	3.49	8T28	1.29
ADC0809	4.49	8T95	.89
ADC0816	14.95	8T96	.89
ADC0817	9.95	8T97	.59
ADC0831	8.95	8T98	.89
DAC0800	4.49	DM88131	2.95
DAC0806	1.95	DP8304	2.29
DAC0808	2.95	DS8833	2.25
DAC1020	8.25	DS8835	1.99
DAC1022	5.95	DS8836	.99
MC1408L8	2.95	DS8837	1.65

VOLTAGE REGULATORS

TO-220 CASE

7805T	.49	7905T	.59
7808T	.49	7908T	.59
7812T	.49	7912T	.59
7815T	.49	7915T	.59

TO-3 CASE

7805K	1.39	7905K	1.49
7812K	1.39	7912K	1.49

TO-92 CASE

78L05	.45	79L05	.69
78L12	.49	79L12	1.49

OTHER VOLTAGE REGS

LM323K	5V	3A	TO-3	4.79
LM338K	ADJ	5A	TO-3	3.95
78H05K	5V	5A	TO-3	7.95
78H12K	12V	5A	TO-3	8.95
78P05K	5V	10A	TO-3	14.95

IC SOCKETS

	1-99	100-
8 PIN ST	.11	.10
14 PIN ST	.11	.09
16 PIN ST	.12	.10
18 PIN ST	.15	.13
20 PIN ST	.18	.15
22 PIN ST	.15	.12
24 PIN ST	.20	.15
28 PIN ST	.22	.16
40 PIN ST	.30	.22
64 PIN ST	1.95	1.49
ST = SOLDERTAIL		
8 PIN WW	.59	.49
14 PIN WW	.69	.52
16 PIN WW	.69	.58
18 PIN WW	.99	.90
20 PIN WW	1.09	.98
22 PIN WW	1.39	1.29
24 PIN WW	1.49	1.35
28 PIN WW	1.65	1.49
40 PIN WW	1.99	1.80
WW = WIREWRAP		
16 PIN ZIF	4.95	CALL
24 PIN ZIF	5.95	CALL
28 PIN ZIF	6.95	CALL
40 PIN ZIF	9.95	CALL
ZIF = TEXTOOL (ZERO INSERTION FORCE)		

LINEAR

TL066	.99	LM733	.98
TL071	.69	LM741	.29
TL072	1.09	LM747	.69
TL074	1.95	LM748	.59
TL081	.59	MC1330	1.69
TL082	.99	MC1350	1.19
TL084	1.49	MC1372	6.95
LM301	.34	LM1414	1.59
LM309K	1.25	LM1458	.49
LM311	.59	LM1488	.49
LM311H	.89	LM1489	.49
LM317K	3.49	LM1496	.85
LM317T	.95	LM1812	8.75
LM318	1.49	LM1889	1.95
LM319	1.25	ULN2003	.79
LM320 see 7900		XR2206	3.95
LM322	1.95	XR2211	2.95
LM323K	4.79	XR2240	1.95
LM324	.49	MPQ2907	1.95
LM331	3.95	LM2917	1.95
LM334	1.19	CA3046	.89
LM335	1.79	CA3081	.99
LM338	1.75	CA3082	.99
LM337K	3.95	CA3086	.80
LM338K	6.95	CA3089	1.95
LM339	.59	CA3130E	.99
LM340 see 7800		CA3146	1.29
LM350T	4.60	CA3160	1.19
LF353	.59	MC3470	1.95
LF356	.99	MC3480	8.95
LF357	.99	MC3487	2.95
LM358	.59	LM3900	.49
LM380	.89	LM3909	.98
LM383	1.95	LM3911	2.25
LM386	.89	LM3914	2.39
LM393	.45	MC4024	3.49
LM394H	5.95	MC4044	3.99
TL494	4.20	RC4136	1.29
TL497	3.25	RC4558	.69
NE555	.29	LM13600	1.49
NE556	.49	75107	1.49
NE558	1.29	75110	1.95
NE564	1.95	75150	1.95
LM565	.95	75154	1.95
LM566	1.49	75188	1.25
LM567	.79	75189	1.75
NE570	2.95	75451	.39
NE590	2.50	75452	.39
NE592	.98	75453	.39
LM710	.75	75477	1.29
LM723	.49	75492	.79

