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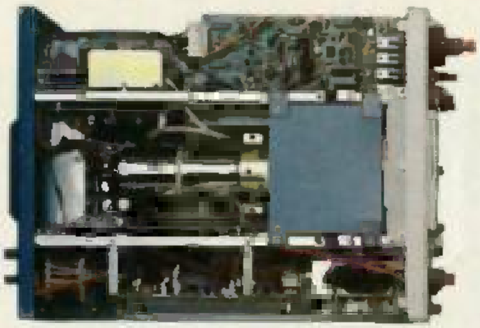
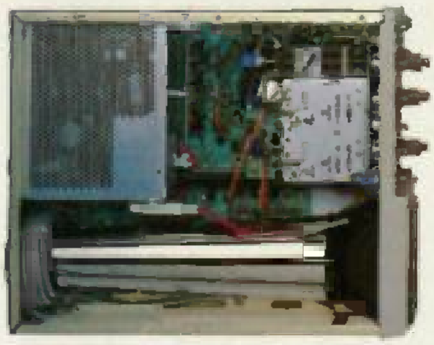
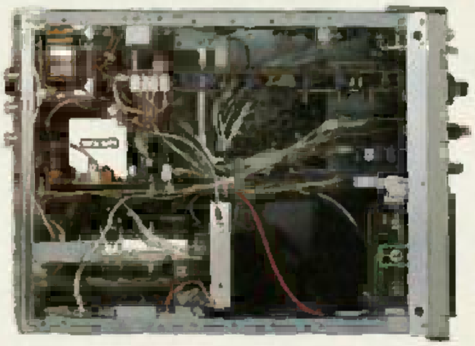
You can't judge a scope by its cover.







When you look at our simplified, practical internal design, you see why the Tek 2200 Series delivers unparalleled high performance and reliability in the field. You get quality that's unmistakably Tektronix in scopes so advanced, they cost you less to buy and own.

Through an innovative new concept in scope design we reduced the number of mechanical parts by 65%. Reduced cabling by 90%. Virtually eliminated board electrical connectors. And eliminated the need for a cooling fan.

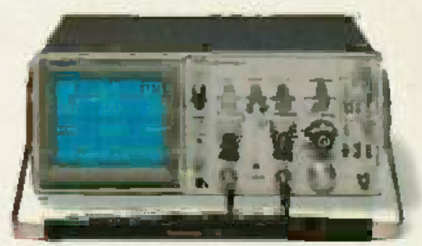
The result: a scope with designed-in simplicity that increases reliability as it cuts downtime and repair costs. All of which means outstanding value in a compact, lightweight package that your service technicians will appreciate.

Plus, you get a selection of performance to precisely match your needs. There are the 60 MHz single time base delay 2213A at $1275* and the 60 MHz dual time base 2215A at $1525.* And at 100 MHz, the dual time base 2235 at $1750* and the 2236 with an integrated counter/timer/multimeter at $2650.*

The industry's first three-year warranty† is testimony to 2200 Series dependability. Adding value to value are a variety of optional service plans that can economically extend this coverage to five years.

Consider what you're paying now in downtime, in service, in back-up scopes. On the bottom line, a Tek 2200 Series scope will save you money, time and trouble now and in the years to come.

Contact your Tek Sales Engineer for a demo today. Or call 1-800-426-2200, Ext. 201. In Oregon, call collect: (503) 627-9000, Ext. 201.



Tektronix
COMMITTED TO EXCELLENCE

*Prices F.O.B. Beaverton, Oregon
†3-year warranty includes CRT and applies to 2200 family oscilloscopes purchased after 1/1/83. Scopes are UL listed, CSA and VDE approved

Prices subject to change

NOVEMBER '85

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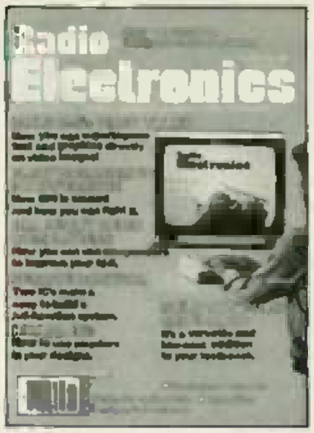
COVER 1



The video titler shown on our cover is not just a standard video titler. This one lets you superimpose characters and graphics directly on a video image. Any other titler on the market will let you add characters—but at the expense of the video image. The screen shown on the Zenith *CV-2562* 25-inch monitor is an actual photograph. The letters and the R-E logo were superimposed onto the image from a Magnavox *Lolite* video camera.

If you want to add more than just titles to your videotapes, you can use your IBM PC, TRS-80 Color Computer, Apple II, or Commodore 64 to access the titler's video-image generator. That will allow you to superimpose complex graphics or even real-time animation over an external signal. For more on this exciting build-it-yourself project, turn to page 45.

NEXT MONTH

THE DECEMBER ISSUE IS ON SALE NOVEMBER 5

WHAT'S NEW IN IC TECHNOLOGY
Two special articles look at the year's advances in both analog and digital IC's.

BUILD A VIDEO TITLER
We continue with details on the circuit and construction.

BUILD A HOME SECURITY SYSTEM
It works like an expensive commercial system, but it's easy-to-build and it's inexpensive.

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All about digital counters.

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NEW! uniden® Bearcat® Regency®

Scanners

Communications Electronics™, the world's largest distributor of radio scanners, introduces new scanners and scanner accessories from J.I.L., Regency and also Uniden/Bearcat. Chances are the police, fire and weather emergencies you'll read about in tomorrow's paper are coming through on a scanner today.

NEW! Regency® MX7000-K

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Frequency range: 25-550 MHz continuous coverage and 800 MHz to 1.2 GHz continuous coverage
In addition to normal scanner listening, the MX7000 offers CB, VHF, and UHF TV audio, FM Broadcast, all aircraft bands (civil and military), 800 MHz communications, cellular telephone, and when connected to a printer or CRT, satellite weather pictures.

NEW! Regency® MX5000-K

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Multi-Band, 20 Channel • No-crystal scanner Search • Lockout • Priority • AC/DC Selectable AM-FM modes • LCD display World's first continuous coverage scanner
Frequency range: 25-550 MHz continuous coverage
Never before have so many features come in such a small package. The *Regency* MX5000 mobile or home scanner has continuous coverage from 25 to 550 MHz. That means you can hear CB, Television audio, FM broadcast stations, all aircraft bands including military and the normal scanner bands, all on your choice of 20 programmable channels.

NEW! Regency® MX4000-K

List price $629.95/CE price $299.00/SPECIAL
Multi-Band, 20 Channel • No-crystal scanner Search • Lockout • Priority • AC/DC Selectable AM-FM modes • LCD display
Bands: 30-50, 118-136, 144-174, 440-512, 800-950 MHz
The *Regency* MX4000 is gives coverage in the standard VHF and UHF ranges with the important addition of the 800 MHz and aircraft bands. It features keyboard entry, multifunction liquid crystal display and variable search increments.

NEW! Regency® Z60-K

List price $379.95/CE price $216.00/SPECIAL
8-Band, 60 Channel • No-crystal scanner
Bands: 30-50, 88-108, 118-136, 144-174, 440-512 MHz
Cover your choice of over 15,000 frequencies on 60 channels at the touch of your finger.

NEW! JIL SX-400-K

List price $799.95/CE price $469.00/SPECIAL
Multi-Band, 20 Channel • No-crystal Scanner Search • Lockout • Priority • AC/DC
Frequency range: 26-520 MHz continuous coverage. With optionally equipped RF converters 150KHz-3.7 GHz.
The *JIL* SX-400 synthesized scanner is designed for commercial and professional monitor users that demand features not found in ordinary scanners. The SX-400 will cover from 150 KHz to 3.7 GHz with RF converters. Order the following RF converters for your SX-400 scanner. RF-1030-K at $259.00 each for frequency range 150 KHz - 30 MHz USB, LSB, CW and AM. (CW filter required for CW signal reception). RF-5080-K at $199.00 each for 500-800 MHz; RF-8014-K at $199.00 each for 800 MHz-1.4 GHz. Be sure to also order ACB-300-K at $99.00 each which is an antenna control box for connection of the RF converters. The RC-4000-K data interface at $259.00 each gives you control of the SX-400 scanner and RF converters through a computer. Add $3.00 shipping for each RF converter, data interface or antenna control box. If you need further information on the JIL scanners, contact JIL directly at 213-926-6727 or write JIL at 17120 Edwards Road, Cerritos, California 90701 U.S.A.

SPECIAL! JIL SX-200-K

List price $499.95/CE special price $159.00
Multi-Band - 16 Channel • No-Crystal Scanner
Frequency range 26-88, 108-180, 380-514 MHz
The *JIL* SX-200 scanner tunes military, F.B.I., Space Satellites, Police and Fire, Drug Enforcement Agencies, Defense Department, Aeronautical AM band, Aero Navigation Band, Fish & Game, Immigration, Paramedics, Amateur Radio, Justice Department, State Department, plus other thousands of radio frequencies most other scanners can't pick up. The SX-200 has selectable AM/FM receiver circuits, tri-switch squelch settings - signal, audio and signal & audio, outboard AC power supply - DC at 12 volts built-in, quartz clock - bright vacuum fluorescent blue readouts and dimmer, dual level search speeds, tri-level scan delay switches, 16 memory channels in two channels banks, receive fine tune (RIT) ± 2KHz., dual level RF gain settings – 20 db pad, AGC test points for optional signal strength meters.

Regency® HX1000-K

List price $329.95/CE price $209.00
6-Band, 30 Channel • No Crystal scanner Search • Lockout • Priority • Scan delay Sidelit liquid crystal display • Digital Clock
Frequency range: 30-50, 144-174, 440-512 MHz.
The new handheld *Regency* HX1000 scanner is fully keyboard programmable for the ultimate in versatility. You can scan up to 30 channels at the same time. When you activate the priority control, you automatically override all other calls to listen to your favorite frequency. The LCD display is even sidelit for night use. Order MA-256-K rapid charge drop-in battery charger for $79.00 plus $3.00 shipping/handling. Includes wall charger, carrying case, belt clip, flexible antenna and nicad battery. Order now.

NEW! Bearcat® 100XL-K

List price $349.95/CE price $229.00
9-Band, 16 Channel • Priority • Scan Delay Search • Limit • Hold • Lockout • AC/DC
Frequency range: 30-50, 118-174, 406-512 MHz
The world's first no-crystal handheld scanner now has a LCD channel display with backlight for low light use and aircraft band coverage at the same low price. Size is 1⅜" x 7½" x 2⅝" 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.

NEW! Regency® HX2000-K

The World's First 800 MHz. Handheld Scanner
List price $569.95/CE price $359.00
7-Band, 20 Channel • No-crystal scanner Priority control • Search/Scan • AC/DC Sidelit liquid crystal display • Memory backup
Bands: 118-136, 144-174, 440-512, 800-950 MHz
The HX2000 scanner operates on 120V AC or 6 VDC. Scans 15 channels per second. Size 3" x 7" x 1½." Includes wall charger, carrying case, belt clip, flexible antenna and nicad batteries. Selectable AM/FM modes.

NEW! Bearcat® 800XLT-K

List price $499.95/CE price $329.00
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-K Shortwave receiver	$179.00
Panasonic RF-B300-K Shortwave receiver	$195.00
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BC-WA-K *Bearcat* Weather Alert™	$39.00
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MA257-K Cigarette lighter cord for HX1000	$19.95
MA917-K Ni-Cad battery pack for HX1000	$24.95
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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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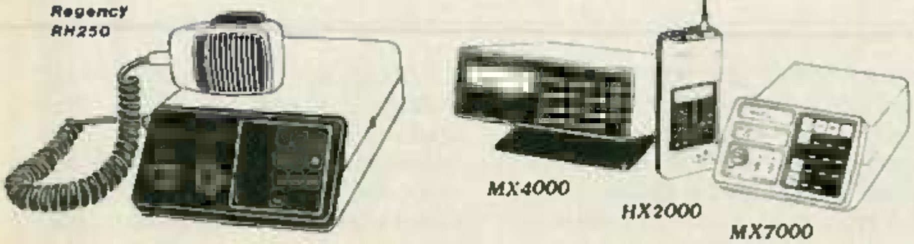

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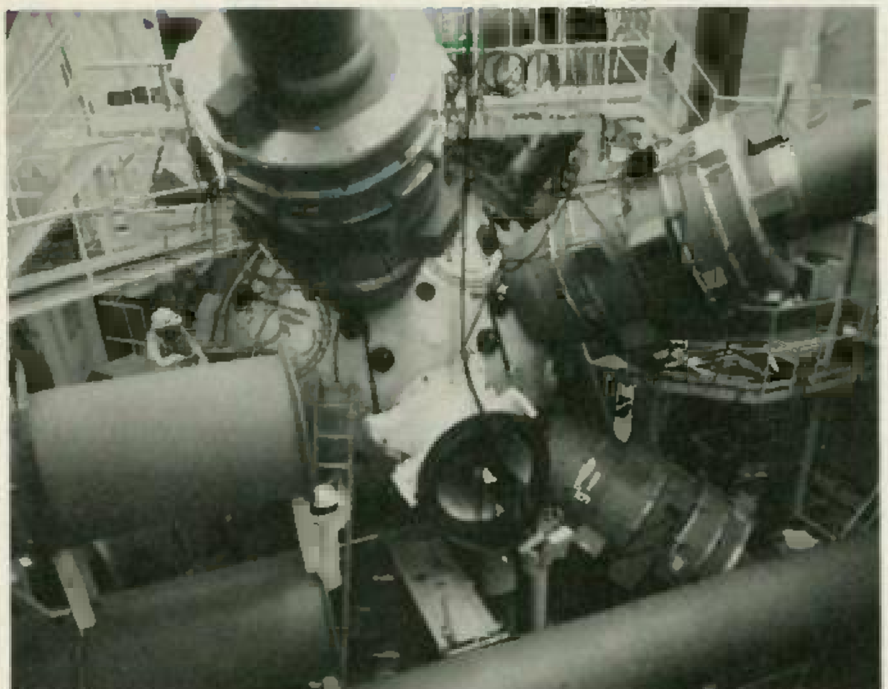
WHAT'S NEWS

World's biggest laser is six stories high



TARGET CHAMBER OF NOVA, WORLD'S LARGEST LASER. The 16-foot-diameter evacuated sphere is shown with some of the lens systems that focus laser beams on a small pellet at its center to produce fusion reactions. The size of the equipment may be judged from the two technicians working on it. The spaceframe holding it and its associated equipment is six stories high. The immediate use of Nova is as a laboratory tool for studying weapons physics. In the long term it is hoped that it will be a tool to help scientists to develop nuclear fusion as a safe, economical, and inexhaustible source of power.

Nova, the world's largest laser, was dedicated this past spring at the Lawrence Livermore Laboratory of the University of California. It will be used as a laboratory tool for studying nuclear physics, and for experiments intended to help scientists in their long-term quest for practical nuclear fusion.

Housed in a four-room building—one room is more than 200 feet long and another is six stories high—it is not only the world's biggest laser, but also the world's largest optical instrument, with more than 300 square meters of optical surfaces.

Nova uses a fantastically powerful capacitor bank to store 40 million joules of electrical energy at 20,000 volts to operate almost 6,000 xenon flashlamps. When the laser is fired, it produces a pulse of infrared light that is divided into ten pulses that are passed through 150 laser amplifiers toward the target. Those amplifiers—neodymium glass rods and discs—release their energy as the laser pulses pass through them.

Large mirrors steer the ten pulses toward the target vacuum chamber, a 16-foot diameter hollow aluminum sphere containing a fuel pellet. When the combined pulse is focused on it, for 30 to 50 trillionths of a second the pellet is subjected to a force 200 times greater than the power produced by the entire electrical generating capacity of the United States.

The high intensity laser pulses heat the fuel pellet, causing its outer shell to boil off and rocket outward. The reaction drives the remaining pellet wall inward, compressing the center of the pellet to a density and temperature comparable to that of the center of the sun.

Nova will thus be able to produce conditions under which atomic fusion can take place. That can provide more light on the theories of what is called inertial confinement fusion, and may be a step toward a practical technology for producing power from nuclear fusion.

Ford and JBL unite to make auto sound

JBL Inc. and the Electrical and Electronics Division of Ford Motor Co. have launched a five-year program to develop high-performance automotive sound systems for Ford's cars and light trucks. Details of the program have been agreed on and engineers are already at work on the first phases of the plan, said a Ford spokesman.

According to a recent survey by *Billboard* Magazine, JBL is the leading supplier of professional loudspeakers to North American recording studios and to international concert touring groups. R-E

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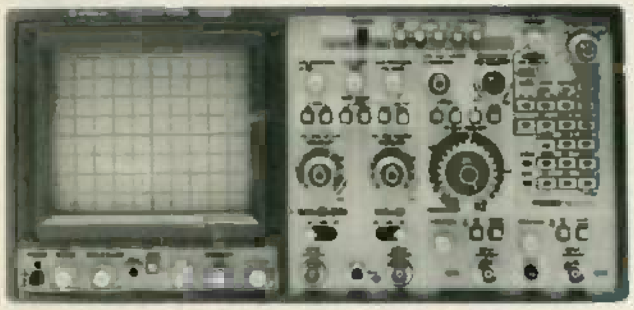
HITACHI (Hitachi Denshi, Ltd) V1100A DC to 100 MHz Portable Readout Oscilloscope

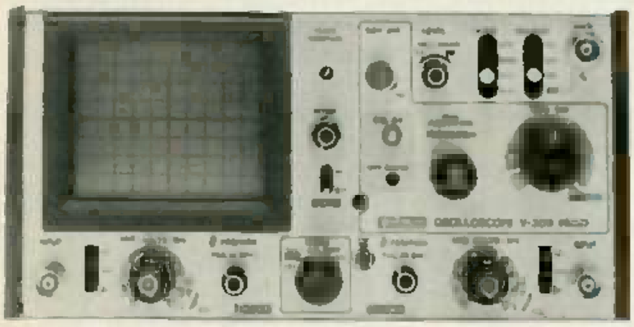


FEATURES

- Character display of set-up information on CRT (VOLTS/DIV, TIME/DIV, CAL or UNCAL, Delay Time, Trigger source, etc.)
- Cursor read-out function eliminates conventional calculation procedures (V, ΔV, ΔV%, ΔT, 1/ΔT, ΔT%, phase).
- Digital measuring function displays, DC voltage, AC voltage, and Frequency.
- Comment display function allows user's comments to be displayed on the CRT such as date and measurement data. Excellent for photo documentation.
- 4 channel, 8 trace, DC to 100 MHz, High sensitivity 1 mV/Div, Delayed sweep, Full TV triggering, Alternate triggering

List Price $2,490.00 **Sale Price $2,250.00**

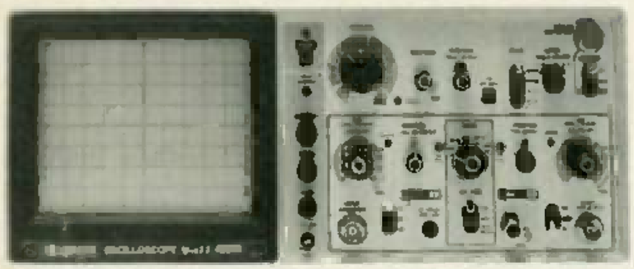
HITACHI (Hitachi Denshi, Ltd) V-209 DC to 20 MHz Mini-Portable Dual-Trace Oscilloscope



- A three-way power supply takes the V-209 anywhere, anytime for speedy field measurements.
- High sensitivity (1 mV/div at 10MHz) and fast sweep times (50ns/div) make the V-209 a valuable tool in R&D as well as servicing in a wide variety of applications including computers and video equipment.
- A Built-In TV sync separation circuit with easily selectable TV-V and TV-H modes ensures stable observation of both vertical and horizontal TV signal waveforms.
- An auto focus feature maintains constant trace without the necessity of troublesome manual focus adjustments.
- The V-209 is just what it claims to be—a powerful field service tool in a compact, lightweight package.

List Price $945.00 **Sale Price $708.00**

HITACHI (Hitachi Denshi, Ltd) Portable Oscilloscopes



Model V-422 shown

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MODEL V-212 **$461.00**

DC to 20 MHz, 1 mV/div, Dual Trace. Features 6" Rectangular CRT (w/two X10 probes).

MODEL V-422 **$694.00**

DC to 40 MHz, 1 mV/div, Dual Trace, D.C. offset for DMM Output, Vertical Mode Trigger 6" CRT (w/two X10 probes).

MODEL V-1050F **$1,276.00**

DC to 100 MHz, .5 mV/div, Quad Trace, Delayed Sweep, Full TV Triggering, Alternate time base (w/two X10 probes).

Full 2 year parts and labor warranties on the above scopes.

HITACHI GSA CONTRACT NUMBER GS00S57322

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over $1000.00	$15.00

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VIDEO NEWS

DAVID LACHENBRUCH
CONTRIBUTING EDITOR

• **RCA's Preview.** RCA gave the industry an advance peek at two of its "products of the future" recently at its laboratories in Princeton. The first product, to be introduced "as soon as possible," is a home satellite receiver component for the company's *Dimensia* audio-video system. The receiver can pick up both C- and Ku-band signals, and has a built-in descrambler designed for the M/A-Com encoding system adopted by HBO and Cinemax.

The other "product of the future" is a digital TV set, built around three basic IC's, containing its own frame memory. The receiver converts the incoming standard interlaced signal, with 60 262.5-line fields per second, to a progressive-scan non-interlaced one with 60 complete 525-line frames per second. The resulting picture showed no line structure or jitter. RCA said that a consumer-priced frame memory would need to be developed before the set could be marketed, but that one wouldn't be available until about 1990.

• **"High Quality" VHS.** The VHS group has decided not to follow Beta's lead in developing "super VCR's" with high-band color—at least not at this time—because of compatibility problems. Instead, VHS manufacturers are introducing an improvement called "High Quality," which uses signal processing to enhance the picture without sacrificing compatibility. Among the picture enhancements are a system called "video-noise reduction," which uses recursive comb filtering, and an increase in white clip level, which results in sharper image edges. JVC, which is given credit for developing the improvements, probably will feature them first, but they're expected to be used eventually by all members of the VHS camp.

• **VCR's to be Made Here.** Matsushita, the world's largest manufacturer of VCR's, has become the first company to announce the establishment of a factory to manufacture videocassette recorders in the United States. Sanyo has since followed, saying that it would also set up a VCR plant here. Hitachi, Toshiba, Sharp, and Sony have also said that they are looking into setting up plants here. Matsushita's announcement came as the Japanese sought to relieve the top-heavy imbalance of trade with the United States. VCR's now constitute Japan's biggest electronics export to the U.S.—worth more than $3.3 billion last year. No consumer VCR's currently are made in this country; all are imported, largely from Japan, with Korea recently getting into the act. The new Japanese-owned VCR plants here are expected to be little more than assembly operations at first; more complete manufacturing operations will come later as U.S.-made parts and components become available.

Meanwhile, Philips has announced that it is setting up a joint venture with a Korean firm to manufacture NTSC VCR's in Korea. They will be sold domestically in Korea and exported to countries that use the NTSC standard, including the U.S. Philips' U.S. affiliate, North American Philips, currently buys VCR's exclusively from Matsushita for its three brands—Magnavox, Sylvania, and Philco. The new Video Corporation of Korea, owned by Philips (70%) and Dongwon Electronics (30%) is scheduled to start up about a year from now and eventually supply VCR's for North American Philips' three U.S. brands.

• **Video Vignettes.** A portable projection TV system with built-in VHS recorder, audio cassette player, and PA system has been introduced by Display Sciences Inc., New York, at $3,995.

Mitsubishi has now introduced the first model with a 35-inch direct-view picture tube (**Radio-Electronics,** March 1985) and priced it at a suggested list of $3,200.

Videocassette players—that is, playback-only devices—seem like a good idea in view of the success of prerecorded software, and they're already being offered by such companies as Emerson, GE, Daewoo, Gold Star, Lloyd's, Magnavox, Quasar, and Panasonic. But few of those companies expect them to be very popular, except for the rental market. The reason: There's very little saving in eliminating the record function, thus the VCP's cost about the same as low-priced VCR's by the time they reach the marketplace. **R-E**

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CIRCLE 254 ON FREE INFORMATION CARD

NEW IDEAS

Commodore-64/VIC-20 cassette interface

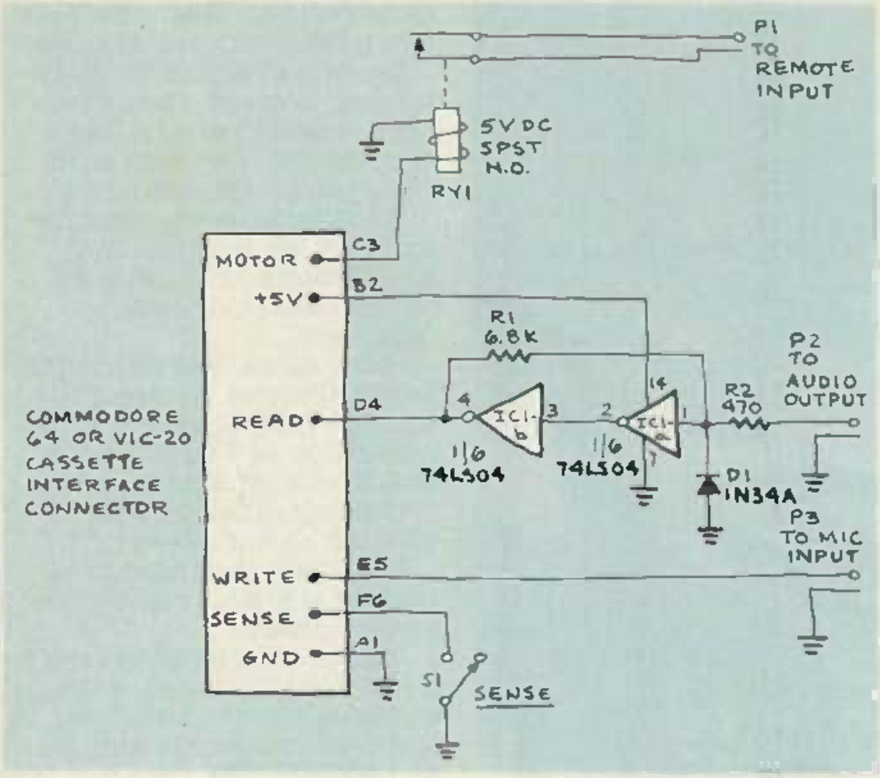


FIG. 1

THE CASSETTE RECORDERS THAT COMmodore sells for use with the Commodore-64 and VIC-20 personal computers are expensive, even though they're not much different from standard audio recorders. Why are the Commodore *Datasette* recorders special? The Commodore CASSETTE WRITE output is a squarewave whose duty cycle is varied to transmit data.

Unfortunately, when you try to record that squarewave on audio tape, what you end up with looks more like a sinewave than a squarewave. When you play the tape back and try to load programs or data, the computer doesn't recognize the signals. However, the circuit presented here will turn the recorded signal back into one that the Commodore computers can use. With it, you'll be able to use almost any recorder for data storage.

Circuit operation

As shown in Fig. 1, audio output from a cassette recorder is fed through the limiting network composed of resistor R2 and diode D1. The resistor limits the peak voltage fed to IC1-a, and the diode ensures that voltages less than zero are not fed to the IC. Inverters IC1-a and IC1-b, together with resistor R1, form what is called a Schmitt trigger, which "squares up" the analog signals from the recorder so that they're acceptable to the computer.

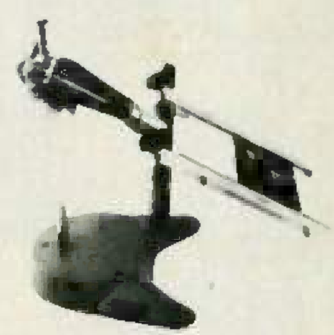
As shown, a 74LS04 was used for the inverters, but you could easily

continued on page 111

NEW IDEAS

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

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



I agree to the above terms, and grant Radio-Electronics Magazine the right to publish my idea and to subsequently republish my idea in collections or compilations of reprints of similar articles. I declare that the attached idea is my own original material and that its publication does not violate any other copyright. I also declare that this material has not been previously published.

Title of Idea

Signature

Print Name Date

Street

City State Zip

Mail your idea along with this coupon to: New Ideas Radio-Electronics, 200 Park Ave. South, New York, NY 10003

SATELLITE TV

BOB COOPER, JR.*
SATELLITE TV EDITOR

TVRO ownership—present and future.

FIG. 1

TWO THOUSAND TVRO OWNERS HAVE provided the home-satellite industry with its first in-depth profile of TVRO users. Many beliefs and assumptions fell by the wayside when the 150-page, *1985 TVRO Market Profile* was completed. Here are some of the findings.

The majority of TVRO owners (72%) do not live in cities, but 26.5% do have access to cable service. Of those who can subscribe to cable, 23% do, but 49% have discontinued their cable service.