H = TO-5 CAN, K = TO-3, T = TO-220

EDGECARD CONNECTORS

100 PIN ST	S-100	.125	3.95
100 PIN WW	S-100	.125	4.95
62 PIN ST	IBM PC	.100	1.95
50 PIN ST	APPLE	.100	2.95
44 PIN ST	STD	.156	1.95
44 PIN WW	STD	.156	4.95

36 PIN CENTRONICS

MALE

IDCEN36	RIBBON CABLE	6.95
CEN36	SOLDER CUP	4.95

FEMALE

IDCEN36/F	RIBBON CABLE	7.95
CEN36PC	RT ANGLE PC MOUNT	4.95

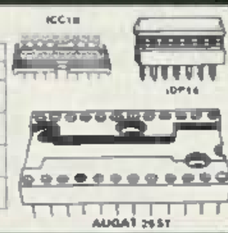
INTERSIL

ICL7106	9.95
ICL7107	12.95
ICL7660	2.95
ICL8038	4.95
ICM7207A	5.95
ICM7208	15.95

DIP CONNECTORS

DESCRIPTION	ORDER BY	CONTACTS 8	14	16	18	20	22	24	28	40
HIGH RELIABILITY TOOLED ST IC SOCKETS	AUGATxxST	.62	.79	.89	1.09	1.29	1.39	1.49	1.69	2.49
HIGH RELIABILITY TOOLED WW IC SOCKETS	AUGATxxWW	1.30	1.80	2.10	2.40	2.60	2.90	3.15	3.70	5.40
COMPONENT CARRIES (DIP HEADERS)	ICCxx	.49	.59	.69	.99	.99	.99	.99	1.09	1.49
RIBBON CABLE DIP PLUGS (IDC)	IDPxx	---	.99	.95	---	---	---	1.75	---	2.95

FOR ORDERING INSTRUCTIONS SEE D-SUBMINIATURE BELOW



DIODES/OPTO/TRANSISTORS

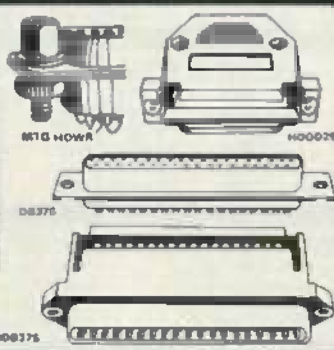
1N751	.25	4N26	.69
1N759	.25	4N27	.49
1N4148	25/1.00	4N28	.69
1N4004	10/1.00	4N33	.89
1N5402	.25	4N37	1.19
KBP04	.55	MCT-2	.59
KBU8A	.95	MCT-6	1.29
MDA990-2	.35	TIL-111	.99
N2222	.25	2N3906	.10
PN2222	.10	2N4401	.25
2N2905	.50	2N4402	.25
2N2907	.25	2N4403	.25
2N3055	.79	2N6045	1.75
2N3904	.10	TIP31	.49

D-SUBMINIATURE

DESCRIPTION		ORDER BY	CONTACTS 9	15	19	25	37	50
SOLDER CUP	MALE	DBxxP	.82	.90	1.25	1.29	1.80	3.48
	FEMALE	DBxxS	.95	1.15	1.50	1.60	2.38	4.32
RIGHT ANGLE PC SOLDER	MALE	DBxxPR	1.20	1.49	---	1.95	2.65	---
	FEMALE	DBxxSR	1.25	1.55	---	2.00	2.79	---
WIRE WRAP	MALE	DBxxPWW	1.69	2.56	---	3.89	5.60	---
	FEMALE	DBxxSWW	2.76	4.27	---	6.84	9.95	---
IDC RIBBON CABLE	MALE	IDBxxP	2.70	2.95	---	5.95	9.70	---
	FEMALE	IDBxxS	2.92	3.20	---	4.33	5.76	---
HOODS	METAL	MHOODxx	1.25	1.25	1.30	1.30	---	---
	GREY	HOODxx	.65	.65	---	.65	.75	.95