For the last six months animosity between TVRO and cable has been increasing. Several cable firms have begun large-scale advertising in which they advise potential purchasers not to buy a TVRO because of the possibility that, when satellite signals scramble, TVRO owners will be left with nothing to view.

Ownership of TVRO systems has been growing tremendously for the past few years: 30% of TVRO owners purchased their systems in 1983, and 59% purchased their systems in 1984. Approximately one third of all TVRO buyers made their purchase after seeing a TVRO in operation at a friend's or neighbor's home; 25% bought after seeing a TVRO demonstrated by a dealer; and 22% bought because they wanted a greater choice of programming and felt that cable was too expensive, or simply unavailable.

When asked to give their reasons for buying a TVRO, 61% said their primary reason was to have access to a wider variety of programming. Significantly, 59% of those buying had access to as many as 4 off-air (terrestrial) television channels, indicating that they live in areas where regular TV programming is not high quality.

Eighty percent of TVRO owners also own more than one TV set, 39% own a VCR, and 21% own a personal computer. VCR ownership and personal-computer ownership is markedly higher than the national average, which indicates the "upscale demographics" of TVRO ownership. Eighty-eight percent have a high school education or better, and 52% earn at least $30,000 per year.

Although the largest market segment (39%) is between 35 and 49 years of age and still has children at home, a large percentage (21%) are over 60 years of age, and are either retired or semi-retired.

Geographic distribution

As shown in Fig. 1, the study found that 47% of all system owners live in either the Pacific or the West-Central regions of the United States. New England has the lowest percentage of TVRO owners (3%), while the mid-Atlantic region claims little over 5%. Those numbers would seem to support the thesis that TVRO is largely a rural—or at least western—phenomenon. But other evidence indicates that where buyers live, as well as who they are, is changing rapidly.

TVRO owners tend to spend many hours watching TV. The national average is in the vicinity of 37 hours per week, but the study found that 54% of TVRO users watched their satellite systems more than 40 hours per week, and that 18.4% use their systems more than 59 hours per week—almost 8.5 hours per day!

It is interesting to note that there is a high degree of user satisfaction with TVRO: 62.6% said they were "very satisfied" with their system, and only 1.6% reported they were

*publisher of CSD magazine

PRINTER BARGAIN

We guarantee that you'll never find a bargain as sensational as the letter-quality daisy wheel printer you see in this advertisement.

We covered up the name of the printer so as not to embarrass the manufacturer.

I realize that what you are about to read may seem incredible. I can understand. But occasionally there are indeed bargains and opportunities that only come once in a lifetime. I'm convinced that this is one of them.

By Joseph Sugarman, President

The letter-quality printer you see above has a suggested retail price of $1795. It prints bi-directionally at 40 characters per second using a daisy wheel print element, comes with a parallel interface and prints a 13.6 inch line.

A similar printer might be found at some discount computer dealers for as low as $1000. And at that price it is indeed a bargain.

AUTOMATIC FEATURES

If we'd offer it to you at $499—a unit that we could be selling for $1795 and that would be a bargain at $1000—you'd probably think that there was a catch. But guess again. As unusual a bargain as this may appear, and despite all its quality features, this printer can be yours for the incredible low price of only $499—below wholesale, below dealer cost and without question, the lowest priced high-speed letter-quality printe. sold today.

JS&A bought out an entire warehouse full of these printers, promised that we would not display the name on the unit, in our photo, mention the name in our ad nor reveal the name over the phone to avoid embarrassing the manufacturer or his dealers.

I'm so convinced that this is one of the greatest values I've ever offered, I am making a bet and a commitment. First, the commitment. I'm giving you 30 days to test it out. If it's not the best printer value in the country, return it for a full refund including your $25 postage.

Finally, I'll bet that you'll immediately recognize the name of the billion dollar company whose name is on the product or you don't deserve to own a computer. The company is a successful computer company whose products you may even now own. They'll back the product with service through its 90-day limited warranty and for years to come with hundreds of national factory service centers throughout the United States.

EXCEPTIONAL VALUE

The printer is not an outdated model with old technology but a brand new unit with the latest electronics and the most advanced technology. For example, there's an automatic print pressure control which automatically varies the printing pressure according to the shape of the character. This single feature produces an incredibly clean impression while prolonging the life of the daisy wheel. But there's more.

An aluminum diecast integral-constructed frame gives the printer a solid home for its advanced electronics. And with a weight of 30 pounds, you know there's built-in commercial-quality construction. The controls include: 'line feed' which advances the carriage by one line, 'page advance' which advances the document to the next page when using continuous form paper and a 'set page' button that tells the printer where the start of the form is located. A lighted condition panel tells you the printer status with red and green LEDs. You can use single sheets or continuous form fan-fold paper and with the 'paper out sensor' the printer detects the last sheet of the fan fold paper and automatically stops. And the printer has a 2K buffer memory.

There are also features that give you enormous printing flexibility. You can underscore words, double print each character which creates a bold look or you can use shadow print which moves the print head 1/120th of an inch between strikes. With the proper daisy wheel you can also set the printer for proportional printing which gives your documents a professional—almost printed look.

SELF-TEST MODE

There's a self-test mode which lets you print out all the characters on your daisy wheel continually until you stop. And the system uses standard Diablo daisy wheels and ribbons which you can get from JS&A or any computer store.

With the Pica pitch, you can print up to 136 columns and with the Elite pitch, up to 163. The 15.5" carriage will take a print area of 13.6 inches. It measures 6 x 16 x 24", comes with a 10-pitch daisy wheel, one ribbon and complete instructions. The unit has provisions for a tractor feed and a sheet feeder which can be purchased locally or at a discount from JS&A.

You can select either 10, 12 or 15 for the print pitch or even use the 10-pitch daisy wheel supplied with the unit at the 12-pitch setting for large and tight letter spacing. There are dip switches which let you customize each printer to any computer with a parallel printer interface. Setting recommendations are supplied for IBM, Apple and other popular computers.

What happened? How can JS&A obtain and then sell these printers—products that are brand new with the latest state-of-the-art technology and from a major manufacturer at a price that at first is hard to believe? Quite frankly, it wasn't easy.

With our low overhead we can efficiently sell these units in tremendous quantities without the high markups that many stores must have to make a profit. And we can do this on a mass-market national scale. Since many manufacturers know this and know that we could quickly move tremendous amounts of merchandise without upsetting many of the retailers (because we keep the name of the manufacturer confidential) they are willing to let us buy their product direct, often at foreign, export prices.

We'll be happy to supply companies with several printers for their computer departments to upgrade their printing speed and quality. There is no limit to the number you can order although we only have a few thousand available so we reserve the right to return your order should we run out.

ACT QUICKLY

There are bargains available that are indeed too good to be true and often end up to be much less than you expected. But here's an example that is not only too good to be true but that we guarantee you'll find better than you expected. Order one at no obligation, today.

Simply send your check or money order using the order numbers shown in parentheses (IL residents add 7% sales tax) plus $25 for postage and handling for each printer ordered. Credit card buyers call toll-free number below. Send your order to: JS&A Special Printer Bargain Offer at the address below.

Printer (6087)	**$499**
Tractor Feed (6084)	189
Sheet Feeder (6088)	239
3-Pack Ribbons (6089)	15
Daisy Wheels: (List supplied with unit)	
Cables/Interfaces (includes everything you need to connect to your computer:	
IBM & Compatibles (25 pin) (6076)	39
Apple II + /e (6099)	69
Apple IIc (7011)	69
Commodore VIC-20 C-64 &C-128 (7002)	89
Atari 400/600/600XL/800/800XL (7003)	69
Visual 1050 (7004)	39
All Other Computers with Standard Parallel Printer Port (36 Pin) (7009)	39

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"very satisfied" with their system, and only 1.6% reported they were "very dissatisfied" with it. A different attitude emerged from TVRO owners (26.5%) with access to cable TV service; 69.7% of them said they were "not pleased" with the quality of the local cable service.

The popularity of satellite reception was not surprising. Motorized dish movers are more often part of a system than not, these days, so most users buying systems now have the ability to scan the Clarke orbit belt and lock in on virtually any U.S. or Canadian satellite in operation. That gives TVRO owners a lot to choose from. More than 88% of our sample reported that they tune in the Hughes Galaxy satellite, 83.8% tune in RCA's F3R, and 54.9% tune in RCA's F4, all at a rate of at least three times per week.

Network service, available on satellite in the form of intra-network feeds intended to be rebroadcast by local stations, drew viewing percentages of about 30–35%, CBS satellite feeds being the most popular. Significantly, of the non-premium (non-pay) satellite services available, Ted Turner's WTBS outranked all others, and actually surpassed the popularity of satellite feeds from ABC and NBC.

What's being watched

Movies are clearly the most popular type of programming (66.2%), although people who have owned TVRO system for three years or more are less enchanted with movies than new owners are (dropping to 57% most popular).

Movies, of course, make up the overwhelming majority of the programming on such premium services as HBO and Showtime. In view of that, and in view of the above mentioned popularity of movies, care should be taken in drawing conclusions from the figures that follow.

HBO had been viewed during the 24 hours preceding our survey by 54.4% of all those responding to it, Cinemax by 49.2%, and Showtime by 46.3%.

Sports programming was the second most popular type of programing: all-sports ESPN pulled 28.9% of all viewers. However, sports programming is widely

continued on page 111

TVRO dealer "Starter Kit" available

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

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

You may not be able to solve the world's problems. But at least you can listen.

The Panasonic Command Series:™ With double superheterodyne tuning, you'll hear the world loud and clear.

Now it's easy to listen in on the world's hot spots. With the Panasonic RF-B600 Command Series FM/LW/MW/SW receiver.

Its advanced microcomputer-controlled tuner lets you preset up to nine different frequencies. And reach them at the touch of a button. Or, press the appropriate buttons and tune in any desired frequency with direct-access digital tuning. It'll lock right in to every signal with a PLL quartz-synthesized tuner. Once tuned in, the Panasonic double superheterodyne system helps deliver a clean, consistent signal.

There's even built-in auto-tuning to let you scan the shortwave band automatically, as well as manually. All this means you can tune in Berlin, pick up Paris, or locate London in an instant. Without dialing all over the band.

Both the RF-B600 and the RF-B300 are packed with features and built to go anywhere.

The Panasonic Command Series offers something for everyone. With equipment sophisticated enough to impress the most avid enthusiast, and automatic features that get you where you want to be. Fast.

There's a whole world out there that's waiting to be heard. Tune in to it with the Panasonic Command Series.

Batteries not included.

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Beckman Industrial™

Beckman Industrial 60MHz and 100MHz oscilloscopes are advanced designed for greater performance and ease of use. They offer more control, more versatility and more features than other models. And they are backed by a nationwide network of factory authorized service centers. Compare and you'll agree. Nothing measures up to Beckman Industrial oscilloscopes.

- ☐ 1mV/DIV Sensitivity
- ☐ 3 Channel, 8 Trace
- ☐ Dual Time Base
- ☐ Delayed Sweep

Check out Beckman Industrial Models 9060 and 9100 oscilloscopes. At your local Beckman Industrial distributor.

Our UC10 Universal Counter gives you more of each. It measures frequency up to 100MHz…and gives you a variety of capabilities including frequency ratio, period, time interval and unit counting.

- ☐ Beeper/LED Function Indicators
- ☐ 20mV Input Sensitivity
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UC10 Universal Counter **$319.95***

You get the same advantages with our FG2 2MHz Function Generator.

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- ☐ Wide 1000:1 VCF Sweep Range
- ☐ 50 OHM Output Impedance

FG2 Function Generator **$199.95***

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*Suggested list price.

Beckman Industrial Corporation, Instrumentation Products Division, A Subsidiary of Emerson Electric Co., 630 Puente St., Brea, CA 92621, (714) 671-4800.

CIRCLE 98 ON FREE INFORMATION CARD

LETTERS

WRITE TO:

LETTERS
Radio-Electronics
200 Park Ave South
New York, NY 10003

PC SERVICE

Your July 1985 article, "PC Service", was very interesting, especially since we make one of those kits you refer to: the *ER-4* Photo Etch set. It's one that works. Its principle is patented. It's been sold to engineers and experimenters, and accepted in industry, for years.

But I'm writing for another reason. In your article, you recommend using the printed page as a poor man's film positive. That may work with some positive resists, but there are a few ways in which you can improve results.

1. You should publish the mirror image of the pattern that is to be reproduced. The pattern can then be placed directly against the sensitized board and exposed. If you continue to print a "right-reading" image, the blank paper side *must* be placed against the sensitized PC board. The printed image is separated from the foil board by the paper thickness, and your paper substrate will cause considerable light diffusion around and under the "black" areas. That causes thin circuit traces to break up or completely wash away.

2. You use a clay-coated paper in **Radio-Electronics**. Frequently, UV brighteners are added to the clay to make the paper look whiter. They absorb UV and retransmit the energy at longer wavelengths. What you now have seems to be OK. If you ever change paper, you'd better check things out again!

3. You should warn your readers that the system will work *only* with positive etch resist boards. It may seem obvious, but plenty of people will try it with negative resist—and waste a board.

4. Your comment about mineral oil is well-taken; yet, it's essential to transparentize the paper to minimize diffusion and to shorten exposure times. A good approach is to use a clear gloss acrylic spray. Here, it's best that the coating resins be *all* acrylic. Alkyds and nitrocellulose are often used as modifiers and they absorb some UV. I experimented with DATAKOAT gloss No. 04177 as a transparentizer and the results follow.

I coated both sides of page 67 from your July 1985 issue with two very wet coats of DATAKOAT. That was to ensure complete penetration of the paper by the clear acrylic resin. The page was hung on clothespins to dry.

I then taped the coated paper and an uncoated page with blank-paper areas to a north-facing window. I used a Glossen Pilot exposure meter held against the unprinted area of each sheet of paper to measure the comparative light transmission. With the ASA index set at 100, my results were:

uncoated 1/250sec @ *f*/3.8;
coated 1/250sec @ *f*/2.8.

Those values can be reduced to relative light-transmission ratios as follows:

The ratio of light intensity to corresponding to *f*/ stop value varies as the inverse square of the *f* value, or

$E = k/f^2$ where k is a constant; so

$E_1 = k/(3.8)^2$ or $k = E_1(3.8)^2$ (1)

and

$E_2 = k/(2.8)^2$ or $k = E_2(2.8)^2$ (2).

Combining (1) and (2) and rearranging gives:

$E_2/E_1 = (3.8/2.8)^2$

$E_2/E_1 = 1.84$ or an *84% improvement* in light transmission. DATAKOAT Gloss No. 04177 is available from many electronics parts distributors. Other 100% acrylic

(Continued on page 20)

NEW!