ORDERING INSTRUCTIONS: INSERT THE NUMBER OF CONTACTS IN THE POSITION MARKED "xx" OF THE "ORDER BY" PART NUMBER LISTED.
EXAMPLE: A 15 PIN RIGHT ANGLE MALE PC SOLDER WOULD BE DB15PR

MOUNTING HARDWARE $1.00



LED DISPLAYS

FND-357(359)	COM CATHODE	.362"	1.25
FND-500(503)	COM CATHODE	.5"	1.49
FND-507(510)	COM ANODE	.5"	1.49
MAN-72	COM ANODE	.3"	.99
MAN-74	COM CATHODE	.3"	.99
MAN-8940	COM CATHODE	.8"	1.99
TIL-313	COM CATHODE	.3"	.45
HP5082-7760	COM CATHODE	.43"	1.29
TIL-311	4x7 HEX W/LOGIC	.270"	9.95
HP5082-7340	4x7 HEX W/LOGIC	.290"	7.95

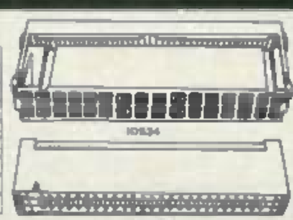
DIFFUSED LEDS

		1-99	100-UP
JUMBO RED	T1¾	.10	.09
JUMBO GREEN	T1¾	.14	.12
JUMBO YELLOW	T1¾	.14	.12
MOUNTING HDW	T1¾	.10	.09
MINI RED	T1	.10	.09

IDC CONNECTORS

DESCRIPTION	ORDER BY	CONTACTS 10	20	26	34	40	50
SOLDER HEADER	IDHxxS	.82	1.29	1.68	2.20	2.58	3.24
RIGHT ANGLE SOLDER HEADER	IDHxxSR	.85	1.39	1.76	2.31	2.72	3.39
WW HEADER	IDHxxW	1.86	2.98	3.84	4.50	5.28	6.63
RIGHT ANGLE WW HEADER	IDHxxWR	2.05	3.29	4.22	4.45	4.88	7.30
RIBBON HEADER SOCKET	IDSxx	.79	.99	1.39	1.59	1.99	2.25
RIBBON HEADER	IDMxx	---	5.50	6.29	7.68	7.50	8.50
RIBBON EDGE CARD	IDExx	1.75	2.25	2.69	2.79	3.80	3.95

FOR ORDERING INSTRUCTIONS SEE D-SUBMINIATURE ABOVE



SWITCHES

SPDT	MINI-TOGGLE ON-ON	1.25
DPDT	MINI-TOGGLE ON-ON	1.50
DPDT	MINI-TOGGLE ON-OFF-ON	1.75
SPST	MINI-PUSHBUTTON N.O.	.35
SPST	MINI-PUSHBUTTON N.C.	.39
SPST	TOGGLE ON-OFF	.49
BCD OUTPUT 10 POSITION 8 PIN DIP		1.95

DIP SWITCHES

4 POSITION	.85	7 POSITION	.95
5 POSITION	.90	8 POSITION	.95
6 POSITION	.90	10 POSITION	1.29

HARD TO FIND "SNAPABLE" HEADERS

CAN BE SNAPPED APART TO MAKE ANY SIZE HEADER. ALL WITH .1" CENTERS

1x40	STRAIGHT LEAD	.99
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2x40	STRAIGHT LEAD	2.49
2x40	RIGHT ANGLE	2.99

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GOLD CONTACTS SPACED AT .1" CENTERS

5/$1.00

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Sincerely, Nicholas Chabre

RIBBON CABLE

CONTACTS	SINGLE COLOR 1'	SINGLE COLOR 10'	COLOR CODED 1'	COLOR CODED 10'
10	.18	1.60	.30	2.79
16	.28	2.50	.48	4.40
20	.36	3.20	.60	5.50
25	.45	4.00	.75	6.85
26	.46	4.10	.78	7.15
34	.61	5.40	1.07	9.35
40	.72	6.40	1.20	11.00
50	.89	7.50	1.50	13.25

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CIRCLE 176 ON FREE INFORMATION CARD

CIRCLE 177 ON FREE INFORMATION CARD

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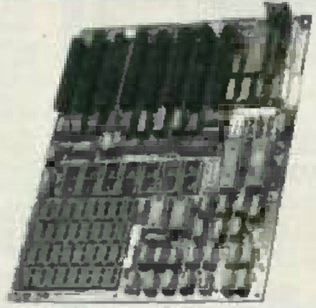
$129.95



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- ALL ICs SOCKETED, HIGHEST QUALITY PC BOARD
- ACCEPTS 2764 OR 27128 ROMS

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PERFECT FOR THE 640K MOTHERBOARD

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- PARALLEL PRINTER PORT
- GAME PORT
- CLOCK/CALENDAR
- SOFTWARE: CLOCK UTILITIES, RAMDISK, SPOOLER

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MULTIFUNCTION CARD $84.95

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- SERIAL PORT
- PARALLEL PORT
- GAME PORT
- SOFTWARE INCLUDED

PRINTER CABLE $9.95
64K RAM UPGRADE 9/$11.61

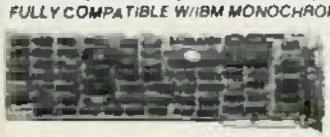
COLOR GRAPHICS ADAPTOR $69.95

FULLY COMPATIBLE WITH IBM COLOR CARD

- 4 VIDEO INTERFACES: RGB, COMPOSITE COLOR, HI-RES COMPOSITE MONOCHROME, CONNECTOR FOR RF MODULATOR
- COLOR GRAPHICS MODE: 320 x 200
- MONO GRAPHICS MODE: 640 x 200
- LIGHT PEN INTERFACE

MONOCHROME GRAPHICS CARD $89.95

FULLY COMPATIBLE W/IBM MONOCHROME ADAPTOR & HERCULES GRAPHICS



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- TEXT MODE: 80 x 25
- GRAPHICS MODE: 720 x 348
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- OPTIONAL SERIAL PORT $19.95

MONOCHROME ADAPTOR $49.95

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MODEL 1200B*
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- 10 INCH CARD
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- INCLUDES SPEAKER

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- LED STATUS INDICATORS

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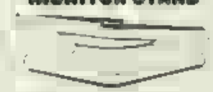

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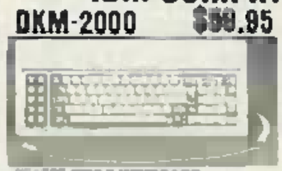

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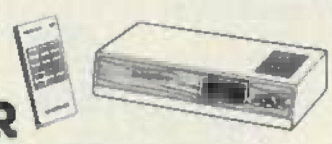

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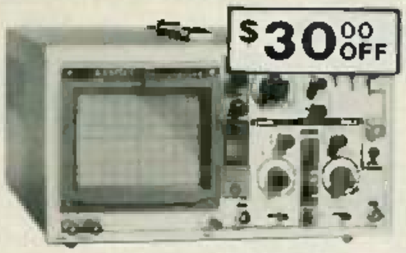


Save $30 on the RAMSEY 20MHz Dual Trace Oscilloscope

Unsurpassed quality at an unbeatable price, the Ramsey oscilloscope compares to others costing hundreds more. Features include a component testing circuit for resistor, capacitor, digital circuit and diode testing • TV video sync filter • wide bandwidth & high sensitivity • internal graticule • front panel trace rotator • Z axis • high sensitivity x-y mode • regulated power supply • built-in calibrator • rock solid triggering

Was $399.95 NOW ONLY $369.95 high quality hook on probes included

NEW RAMSEY 1200 VOM MULTITESTER

Check transistors, diodes and LEDs with this professional quality meter. Other features include: decibel scale • 20K volt metering system • 3½" mirrored scale • polarity switch • 20 measuring ranges • safety probes • high impact plastic case