Satellite Communications Training from NRI!

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

Explore Every Aspect of Satellite Transmission and Reception As You Assemble, Install, and Train With the Complete TVRO System Included in Your Course

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

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

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

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

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

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

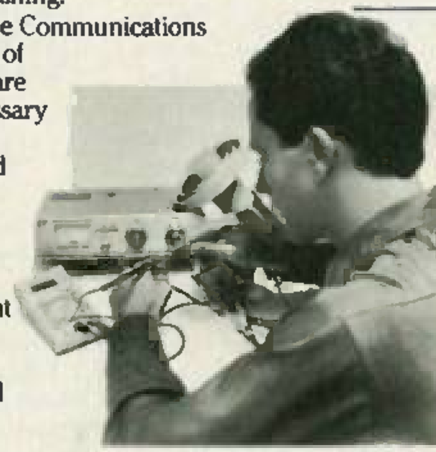
New Jobs, New Careers for the Trained Technician

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

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

NRI Brings Satellite Technology Down to Earth

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



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

Using the remarkable NRI Discovery Lab®, you demonstrate first-hand many important points covered in your lessons. You perform critical tests and measurements with your digital multimeter. And, using your NRI Antenna Applications and Design Lab, you assemble and test various types of antennas and matching sections.

Then you concentrate on both commercial and consumer satellite earth station equipment, putting theory to practice as you assemble and install the 5′ parabolic dish antenna system included in your course.

Your Home Satellite TV System Brings Theory to Life!

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

By training with an actual TVRO system, you'll come to understand the function and operation of a satellite earth station—knowledge that you can apply to both consumer and commercial equipment. And once you have completed your TVRO system, you'll have access to the best television entertainment available—direct from the satellite to your home.

At-Home Training the Uniquely Successful NRI Way

It's hands-on training, at home... designed around the latest state-of-the-art electronic equipment you work with as part of your training. You start from scratch and "discover by doing" all the way up to the level of a fully qualified professional. You conduct key experiments... perform vital tests... install your own system... and you do it at the pace that suits you best.

But, most important to your success, you don't do it alone. Built into your NRI training is the enormous experience of our development specialists and instructors, whose long-proven training skills and personal guidance come to you on a one-to-one basis. They are always available for consultation and help.

Make Your Move Into the Future Today! Send for Your FREE NRI Catalog

Only NRI can train you at home for an exciting and rewarding career as a satellite communications technician. The knowledge and know-how you gain from your NRI training provide you with the soundest possible foundation for further growth with the industry. But now is the time to act. Return the post-paid card to us today. You will receive your 100-page catalog free. It's filled with all the details you'll want to know about our training methods and materials and our more than 70 years of successful innovation in at-home, hands-on career training—the kind of experience that enables NRI to provide the most effective training possible to prepare you for today's, and tomorrow's, high-tech opportunities. (If the card is missing, write to us at the address below.)

NRI SCHOOL OF ELECTRONICS

McGraw-Hill Continuing Education Center
3939 Wisconsin Avenue, NW
Washington, DC 20016

We'll give you tomorrow.

LETTERS

continued from page 15

gloss sprays should give comparable results, but additional coats may be required.
BARRY DAVID BROWN,
President,
The Datak Corporation,
Sparks, NE.

Thanks for your informative letter. We should point out one thing, though: The PC-board image printed on the page is not a right-reading one. The dimensions read right, but the pattern is flopped to minimize diffusion. We hope to hear from others on their experiences as well.—Editor

MANUAL NEEDED

I need a service manual for a Fisher, model *1434*, 4-channel/stereo receiver. I am willing to pay a reasonable sum for a schematic and parts list. That material is not available from the Fisher Radio Corp., or from *Sams Photofact*. Thank you very much.
CHARLES D. PRATER
Edna, KY 41419

ELECTRONIC TESTING OF AUTOS

I have been a reader of Radio-Electronics for the last eight years and have seen the radical changes that it has gone through. It is the last of a breed of consumer-experimenter-technical-amateur electronics magazines.

I would like to see some articles devoted to electronic testing of autos, such as special scopes for electronic-ignition type cars without points. I would also like to see some articles devoted to higher-band video recording, such as is coming out in Beta machines, as well as editing machines with flying erase heads.

Keep up the good work, and don't go the way of all the computer-based competition.
BERNARD H. WEISS
Edison, NJ

We have good news for you! An article, "Automotive Electronic Troubleshooting," by Herbert Freidman, will appear in Issue Number 6 of our sister publication, Hands-On Electronics, *which is due to go on sale October 15, 1985*—Editor.

ELECTRICAL SAFETY

I just finished reading Earl "Doc" Savage's "Hobby Corner," in the May 1985 **Radio-Electronics**—and after reading the section about the Headphone Adapter, I was *horrified*. Shame on you, "Doc!" I know you know better—but you forgot something.

The circuits you show are perfectly OK, but you left out the most important part: *electrical safety*. I'm sure you're aware that most new equipment— especially TV sets that have been built over the last three to four years—are *hot chassis*. Therefore, hooking any external wires or exposed equipment to anything in that set will create an extreme shock hazard, or even death under the right conditions.

Of course, the correct way to make those installations is first to wire a 1-to-1 isolation transformer between the set and the speaker. That will eliminate the shock hazard, as well as give some overload protection to the output circuits. Then the headphone jack can be hooked up in the manner that you show. Most manufacturers use that same system.
AL LAMER, CET
Keizer, OR

THE e-Z BOARD

I am delighted at the review of our product, the *e-Z board*, which appeared in the "Equipment Reports" section, July 1985 issue of **Radio-Electronics**.

A further item of possible interest to you is that we are using a mylar label with an excellent adhesive backing to identify the bus signals on the *e-Z Board*. For some reason, it probably appears that we have glued two strips of ordinary paper, as your review indicates. We realized that a cup of coffee is frequently at hand when someone is breadboarding, and we wanted the label to be stainproof, as it were. So, in designing the label, we asked the manufacturer to make sure that the identification is printed onto a mylar backing, and an insulator is placed over the backing. That will also ensure that the identification is permanent and won't fade away in time, or as a result of being exposed to the atmosphere.
RAHIM SABADIA
Yorba Linda, CA

COMMODORE MONITOR

In the "Letters" section of the **June 1985 Radio-Electronics**, Mr. Charles Matlin, Bell Gardens, CA, says that he is looking for a schematic and a block diagram of the Commodore *1702* color monitor.

In reviewing my copy of *Sams Photofact Annual Index 1985* (Howard W. Sams & Co., Inc., PO Box 7092, Indianapolis, IN 46206), page 11, I find that there is available, as of January 1985, tentative computerfact schedule production of repair data for the Commodore *1701* monitor.

Sams may be able to provide that data Mr. Matlin needs for his Commodore *1702*. He should write or call Sams (800-428 SAMS) for information.
DENNIS DERRY
Niceville, FL

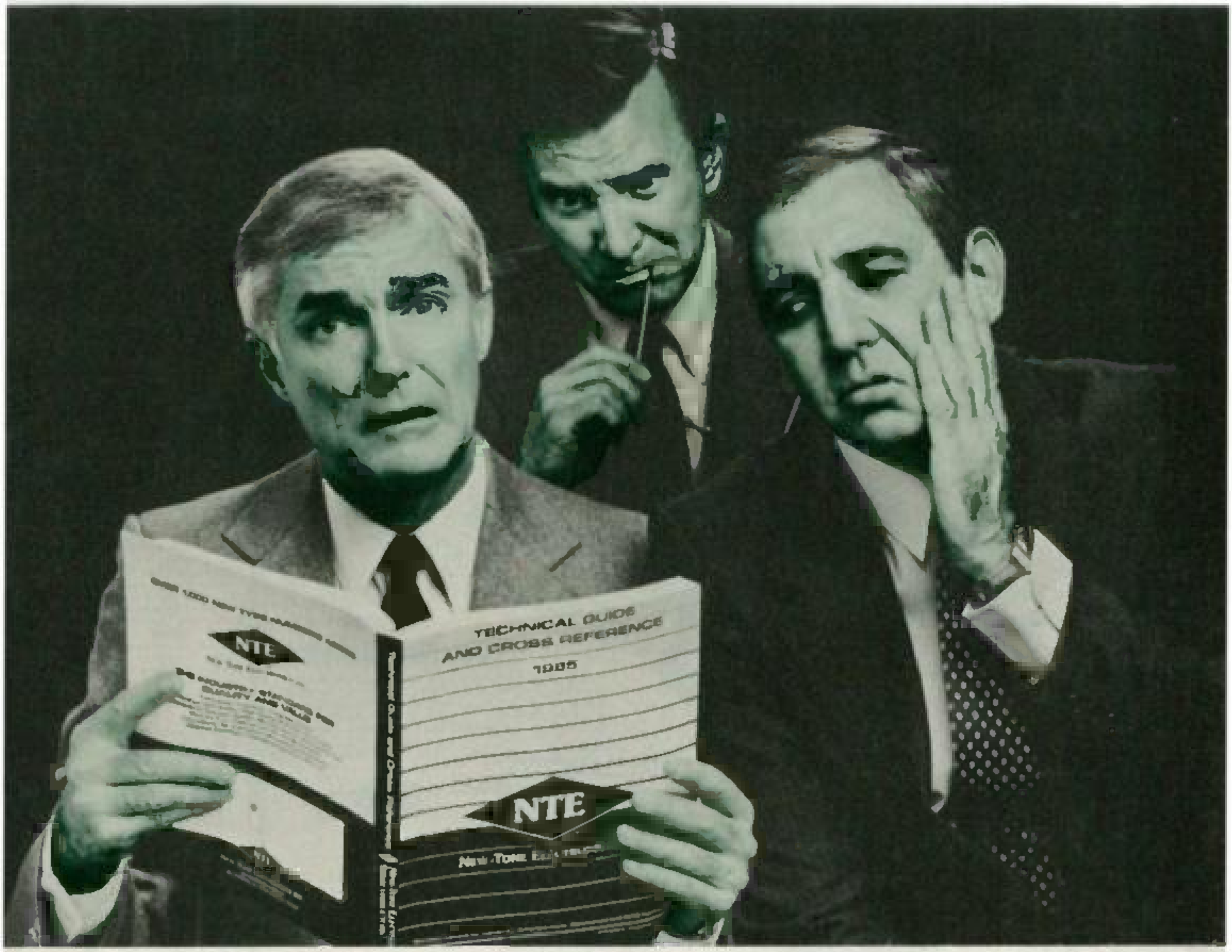
AGREES WITH ROBERT GROSSBLATT

I am writing this letter to express agreement with comments made by Robert Grossblatt in his article, "Understanding Memory IC's" (**Radio-Electronics, Feburary 1985**).

I have a 15-year-old son, Saul, who spends much of his free time glued to his TRS-80 computer. He listened to me as I began to read Mr. Grossblatt's article, aloud. The obvious point being made in the introductory paragraph was how brainwashed we are that we all need computers. I quote the article: "People are buying them like umbrellas in a rainstorm, whether they need them or not. In what has to be a classic case of consumer brainwashing, the public has been convinced that the list of life's basic necessities now includes a 64K memory. Well, it just ain't so!" At that point, my son asked: "Well, then, how much memory *do* we need?"

Consumer brainwashing? I must agree—how right you are!
BARRY KELNER,
Manalapan, NJ

R-E



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Using the *Typestar 6*

The *Typestar 6* has several modes of operation, selected by use of the MODE key. In the *character* mode, characters are printed one-by-one as they are entered at the keyboard. In the *line* mode, a whole line is entered before it is printed. That gives you a chance to correct mistakes before

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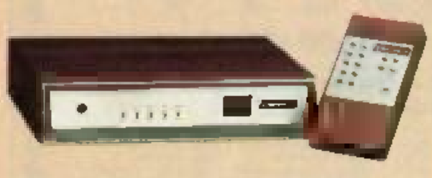

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committing them to paper. Finally, the *memory* mode allows you to enter and edit data in the *Typestar 6's* 2000-character memory.

That memory may be divided into as many as 26 different buffers of arbitrary length, each of which may be edited and printed separately. To edit a buffer, you press the TEXT key, a letter from A to Z (representing the desired buffer), and the CODE key. At that point you may use the DELETE key, LEFT and RIGHT arrow keys, and the RELOCATE key to clean up your text. The RELOCATE key moves the cursor to the beginning or end of the current buffer on alternate keystrokes. The arrow keys move the cursor one character at a time in the appropriate direction, and the DELETE key deletes the character at the current cursor position.

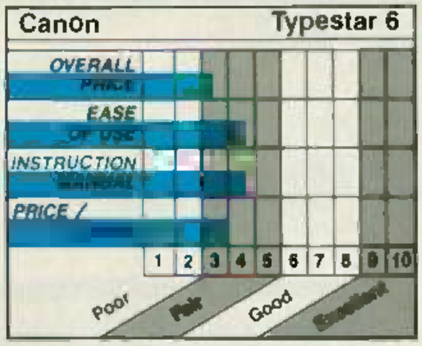
A collection agency, for example, might make use of that memory to store a set of messages to be used in printing form letters. The contents of each message would vary depending on how long an account had been overdue. To print a letter, the typist would manually type the name and address block, then choose the appropriate buffer, as done for editing, and then press the TEXT PRINT key. Finally, a signature line would be typed in manually.

One nice thing about the keyboard is that the SHIFT LOCK key has a small red indicator that lights up when that key has been depressed. There are separate keys for setting left and right margins, keys for setting and clearing tab stops, a margin release key, a REPEAT key, and the KB (keyboard) key, which allows you to choose between several different foreign language character sets.

The printer

The *Typestar 6* has a thermal-transfer printer that uses special miniature ribbon cartridges. The thermal process ensures that operation is fairly quiet. As a matter of fact, operation is noisiest when the printhead returns to the left side of the page after printing a line. The whirring sound emitted when that happens seems loud because there is so little noise otherwise!

It is interesting that the *Typestar*



6 uses a much higher density printhead than is common with even the best of today's dot-matrix printers. A 24 × 9 matrix is about the highest density available on current printers, but the *Typestar 6* uses a 32 × 26 matrix, which yields characters almost indistinguishable from those formed by daisy-wheel or ball printers.

In addition, you may choose from among five different typefaces. The *Typestar 6* comes with Courier 10 built in, but has a slot on the left side of the machine that will accept one ROM (*R*ead *O*nly *M*emory) cartridge containing an alternate character set. At the present time you may choose from Courier 12, Cubic PS, Ameria PS, and Courier Italic 10, each of which retails for about $30.