$24.95 test leads and battery included

NEW

RAMSEY D-4100 COMPACT DIGITAL MULTITESTER

Compact sized reliability and accuracy. This LCD digital multitester easily fits in your pocket, you can take it anywhere. It features full overload protection • 3½ digit LCD readout • recessed input jacks • safety probes • diode check function • 2000 hours battery life

$24.95 test leads and battery included

NEW **35 MHz DUAL TRACE OSCILLOSCOPE**

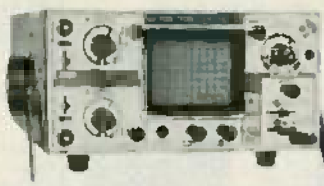
A heavy duty and accurate scope for service as well as production use. Features include • wide frequency bandwidth • optimal sensitivity • extremely bright display • delayed triggering sweep • hold off • ALT trigger • single sweep • TV sync • 5X magnification • XY or XYZ operation • HF/LF noise reduction

3500 Dual Trace Oscilloscope

$499.95 includes 2 high quality probes

ALL OSCILLOSCOPES INCLUDE 2 PROBES

NEW **15 MHz DUAL TRACE PORTABLE OSCILLOSCOPE**



Ideal for field/bench applications, this scope can display up to 15 MHz signals. Internal battery pack allows up to 2 hours operation on a single charge. Features include • built-in battery charger • 5X horizontal magnification • high brightness CRT • front panel trace rotator • internal rechargeable battery pack

2500 Portable Oscilloscope

$449.95 includes 2 high quality probes

MINI-100 FREQUENCY COUNTER

Features and capabilities of counters costing twice as much • compact • high sensitivity • low current drain • very accurate • leading zero blanking • field or shop use • 1 MHz to 500 MHz range • diode protected • 7 digit display

$119.95 BATTERY CHARGER NICAD BATTERIES AND AC ADAPTER INCLUDED

CT-70 7 DIGIT 525 MHz COUNTER

Lab quality at a breakthrough price. Features • 3 frequency ranges each with pre amp • dual selectable gate times • gate activity indicator • 50mV @ 150 MHz typical sensitivity • wide frequency range • 1 ppm accuracy

$139.95 wired includes AC adapter

CT-70 kit $119.95
BP-4 nicad pack 8.95

CT-90 9 DIGIT 600 MHz COUNTER

The most versatile for less than $300. Features 3 selectable gate times • 9 digits • gate indicator • display hold • 25mV @ 150 MHz typical sensitivity • 10 MHz timebase for WWV calibration • 1 ppm accuracy

$169.95 wired includes AC adapter

CT-90 kit $149.95
OV-1 0.1 PPM oven timebase 59.95
BP-4 nicad pack 8.95

CT-50 8 DIGIT 600 MHz COUNTER

$189.95 wired

CT-50 kit $159.95
RA-1 receiver adapter kit 14.95

CT-125 9 DIGIT 1.2 GHz COUNTER

$189.95 wired includes AC adapter

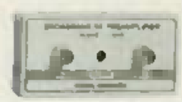
BP-4 nicad $8.95

DM-700 DIGITAL MULTIMETER

Professional quality at a hobbyist price. Features include 26 different ranges and 5 functions • 3½ digit, ½ inch LED display • automatic decimal placement • automatic polarity

$119.95 wired includes AC adapter

DM-700 kit $99.95
MP-1 probe set 4.95

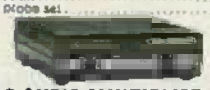


PR-2 COUNTER PREAMP

The PR-2 is ideal for measuring weak signals from 10 to 1,000 MHz • flat 25 db gain • BNC connectors • great for shifting RF • ideal receiver/TV preamp

$49.95 wired includes AC adapter

PR-2 kit $39.95



PS-2 AUDIO MULTIPLIER

The PS-2 is handy for high resolution audio resolution measurements, multiplies UP in frequency • great for PL tone measurements • multiplies by 10 or 100 • 0.01 Hz resolution & built-in signal preamp/conditioner

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PS-10B 1.5 GHz PRESCALER

Extends the range of your present counter to 1.5 GHz • 2 stage preamp • divide by 1000 circuitry • super sensitive (50 mV typical) • BNC connectors • 1 GHz in, 1 MHz out • drive any counter

PS 10-B Prescaler $89.95

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FM-3 Kit $14.95
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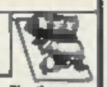
Color Organ

See music come alive! 3 different lights flicker with music. One light each for, high, mid-range and lows. Each individually adjustable and drives up to 300 W, runs on 110VAC.

Complete kit, ML-1 $8.95

Video Modulator Kit

Converts any TV to video monitor. Super stable, tunable over ch 4-6. Runs on 5-15V, accepts std. video signal. Best unit on the market! Complete kit, VD-1 $7.95



Led Blinky Kit

A great attention getter which alternately flashes 2 jumbo LEDs. Use for name badges, buttons, warning panel lights, anything! Runs on 3 to 15 volts.

Complete kit, BL-1 $2.95

Super Sleuth

A super sensitive amplifier which will pick up a pin drop at 15 feet! Great for monitoring baby's room or as general purpose amplifier. Full 2W rms output, runs on 6 to 15 volts, uses 8-45 ohm speaker

Complete kit, BN-9 $5.95

CPO-1

Runs on 3-12 vdc 1 watt out, 1 KHZ good for CPO, Alarm, Audio Oscillator. Complete kit $2.95

FM Wireless Mike Kit

Transmits up to 300' to any FM broadcast radio, uses any type of mike. Runs on 3 to 9V. Type FM-2 has added sensitive mike preamp stage.

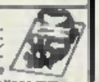
FM-1 Kit $3.95 FM-2 Kit $4.95

Whisper Light Kit

An interesting kit, small mike picks up sounds and converts them to light. The louder the sound, the brighter the light. Includes mike, controls up to 300 W, runs on 110 VAC.

Complete kit, WL-1 $6.95

Tone Decoder



A complete tone decoder on a single PC board. Features 400-5000 Hz adjustable range via 20 turn pot, voltage regulation, 567 IC. Useful for touch-tone burst detection, FSK, etc. Can also be used as a stable tone encoder. Runs on 5 to 12 volts.

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Provides the basic parts and PC board required to provide a source of precision timing and pulse generation. Uses 555 timer IC and includes a range of parts for most timing needs.

UT-5 Kit $5.95

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Produces LOUD ear shattering and attention getting siren like sound. Can supply up to 15 watts of obnoxious audio. Runs on 6-15 VDC

MB-1 Kit $4.95

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Produces upward and downward wail characteristic of a police siren. 5 W peak audio output, runs on 3-15 volts, uses 3-45 ohm speaker.

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Runs on 5-15 VDC. Low current (25ma). 1 min/month accuracy. TB-7 Kit $5.50
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30 Watt 2 mtr PWR AMP

Simple Class C power amp features 8 times power gain. 1 W in for 8 out, 2 W in for 15 out, 4 W in for 30 out. Max output of 35 W, incredible value, complete with all parts, less case and T-R relay.

PA-1, 30 W pwr amp kit $22.95
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Complete triple regulated power supply provides variable 6 to 18 volts at 200 ma and +5 at 1 Amp. Excellent load regulation, good filtering and small size. Less transformers, requires 6.3V @ 1 A and 24 VCT. Complete kit, PS-3LT $6.95

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ST225 Compatible. Fits standard 5¼" spacing. Shock mounted. High speed, low power.
Mfr — MMI #MM212
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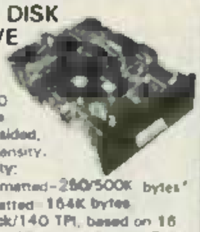
MPI 52S (IBM® Compatible) 5¼" FULL HEIGHT DISK DRIVE

Double sided/double density, full height drive. 48 T.P.I., 80 tracks
Item #7928 **$79.95**
2 for **$150.00**

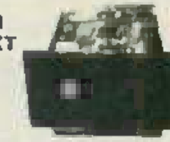
IBM FORMAT COMPATIBLE 3½" DISK DRIVE



Tabor TC-500 drivette. Single-sided, quad density.
Capacity:
Unformatted—250/500K bytes*
Formatted 164K bytes
80 track/140 TPI, based on 16 sectors. Will work with any 5¼" disk controller.
Item #8824 **$79.95**
*Total cap. 500K bytes with special software.