Word-processing functions

So far, the *Typestar 6* might not sound much different from a standard memory typewriter. Its word-processing functions are what distinguish it. For example, it can center a line of text between the current margins, or between tabs, at the touch of a key. You can specify that your text come out left justified (with a ragged right margin), right justified (with a ragged left margin), or fully justified (both margins even). In addition to setting the usual tabs and margins, the *Typestar 6* handles decimal tabs, allowing you to align columns of numbers easily.

Other parameters you can specify include line spacing, automatic underlining, double-width printing, and automatically underlined double-width printing. You can set the *Typestar 6* up to return the carriage and feed the paper only when you press the RETURN key. Or you can let the *Typestar 6* return

(Continued on page 30)

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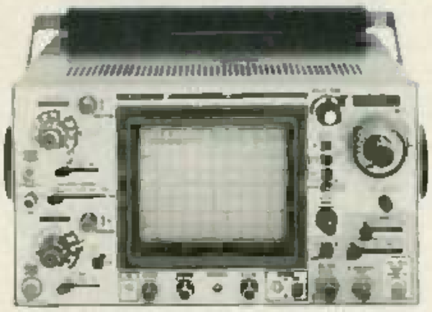

LBO 524L DC to 40 MHz

The LBO-524L is designed to meet a broad range of applications in design, testing and servicing of both analog and digital circuits and equipment. Its large 8x10 cm PDA CRT provides sharp, bright displays even at highest sweep rates. Comprehensive triggering controls including holdoff, alternate triggering and delayed sweep triggered functions permit stable displays for even the most complex signals. With 0.5 millivolt sensitivity, extremely low-level signals can easily be observed. A channel 1 output is available on the rear panel to drive other less sensitive instruments such as a frequency counter with an input level as low as 500 microvolts. The dual time base permits accurate observation and time interval measurements of complex waveforms.

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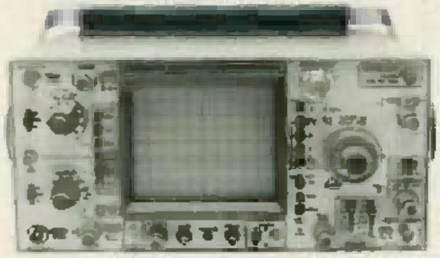

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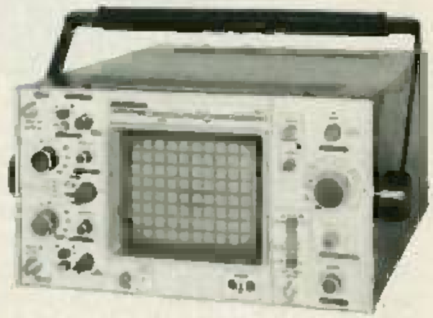

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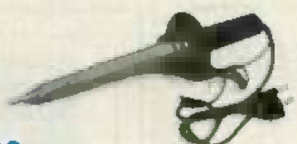

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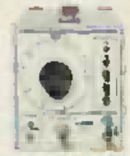

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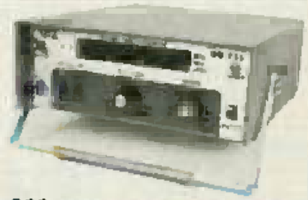

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Resistance: 2KΩ-200KΩ±(0.1%rdg + 3dgt)
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3½-Digit Capacitance Meter
Range: 200PF - 20mF

MODEL EDC110A $89.00

Accuracy:
20PF-20uF ±(0.5%rdg+1dgt+0.5PF)
200uF ±(1.0%rdg+1dgt)
2000uF-20mF ±(2.0% rdg+ 1dgt)

CIRCLE 258 ON FREE INFORMATION CARD

POWER DESIGNS · Simpson · PRIMELINE A SOLTEC PRODUCT · STACO · VACO · VIZ · WAYNE KERR the carriage for you automatically when you approach the end of a line. How do you know when you're nearing the end of the line? The *Typestar 6* allows you to set the column at which an alarm bell sounds. Further, the *Typestar 6* has the capability of doing hyphenation. With that feature enabled, as you approach the end of a line and press the hyphen key, the typewriter will automatically print the hyphen and move to the next line.

As capable as it is, the *Typestar 6* does have a few drawbacks. First, it is slow. An experienced typist can easily run several lines ahead of the printhead; and while the microprocessor is taking care of its printing chores, the display is updated very slowly.

Another drawback is the type of paper that must be used. Although you can use inexpensive bond paper for general typing, if you would like high-quality work, then you must use special paper available from Canon that takes advantage of the *Typestar 6's* special thermal-transfer printing process.

You should also be aware that the miniature ribbon cartridges the *Typestar 6* uses are good for only about 20 pages before printing starts to fade. On the other hand, the ribbons are quite inexpensive—about $2.00.

It would be nice if the unit could be used as a computer printer. (After all, its 26 × 34-dot-matrix printhead is capable of producing nicer output than just about any printer in its price class.) Unfortunately, as no computer interface has been provided, that is not easily done.

The documentation is very good. It is written in clear, readable language, and is printed on high-quality stock. It quickly takes you through the basic operation of the typewriter, and gives you a good understanding of how to use and get the most from its many advanced capabilities.

The Canon *Typestar 6* retails for $299.95; for more information on that product contact Canon USA, One Canon Plaza, Lake Success, NY, 11042. **R-E**

A PRECISION DIGITAL THERMOMETER IS a vital addition to any laboratory. But even around the house, there are a great many instances when it would be useful to know a temperature with a fair degree of precision (such as when you are checking your stove, refrigerator, or heating system.) However, a precision digital thermometer can cost in excess of a few hundred dollars. That's quite a sum to pay when you consider that if you own a DMM, you already own a much of the circuitry in such a thermometer.

Fluke (PO Box C9090, Everett, WA 98206) has recently introduced a low-cost alternative. It is the *80TK* thermocouple converter. That device takes the output of a K-type thermocouple and converts it so that it can be fed to a standard hand-held or bench-type DMM. (If you are unfamiliar with thermocouples, see "Making Measurements Electronically" in the May 1984 issue of **Radio-Electronics**. That article includes information on thermocouples, their ratings, and how they are used.)

The *80TK*

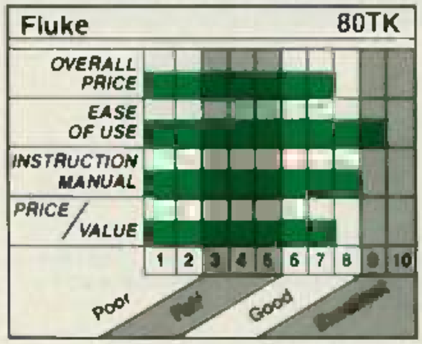
The *80TK* converts the output of a k-type thermocouple into a 1-millivolt-per-degree signal that can be input directly to a DMM. The temperature can be read from the DMM's display, with a resolution as high as 0.1 degree. Of course, the level of resolution will depend on the voltage scale that the meter is set on (of course, higher temperatures will require use of a higher scale).

Temperatures can be measured in either degrees Celsius or Fahrenheit. The temperature scale is switch-selectable from the front of the converter. As that is the only control on the unit, the same switch is used to turn the *80TK* on and off.

Using the converter is very simple. The unit is plugged into a DMM, and, in turn, a thermocouple is plugged into the converter. The converter and DMM are turned on, the thermocouple is exposed to whatever it is you want to measure, and the temperature is displayed on the DMM's readout.

The converter itself is lightweight, weighing in at just 4.5 ounces. It's overall length, including the banana-plug outputs, is just 4⅝ inches. The banana plugs are spaced ¾ inches apart, so the unit can be plugged directly into any DMM that adheres to that spacing for its v and COMMON inputs (as most DMM's do).

The *80TK* is powered by a nine-volt battery. Estimated battery life is claimed to be 1600 hours by the manufacturer.



Thermocouples

The unit is supplied with a general-purpose bead thermocouple probe. That probe has a measurement range of −40°C to +260°C (−40°F to +500°F). In addition Fluke offers an optional immersion probe for liquids or gels and a surface probe for direct contact with the surface being measured. All of the Fluke probes attach to the converter via a mini thermocouple connector (subminiature K plug). The unit can also be used with probes from other manufacturers that use similar thermocouple connectors.

The converter's specified temperature measurement range is −50 to +1000°C (−58 to +1832°F). Accuracy, provided that the converter is kept within its ambient temperature range (0 to 50°C), varies between 0.5% ± 2°C (0.5% ± 3.6°F) and 2.5% ± 2°C (2.5% ± 3.6°F), depending on the temperature being measured.

Note that those specifications refer only to the converter itself. They do not include the error introduced by either the thermocouple or the DMM.

The documentation supplied with the unit is brief, but to the point. It does a good job of describing how to use the unit effectively. Maintenance, testing, and calibration information is also provided, as is a schematic diagram and parts list.

While the unit does not have the accuracy of some of the more expensive laboratory models, it should prove more than accurate enough for most applications. The *80TK* thermocouple converter carries a one-year warranty, and sells for $59.00. **R-E**

"It looks as if his horizontal hold needs some adjusting."

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NTO PC SERVICING
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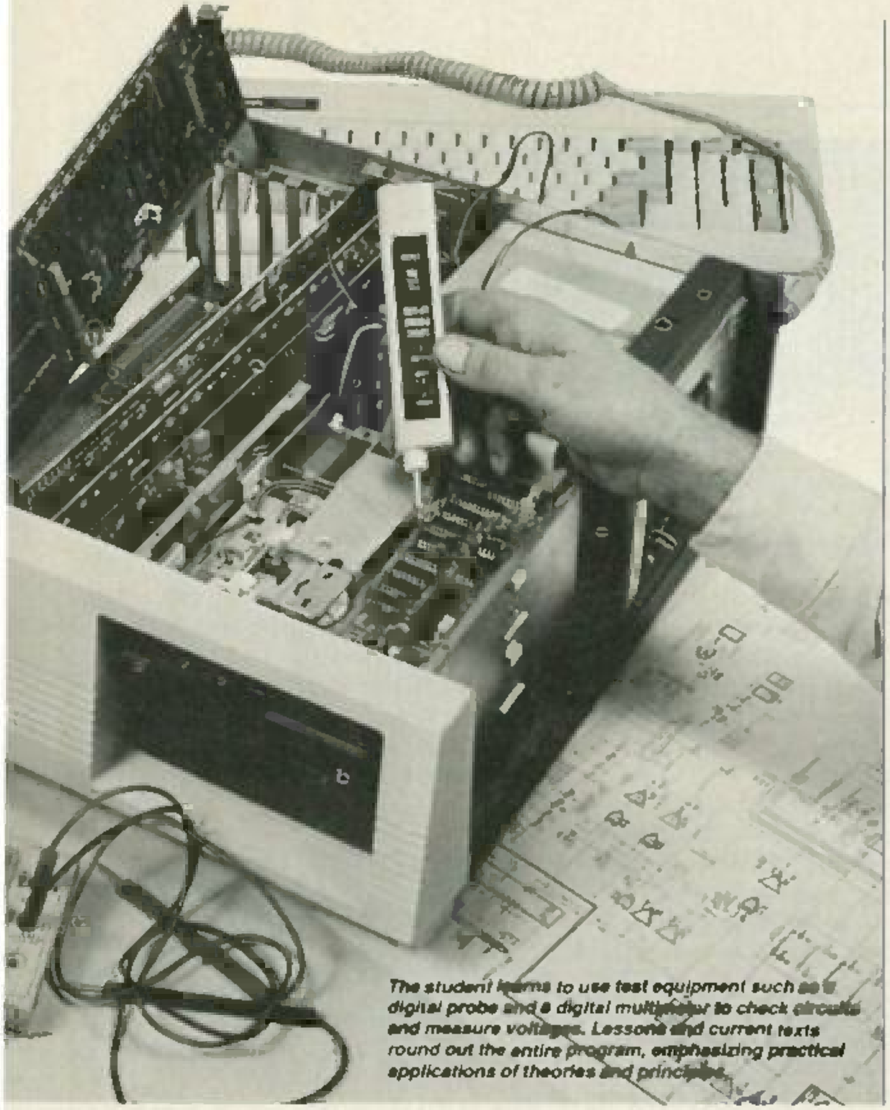

The student learns to use test equipment such as a digital probe and a digital multimeter to check circuits and measure voltages. Lessons and current texts round out the entire program, emphasizing practical applications of theories and principles.

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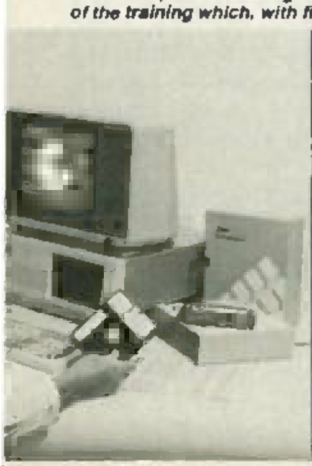

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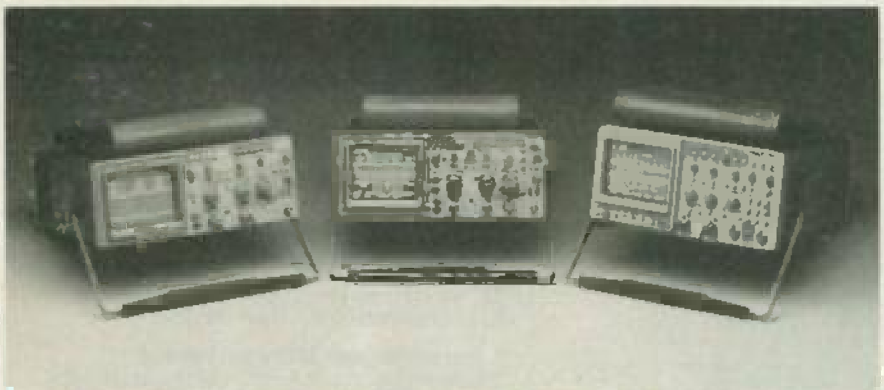

CIRCLE 21 ON FREE INFORMATION CARD

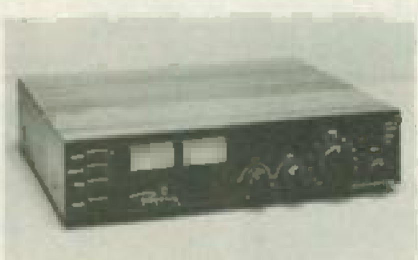
DIGITAL STORAGE OSCILLOSCOPES, models *2220, 2230* and *2430* offer high speed in portable packages. The top-of-the-line model *2430* has a digitizing speed of 100 million samples per second, a bandwidth of 150 Mhz, and can catch glitches as narrow as 2 nsec. The *2430* has two CCD's (Charge Coupled Devices) for simultaneous dual-channel signal acquisition. Its extensive trigger capabilities include time- and event-delay, combination, variable hold-off, auto-level, etc.