DUAL 3½" DISK DRIVE EXPANSION MODULE

IBM PC/XT

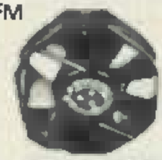


Stacked mounting, replaces old-fashioned 5¼" disk drives. Contains 2 Tabor TC-500 3½" disk drives. Ttl. cap. 500K bytes unformatted.* Plugs right into your controller.
Item #8827 **$169.00**
*Ttl. capac. IBM unformatted w. special software. Each unit supplied with two 3½" flexible diskettes.

12 VDC SPRINT® FAN

27 CFM, 12 VDC, 1.4 Watts. Polarity protected. Can be mounted for cooling or exhaust.
Dim.: 3⅛" sq. x 1¼" deep
Mfr — Rotron — DAYNA
Item #9218 **$12.95** New

250 CFM SPACE SAVER FAN



115VAC/60Hz., 24W. For high volume in limited space (depth). Cooling in electronic equipment, computer chassis, etc. 7-die cast alum. blades, alum. housing. Sealed bearings, thermally protected.
Dim.: 6⅝"W x 5⅞"H x 1½" deep
Mfr — EBM #W2E142
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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.: 4¹¹⁄₁₆" sq. x 1½" deep
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5¼" DISK DRIVE ½ HT: 96 T.P.I.

Tandon TM55-4 DS/Quad
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(Less printer & w/o cabinet)

Build it yourself from subassemblies. No wiring necessary (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. Is capable of running CP/M, has built in word processor.
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+5V @ 20A
−12V @ .5A
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Input: 115/230V
Dimensions: 9⅜"L x 4⅝" deep
Mfr — Power Systems PS1554
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DIGITAL VOLTMETER

3½ digits, .3" high. Bipolar. Movable decimal point. Accuracy: .05%. Nominal range 2 VDC
Case size: 2⅝"W x ⅞"H x 3⅛"L
Mfr–Non-Linear Systems #PM349
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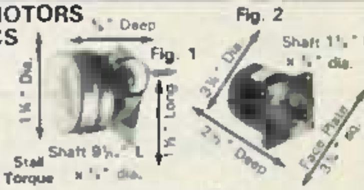
Precision steppers with increments from 1 to 7.5 degrees. Speeds up to 5,000 steps



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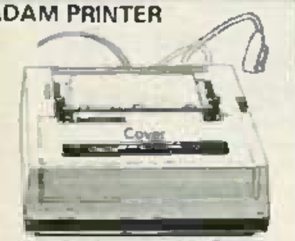
5275	1.8	1.8	72	PM	Superior Electric 2 ø M061-FF-82018	2	$19.95 ea. 2/$37.50

ADAM PRINTER



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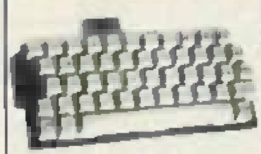
(Assorted)

Consists of Smart Basic, Buck Rogers, and blank cassettes (all can be easily erased).
Item #7786 — Bakers Dozen
13 for **$19.95** New

48-KEY KEYBOARD



Replace the membrane keyboard on your Timex/Sinclair Z-81/1000 with this brand new "big computer" keyboard from Texas Instruments. Simple to install — complete instructions and schematic included.
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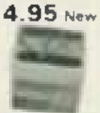
(Rechargeable)

For use with model cars, trains, boats, planes, etc.

6V @ 9.5 AH
Dim.: 5½"H x 4⅜"W x 2⅝" deep
Mfr — Elpower #695
Item #7039 **$14.95** New



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Mfr — Globe GC610
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Contains 10 AA cells. Recharge rate: 45 ma. 16–18 hours. Case with tab output connections.
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Mfr — GE 123233 or equiv.
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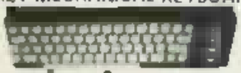
13.2V @ 1.65 AH
Contains 11 C cells
For model boats, toys, etc.
Mfr — GE #41B035BB00101
Item #5444 **$15.95** New

COMMODORE SPECIALS!