A special patented feature, "save-on-delta," allows the *2430* to compare incoming waveforms with a previously stored reference, and save the incoming wave if it differs from the reference. That makes the unit ideal for "babysitting" applications. The *2430* can store as many as six waveforms after power is removed. The *2430* comes standard with a GPIB interface, through which it may be programmed. The unit may also be programmed using menus selected through five front-panel pushbuttons.

Models *2230* and *2220* offer similar capabilities at lesser speeds: 100 MHz and 60 MHz, respectively. Both models offer digitizing speeds of 20 million samples per second, glitch-capture speeds of 100 nsec, and optional GPIB and RS232C interface modules.

Models *2240* and *2230* allow the user to position cursors on the screen to read out delta-time, inverse of delta-time (frequency) and delta-volts. The *2240* lists for $8900; the *2230* lists for $5150; and the *2220* lists for $4150.—**Tektronix, Inc.,** P. O. Box 500, Beaverton, OR 97077.

STEREO SATELLITE RECEIVER, the model *SR3500*, uses a block down-converter instead of the usual single conversion type. The block system ensures a clean, crisp picture, and allows the user to install a multiple-receiver system. The unit can also receive stereo broadcasts in either the discrete or matrix mode.


CIRCLE 22 ON FREE INFORMATION CARD

Other features include signal strength and tuning meters, built-in Chaparral Polarotor 1 polarity control, channel 2 or 3 RF modulator, and a contemporary design with simulated woodgrain cabinet. An A/B switch, compatible with the Regency SR5000 block system, is also available for dual feed installations. The model *SR3500* is priced at $599.95.—**Regency Electronics, Inc.,** 7707 Records Street, Indianapolis, IN 46226-9989.

MULTI-COUNTER, model *WD-757*, is capable of frequency, period, totalize, ratio, and time-interval measurements. It achieves ±0.003% accuracy and ±.002% stability tolerance through a combination of CMOS, TTL, low-power Schottky, and LSI technology. It is equipped with three inputs and a switchable attenuator to reduce high-amplitude signals by a factor of 10. A switchable lowpass filter has a cutoff frequency of 10 MHz.


CIRCLE 23 ON FREE INFORMATION CARD

The model *WD-757* has a suggested list price of $479.00—**VIZ Test Equipment,** 335 East Price Street, Philadelphia, PA 19144.

PROBE, model *IR-10*, is a non-contact, infrared temperature probe. The model *IR-10* converts a Simpson (or other) DMM or VOM to a

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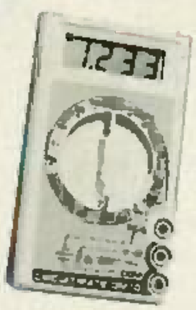

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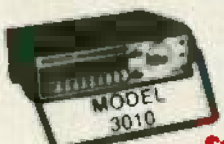

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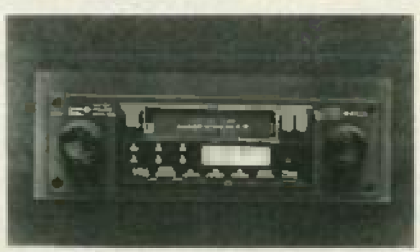
Probe size is 1.4 inches in diameter × 5.4 inches long, with a 36-inch (uncoiled) cord. The electronic control unit is 2.5 × 1.2 × 4.5-inches. A single 9-volt alkaline battery provides up to 6 months of typical (>100 hours continuous) operation. The model *IR-10* is priced at $395.00.—**Simpson Electric Company**, 853 Dundee Ave., Elgin, IL 60120.

AM/FM CASSETTE PLAYERS. *CAR 335, CAR 362*, and *CAR 372* (shown) are auto-reverse, AM/FM stereo cassette players.

The analog *CAR 335* features auto-reverse, a fader, preamp outputs, night illumination, metal tape equalization, auto eject, a DIN-size chassis, and an output of four watts per channel with no more than 1% THD. It is priced at $149.95.

Both the *CAR 362* and the *CAR 372* feature a liquid-crystal display with a clock, digital AM/FM tuners with six AM and six FM station memories, auto-reverse, fader, night illumination, auto seek, preamp outputs, metal tape equalization, automatic pinch roller retraction, locking fast forward and rewind, power-antenna leads, and a DIN chassis size.



CIRCLE 25 ON FREE INFORMATION CARD

The *CAR 3562* has a single tone control and an output of four watts per channel, with no more than 1% THD. It is priced at $239.95.

The *CAR 372* features, as well, Dolby noise reduction, separate bass and treble controls, and an output of 10 watts per channel with no more than 1% THD. It is priced at $299.95.

Marantz also offers a mobile power amplifier, model *SA402*, featuring an output of 40 watts per channel at 10% THD and 30 watts per channel at 1% THD, high and low level inputs, adjustable gain controls, integral heat-sink cooling, and remote on/off sensing. It is priced at $99.95.—**Marantz**, 20525 Nordhoff St., Chatsworth, CA 91311.

SOLDERLESS BREADBOARD, the *ACE 118*, features four binding posts, something usually found on much larger boards. The four standard five-way posts, attached to the base plate, make convenient connections to power supplies, signal generators, or other external equipment.

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The *ACE 118* has 1280 terminal tie points. Up to 18 14-pin DIPS or 16 16-pin DIPS can be used on the breadboard. Included are 544 distribution tie points, which can be used to offer such functions as voltage and ground buses, reset and clock lines, etc. The *ACE 118* accepts all DIP sizes, as well as a wide variety of discreet components. It has a suggested retail

continued on page 112

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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.

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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:

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3. **SPECIALLT LUBRICATED DISK** - *Super Disk* uses a special oxide lubricant which is added to the base media in the production of their diskettes. This gives you a better disk drive head to media contact and longer head and disk life.
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5¼" Same as above, but bulk pack w/o envelope	6487-ZJ	0.64
5¼" DSDD Soft Sector w/Hub Ring	6491-ZJ	0.94
5¼" Same as above, but bulk pack w/o envelope	6497-ZJ	0.74
5¼" DSQD Soft Sector w/Hub Ring (96 TPI)	6501-ZJ	1.49

SSSD = Single Sided Single Density; SSDD = Single Sided Double Density; DSDD = Double Sided Double Density; DSQD = Double Sided Quad Density; TPI = Tracks per inch.

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VIDEO TITLER

Now you can superimpose titles and computer graphics on video images!

JACK FLACK

HAVE YOU EVER WANTED TO ADD TITLES TO SOME OF YOUR VCR RECORDINGS? WHILE THERE ARE MANY titlers commercially available that let you liven up your video presentations by adding characters, they do so at the expense of the video image. But the titler we'll describe will change all that. It lets you *superimpose* characters directly on the video image from a VCR, video camera, videodisk player, or even an over-the-air broadcast!

If characters aren't enough for your needs, the titler can be interfaced with a home computer such as the IBM PC, TRS-80 Color Computer, Commodore 64, or Apple II to allow you to superimpose computer-generated graphics or even real-time animation on a standard video signal.

Even with the current "video boom," a device such as this has not been available commercially to the home video enthusiast—until now. Why not? After all, the networks and even local television station have had expensive computer-based character generators for over 10 years.

Unlike audio, video signals are very complex; they must contain synchronizing, color, detail, and other information necessary to generate a television picture. And to superimpose one video image on top of another, both signals must be synchronized. The difficulty in doing that—because there are no LSI IC's available to do it—is apparently what has kept a product like our titler off the market...until now.

The video titler uses

Motorola's 6809 microprocessor and Texas Instruments' TMS9128 VDP (*V*ideo *D*isplay *P*rocessor. The VDP performs most of the functions needed to generate computer images. It provides: refresh for 16K dynamic video RAM's, asynchronous bi-directional data transfer to internal registers and video RAM. 256×192-pixel resolution. 16 colors. up to 32 separate movable objects called sprites. and—most important for superimposition—the ability to be synchronized (gen-locked) with an external video signal.

Before we go any further in our description of how the video titler works. we should review some of the fundamentals of video and television.

FIG. 1—THE NTSC VIDEO FIELD consists of two frames, which combine for a total of 525 horizontal lines.

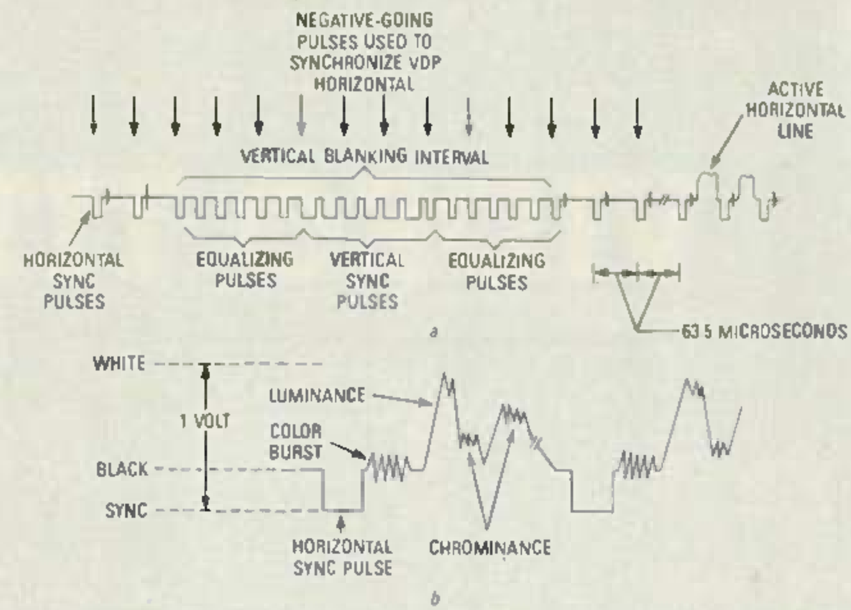


FIG. 2—THE NTSC COMPOSITE VIDEO SIGNAL contains several timing components. For superimposition it's important that the video titler's output be synchronized with them. The vertical blanking pulse is shown in *a*, and the horizontal sync pulse is shown in *b*.

Background on video

The standards for television in the U.S. were adopted during the 1940's for black-and-white TV and enhanced in the early 1950's to provide for color. The group of industry representatives responsible for these standards was the National Television Systems Committee (NTSC).

The NTSC standards call for a *raster* (which is the pattern of scanning lines on a TV picture tube when no signal is being received) of 525 horizontal lines. The raster *frame* of 525 lines consists of 2 *fields*. usually referred to as the odd and even fields. Each field therefore consists of 262.5 horizontal lines. See Fig. 1.

To generate the frame. all the odd lines from the top of the screen to the bottom are scanned first (making up the odd field). Then the beam is returned to the top of the screen. and the even lines are then scanned from the top to the bottom (making up the even field). The process of "weaving together" the odd and even fields to form a raster is called *interlacing*.

Each field is scanned in 1/60 second. so each complete frame is repeated at a rate of 30 frames per second.

The reason that interlaced scanning was chosen by the NTSC is that it helps to eliminate flicker by producing a relatively smooth transition between fields. You can sometimes observe flicker. which is the slight shifting up and down of images on the screen. with large white-on-black characters (or other high-contrast images). Flicker. which can make it difficult to read characters. especially small characters. is the primary reason computer designers chose not to use 30 frame-per-second interlacing. Home computers usually operate with 262 horizontal lines in each field. The beam then traces the same path 60 times per second. This approach eliminates flicker: however. it also reduces the vertical resolution to one half of the resolution of 525 line interlaced images.

Composite video

The NTSC composite-video signal that is used to transmit television picture information was also standardized in the 1940's and 1950's. (It is also sometimes referred to as RS-170). Although the polarity and peak-to-peak voltage of the composite video signal is not mentioned in the standard. the other parts of the waveform are fixed. Fortunately. the VCR and video camera industry have standardized the polarity and peak-to-peak voltage of the composite video signals as negative-going sync and 1 volt peak-to-peak amplitude (AC) into a 75-ohm impedance. Make sure that any device you use with the video titler follows those standards!

Figure 2 shows the composite video signal. The signal contains timing components and picture-definition components. For superimposing. the timing components from the titler's video signal (the *vertical sync*. *horizontal sync* and *colorburst*) must be synchronized with the those of the external video signal.

The horizontal sync and blanking pulses keep the TV receiver's horizontal scanning in step with that at the transmitter. and cut off the picture tube during horizontal retrace. The duration of one horizontal line is 63.5 µs. and the blanking pulse interval lasts for about 10 µs. Thus. the active video portion of one horizontal line that is actually seen lasts for 53.5 µs.

The horizontal sync pulses are about 5 microseconds wide and ride on the blanking pulse pedestal. The colorburst ride on the *back porch* of the horizontal blank ing pulse.

The vertical sync and blanking pulse must be provided between each field to ensure that vertical retrace begins at the proper time. and to hide the visual effects of the retrace. The pulse occurs at the end of each field. and lasts until vertical retrace has ended. Each vertical blanking interval lasts for between 13 and 21 horizontal lines. (Thus for each frame. 26 to 42 horizontal lines are lost to vertical blanking.)

There are three types of pulses riding on the vertical blanking pulse: equalizing. vertical-sync. and horizontal sync pulses. (A colorburst is inserted after each horizontal sync pulse for color signals.)

Note the waveform of the vertical sync in Fig. 2. Remember that vertical sync occurs after 262.5 horizontal lines. In order to maintain horizontal synchronization during the vertical sync. *vertical serrations* are inserted inbetween the vertical sync pulses and occur at twice the horizontal frequency. The equalizing pulses before and after the vertical sync also occur at twice the horizontal frequency. You will later see that all negative edges of the equalizing pulses. vertical serrations. and horizontal sync pulses are used to synchronize the video titler's horizontal frequency.

The colorburst is the heart of the

color-reproduction process. Although this precise 3.579545-MHz (referred to as 3.58 MHz) burst appears only for a few microseconds during the back porch of the horizontal sync, it is used to generate a continuous 3.58 MHz sinewave. This sinewave's frequency and phase is re-established every active horizontal line (except during the vertical blanking period). The way in which the colorburst is used in the generation of colors will be discussed later. For now, it's sufficient to say that the video titler must synchronize its color clock to the external colorburst. Otherwise, images generated by the titler will appear in a rainbow of random colors.

The luminance represents the black-and-white picture detail. It basically is the brightness or degree of white present in each picture element, without regard to the color.

The chrominance is the color information of the video signal. The chrominance signal carries the hue and saturation information. Figure 3 illustrates how the chrominance information is encoded and decoded.

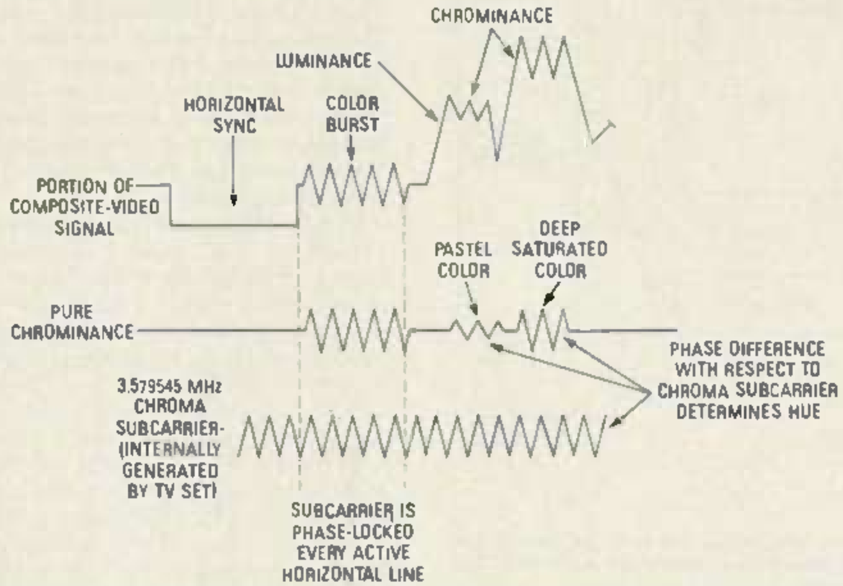


FIG. 3—THE CHROMINANCE SIGNAL AND CHROMA SUBCARRIER, which is generated by the TV set using the colorburst as a reference, are compared to each other. A phase change represents changes in hue.

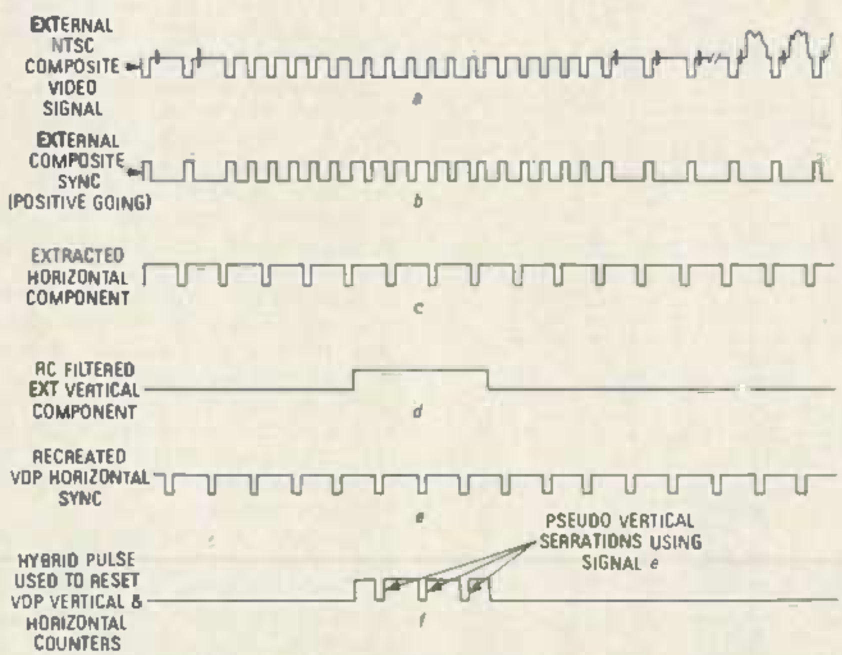


FIG. 4—TIMING SIGNALS USED TO SYNCHRONIZE THE VDP with external horizontal and vertical timing elements. Shown in *a* is the external composite-video signal, and in *b*, the external composite sync. In *c*, we see the extracted horizontal component. The vertical component is shown in *d*, and the recreated horizontal sync is shown in *e*. Finally, the hybrid pulse used to reset the VDP's horizontal and vertical counters is shown in *f*.

The chrominance signal is compared to the chroma subcarrier, which is internally generated by the TV set using the colorburst as a reference sample. Differences in phase result in different hues. The relative amplitude of the chrominance with respect to the chroma subcarrier determines the saturation of the color. A chrominance signal with a small amplitude will result in a pastel color. On the other hand, a large amplitude will result in deep saturated colors.

How the video titler works

Now that we have a basic understanding of the standard video signal, let's look at how the video titler can superimpose its video image over an external NTSC composite video signal. Certain conditions must be met before the two signals can be mixed. The vertical, horizontal and color clocks must be synchronized and the amplitude and DC level must be matched.

The heart of the video titler is Texas Instruments' TMS9128 VDP. The VDP operates operates with a 10.738635-MHz clock (which is 3 times the color subcarrier frequency of 3.58 MHz), from which all of the other internal clocks are derived. The pixel clock is 5.4 MHz (10.7/2), which means that each pixel is approximately 186 nanoseconds wide. The pixel clock is divided by 342 to generate horizontal sync.

The VDP provides for vertical and horizontal synchronization to an external composite video signal through a 3 level RESET/SYNC input. System reset occurs when that input is brought low (less than 0.8 volts). For normal operation, the SYNC/RESET input is held at 5 volts. When it exceeds 9 volts for greater than 7 microseconds, the VDP resets its internal video counters.

That would seem to mean that all we need is a positive-going external sync-signal applied to the RESET/SYNC input, operating between 5 and greater than 9 volts, to synchronize the VDP's internal vertical and horizontal counters with the external signal. Unfortunately, that's not exactly true. Texas Instruments chose not to use the NTSC standard for its sync pulses, and that results in problems with the external reset mechanism.

The VDP resets its horizontal clocks on the leading edge of the pixel clock. If you use some simple math you find that the NTSC horizontal sync occurs about every 63.556 microseconds. That works out to 341.25 pixel clocks. The one-fourth pixel difference causes jagged edges to appear on the images being superimposed on the screen.

The TMS9128 VDP does not internally generate the 3.58 MHz chrominance information. To generate color, it uses color difference signals (R – Y and B – Y) in connection with an external chrominance modulator.

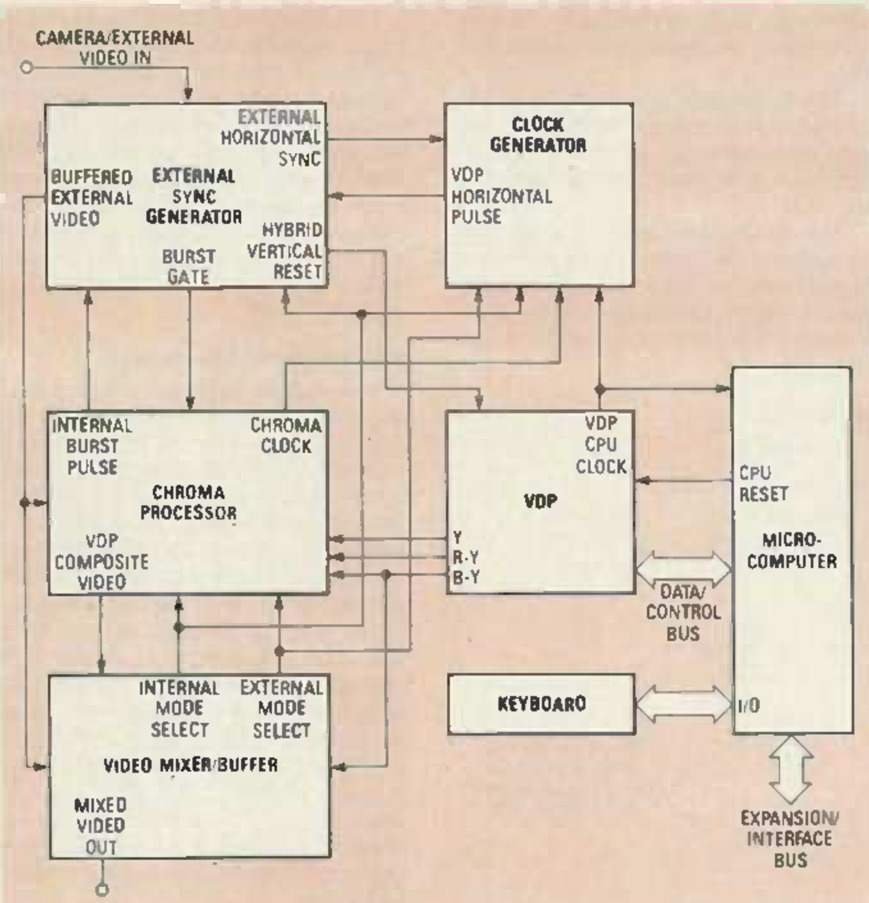


FIG. 5—THE BLOCK DIAGRAM OF THE VIDEO TITLER shows its main sections: the external sync generator, clock generator, video display processor, chroma processor, video mixer/buffer, and microcomputer. We'll discuss those sections in detail next month.

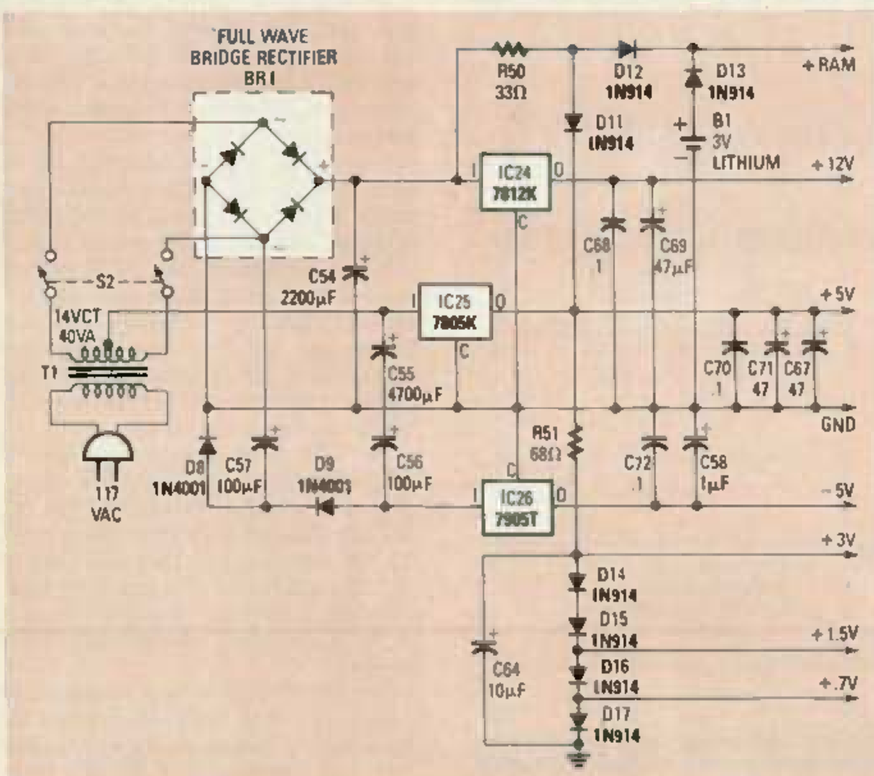


FIG. 6—THE POWER SUPPLY. While the titler operates mainly on +5 volts, the supply also provides the operating voltage for an external video camera.

The TMS9128 can operate quite well at frequencies slightly higher or lower than 10.738635 MHz without affecting the color-generation process. With a standard NTSC horizontal line of 63.556 microseconds, a VDP pixel width of 185.8349 nanoseconds (63.556 divided by 342 pixels per line) will result in the VDP operating at the NTSC horizontal rate. This pixel width can be derived from a master clock of 10.762237 MHz. You'd think with this problem overcome we'd be all set. But not yet.

A second problem exists with the VDP's process of synchronizing to an external VCR or videodisc-player signal. The sync pulses coming from these devices are not as stable as those from a camera or direct video broadcast. That is because VCR's and videodisc players have servo motors controlling the generation of the vertical and horizontal sync pulses during playback.

That instability is referred to as "jitter." Vertical jitter is not as much of a concern because of the relatively slow frequency of the vertical timing element. On the other hand, horizontal jitter may actually be observed when a jittery signal is used to directly reset the VDP's horizontal counters. Once again, what is seen is jagged edges on the VDP's images.

The video titler overcomes the jitter problem by letting the horizontal sync track the external horizontal sync using a phase-locked loop (PLL) to "average out" the jitter. However, the VDP does not provide a separate horizontal output pulse and does not generate vertical serrations or equalizing pulses in its non-standard video signal. Therefore to obtain a horizontal sync during the vertical period, a pseudo horizontal pulse has to be constructed using available signals.

That pulse could be derived by dividing the master clock by 684. However, since the CPU CLOCK output on the VDP is merely the master clock divided by 3, we can further divide the signal by 228 and accomplish the same result. (Using that technique actually allowed us to use one less 4-bit binary counter in the circuit.)

The vertical counters within the VDP must still be reset in order to superimpose. By doing that, however, we introduce an additional problem. Using a simple RC filter, we can extract the vertical sync from the external composite sync. After proper level adjustment, that signal can be applied to the VDP's RESET/SYNC input. So far, so good.

Remember, however, that the leading edges of any pulse applied to the RESET/SYNC input resets the VDP's horizontal counters. Also remember that the standard NTSC composite video calls for 262.5 horizontal lines for each vertical sync pulse. This means that each successive external vertical sync pulse will also reset the VDP's horizontal counters

PARTS LIST

All resistors 1/4-watt, 5% unless otherwise noted.