66-KEY MECHANICAL KEYBOARD



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Grey keys with black letters. Connecting cable included.
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Output: 9.5V @ 1A
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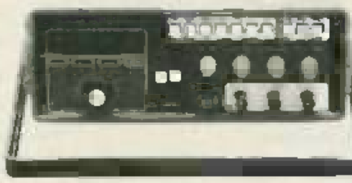
▪ Six digit display ▪ Output range: .2Hz-2MHz, seven ranges ▪ Counter range: .1Hz-10MHz ▪ 5-15V TTL and CMOS output ▪ Wave forms: sine, triangle, square, pulse, and ramp. For detailed specifications call for a complete Tenma catalog.

#72-380

$219.90 (ea.) — 1 YEAR LIMITED WARRANTY

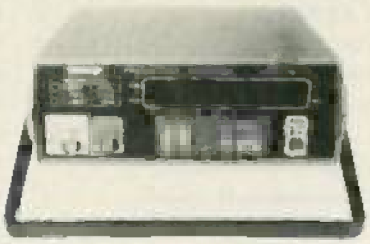


TENMA 120MHz Frequency Counter

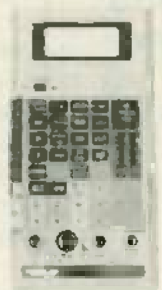
▪ Eight digit LED display ▪ Measurement range: .1Hz-120MHz ▪ High input sensitivity of 20mV RMS. For detailed specifications call for a complete Tenma catalog.

#72-375

$189.95 (ea.) — 1 YEAR LIMITED WARRANTY



TENMA Combination DMM/Capacitance Meter



▪ Measures voltage, AC and DC current up to 10A
▪ Resistance up to 20Mohm
▪ Capacitance up to 20μF
▪ Built-in transistor tester
▪ Test leads and carrying case included ▪ For detailed specifications call for a complete Tenma Catalog

#72-045

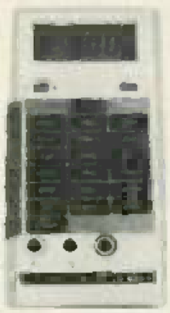
$74.95 (ea.) — 1 YEAR LIMITED WARRANTY

TENMA 30A Power Supply

▪ Output voltage: 1-15VDC ▪ Lighted cross needle meter: Displays voltage, current and power simultaneously ▪ Output current: 30A, 24A continuous ▪ Fan cooled

#72-035

$227.80 (ea.)



TENMA Digital LCR Meter

▪ Measures inductance, capacitance and resistance ▪ L = 1μH-200H, C = .1pF-200μF, R = .01ohm-20Mohm
▪ Carrying case included. For detailed specifications call for a complete Tenma catalog.

#72-370

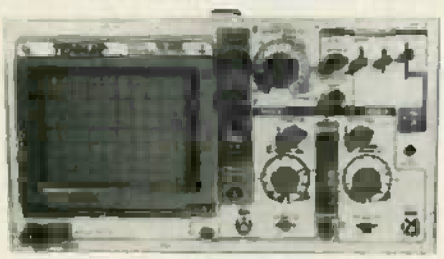
$149.95 (ea.) — 1 YEAR LIMITED WARRANTY

TENMA Clamp-On/DMM

▪ Measures AC current via clamp ▪ High quality built-in DMM measures DC volts, AC volts, resistance, AC current ▪ Peak hold ▪ Data hold ▪ Audible continuity buzzer ▪ Test leads and carrying case included. For detailed specifications call for a complete Tenma catalog.

#72-395

$84.90 (ea.) — 1 YEAR LIMITED WARRANTY



TENMA 20MHz Dual Trace Oscilloscope

▪ Two high quality 10:1 probes included. For detailed specifications call for a complete Tenma catalog.

2 YEAR LIMITED WARRANTY

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TENMA 4½" Digit Multimeter

▪ True RMS AC voltage and current functions ▪ Built-in frequency counter, 20KHz and 200KHz range ▪ Data hold feature ▪ Measures AC and DC voltage/current, resistance and frequency ▪ Carrying case included.

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