RN1—10,000 ohms × 9 resistor network
R1,R16—10,000 ohms
R2—6800 ohms
R3—75 ohms
R4,R48—51,000 ohms
R5, R11, R12, R15, R25–R27, R35, R43, R49—1000 ohms
R6, R8, R30, R31, R39—4700 ohms
R7—3900 ohms
R9—5100 ohms, metal film, 1%
R10—4300 ohms, metal film, 1%
R13, R16, R18, R22, R24, R28, R33, R40—2200 ohms
R14, R23—680 ohms
R17, R36—120,000 ohms
R19, R20, R21—470 ohms
R29, R32—1000 ohms, PC-mount trimmer potentiometer
R34, R47—220 ohms
R37—1500 ohms
R38—5100 ohms
R41, R42—3300 ohms
R44, R45—820 ohms
R46—10,000 ohms, PC-mount trimmer potentiometer
R50—33 ohms
R51—68 ohms

Capacitors

C1, C40–C42, C44, C64—10 μF, 25 volts, electrolytic
C2, C3, C5, C9, C11, C14, C15, C16,C26, C33, C38, C39, C45, C47, C48, C49, C50, C51, C53, C60, C61, C62, C63, C68, C70, C72, C73—0.1 μF ceramic disc
C4—0.01 Metallized film, 5%
C6—0.002 μF ceramic disc
C7—0.005 μF ceramic disc
C8—0.001 μF ceramic disc
C10—47 μF, 25 volts, electrolytic
C12, C27—5–30 pF PC-mount trimmer
C13, C28—12 pF, ceramic disc
C17–C19, C66—220 pF, ceramic disc
C20—150pF ceramic disc
C21—390 pF ceramic disc
C24, C30, C58—1 μF, 25 volts, electrolytic
C35, C37—47 pF ceramic disc
C45—22 μF, 10 volts, electrolytic
C46, C56, C57, C59—100 μF, 25 volts, electrolytic
C52, C67, C69, C71—47μF, 16 volts, electrolytic
C54—2200 μF, 25 volts, electrolytic
C55—4700 μF, 16 volts, electrolytic
C65—33 pF, ceramic disc

Semiconductors

IC1—LM339 quad comparator
IC2—74LS221 dual non-retriggerable one-shot
IC3—74LS05 hex inverter
IC4—MC4044 phase-frequency detector
IC5—MC4024 dual voltage-controlled multivibrator
IC6, IC7—74LS191 up/down binary counter
IC8, IC9, IC13—4066 quad analog switch
IC10—TMS9128 video display processor (Texas Instruments)
IC11, IC12—4416 16K × 4 dynamic RAM, 150 ns
IC14—CA3126 chroma processor (RCA)
IC15—74LS00 quad nand gate
IC16—LM1889 TV video modulator (National—
IC17—LM361 high-speed comparator
IC18—74LS139 dual 1-of-4 decoder
IC19—2732 4K × 8 EPROM
IC20—6116 2K × 8 static RAM (or 2016)
IC21—74LS273 octal D-type flip-flop
IC22—74LS244 octal 3-state driver
IC23—MC6809 microprocessor
IC24—7812K regulator, +12-volts
IC25—7805K regulator, +5-volts
IC26—7905T regulator, −5-volts
D1, D3, D4, D5–D7, D11–D18—1N914
D2—1N751 Zener, 5.1 volts
D8, D9—1N4001 rectifier, 50 PIV
D10—not used
BR1—full-wave bridge rectifier, 6 amps
LED1—standard red LED
Q1, Q6—2N2222
Q2, Q3—2N3906
Q4, Q5—2N3904

Other components

XTAL1—3.579545 MHz
L1—56 μH
T1—14-volt secondary, center-tapped
J1—10-pin video camera jack
J2, J4–J6—PC-mount phono jack
J3—3/32 inch phone jack
S1—SPST PC-mount slide switch
S2—DPDT rocker switch, vertical PC mount

Miscellaneous: Lithium-battery holder and battery, 49-key keyboard, 16-conductor ribbon cable, enclosure, etc.

The following are available prepaid from Micro-Video-Technology, P.O. Box 76, Chattanooga, TN 37343: main PC board (silk screened, with gold fingers), $40; Programmed EPROM, $25; Custom keyboard (Cherry Electric), $80; Custom enclosure, $40; All switches, jacks, and connectors, $30; 14 VCT wall transformer, $30; TMS9128 VDP, $30; partial kit (includes all the above), $250. All orders add $5 ($13 outside U.S.) for shipping and handling.

The following is available from MFJ Enterprises, Inc., 921 Louisville Road, Starkville, MS 39759: Complete titler, assembled and tested with 1 year unconditional guarantee, $599.95 plus $6 shipping. (Return if not satisfied within 30 days for refund, less shipping.) Orders only (outside Mississippi) 1-800-647-1800. Information and Mississippi orders 601-323-5869. MasterCard and Visa accepted.

at a point that is one half horizontal line different from the previous frame.

In the meantime, the recreated VDP horizontal pulse is still tracking the external horizontal frequency. That would cause characters on the left of the screen to jump to the center and back to the left with each successive external vertical sync pulse!

In order to deal with that within the video titler, pseudo vertical serrations (inverted VDP horizontal sync pulses) were inserted into the vertical pulse used to reset the VDP. Those horizontal pulses are, in fact, the same recreated pulses used by the PLL. Figure 4 shows the signals used to synchronize the VDP with external horizontal and vertical timing elements.

As for the color synchronization of the titler, there are a number of chroma-processor integrated circuits designed specifically to generate a synchronous chroma subcarrier. The RCA CA3126 was selected primarily because of its sinewave output, which provides relatively easy interface with the video titler's chroma modulator, National's LM1889.

The last design area of the titler worth mentioning here is the requirement for matched signal amplitude and DC level. Fortunately the video signal amplitude of the VDP is very close to the external signal being used and the DC level adjustment is handled by a simple diode clamp.

The video titler circuit

Figure 5 is a block diagram of the video titler. The six main sections of the titler are: the external sync generator, clock generator, video display processor, chroma processor, video mixer/buffer, and microcomputer.

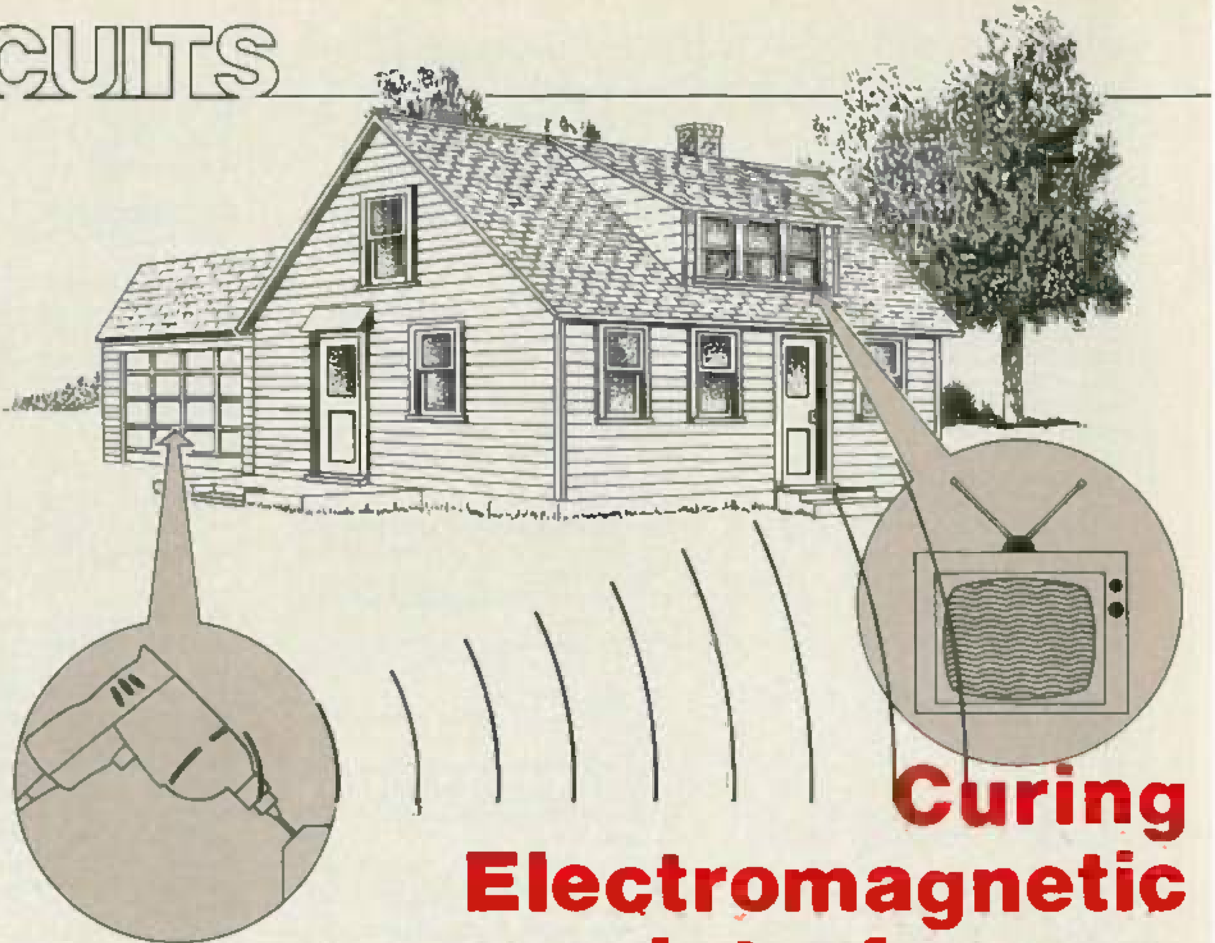
There is an additional section to the titler—the power supply—that isn't shown in the block diagram. Its schematic is, however, shown in Fig. 6. The power supply provides several separate DC voltages: +12, +5, +3, +1.5, +.7, and −5.

The power supply obtains the necessary positive and negative voltages from a wall-mounted transformer.

The −5 volts is obtained by applying the 14-volt AC signal through C57 and clamping the most positive peak at zero using D8. Diode D9 serves as a half wave rectifier whose output is filtered by C56 before going to the −5 volt regulator (IC26).

Two positive voltages of about +8.5 and 17 are regulated to provide +12 and +5-volt supplies. Simple 3 terminal voltage regulators with TO3 cases (IC24 and IC25) were selected because of their heat sinking capacity.

That's all the circuit we have room to talk about this month. When we continue, we'll discuss other features of the power supply, and we'll present the rest of the circuit, along with foil patterns and construction details. R-E



Curing Electromagnetic Interference

MICHAEL F. VIOLETTE

Learn all about the causes of electromagnetic interference, and what you can do to neutralize its effects.

EACH AND EVERY ONE OF US HAS EXPERIenced the effects of electromagnetic interference (EMI). For instance, that phenomenon is what causes static on your TV every time someone turns on another appliance. But EMI can have some far more serious consequences. For instance, the EMI generated by an electrostatic discharge ("shocks" caused by static electricity) can severely affect nearby computers. In dry weather, it is not uncommon for those mild shocks to cause a computer located on the other side of a fair sized room to "crash." The effects of EMI can even cause an otherwise sound device or circuit to fail to operate at all. And the effects of EMI can be dangerous, such as when the starting of a motor inadvertently triggers a nearby remotely controlled piece of industrial equipment.

The above mentioned effects of EMI, as well as many, many others are familiar to hobbyists, engineers, and users of electronic equipment. Sometimes EMI-caused problems have simple solutions. Such solutions might involve rerouting some wires or adding a bypass capacitor to a circuit. Other times, a less-than-severe problem is simply tolerated. More troublesome cases are cured only after extensive trial-and-error attempts and a lot of wasted time.

This article is an introduction to a few of the most common causes of EMI and some of the remedies that can be used to combat EMI's effects. Our goal is to achieve "electromagnetic compatibility" (EMC). Electronic circuits and systems are said to have achieved EMC when they can operate within the same electrical and physical environment without any one circuit or system causing problems for another.

Types of EMI

EMI can be loosely defined as an undesirable signal that affects the normal operation of equipment such that the equipment malfunctions, or the performance of the equipment is degraded in some manner. The phenomenon, its causes, and its cure have all become especially important as new technologies that use low voltage levels and high-density packaging have been developed. Such technologies are especially sensitive to EMI.

Just as electrical energy is moved from one place to another either by conduction (through wires) or radiation (through the atmosphere or space), EMI "reaches" its "victim" via radiation and/or conduction. For instance, consider the case of static on a television caused by someone using an electric hair dryer. If you look at the dryer motor while the dryer is in use, you can see electricity arcing between the motor's commutator and brushes. Those arcs are a source of both conducted and radiated broadband electric noise that can affect the normal operation of a TV set. By *broadband* we mean that the noise signal contains a wide variety of frequencies, including in most cases those that fall in the TV band (54–216 MHz VHF, 470–890 MHz UHF).

Figure 1 shows a situation that is found in millions of households—an electric

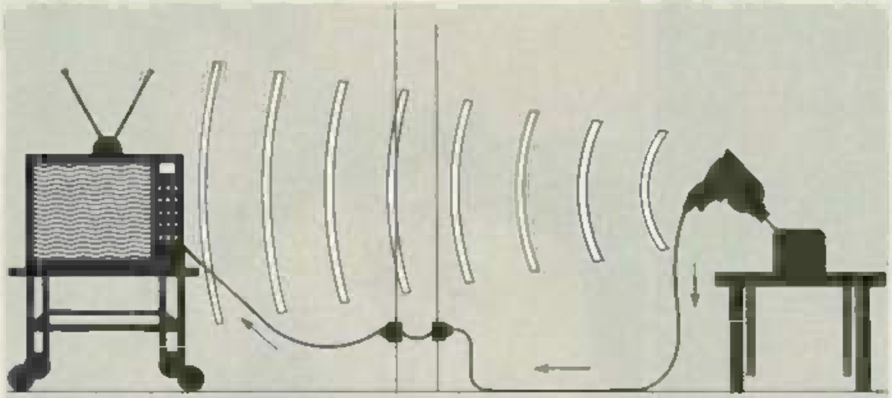


FIG. 1—A COMMON INTERFERENCE SITUATION. The electric drill generates EMI, which is coupled to the TV set via two separate paths.

drill in use in one room affecting the operation of a TV set in another. Note that though the drill and the TV set are physically separated, they are both fed from the same branch of the house's wiring. The signal generated by the arcing within the drill motor is conducted to the TV set via the line cords of the two devices and the house wiring. Once the signal reaches the TV set, it can be *coupled* into the set's circuitry (more on that in a moment) and processed as if it were a video signal. The result is displayed on the screen as static.

At the same time, the noise signal traveling through the line cord of the drill causes an electromagnetic field to form around that cord; that is, the line cord becomes a "transmitting antenna." The noise signal that is "broadcast" from that antenna can then be picked up by the TV antenna and processed like any other signal.

Table 1 lists some typical sources of EMI, both man-made and natural. That list is not intended to be exhaustive, but only to give you an idea of the variety of those sources. Table 2 is a brief list of the types of equipment that are subject to electromagnetic interference.

Also, it is possible that the source and victim of the interference is the same piece of equipment. That "self-jamming" occurs when there are several different systems within the same piece of equipment and one of those systems is interfering with another.

TABLE 1—SOURCES OF ELECTROMAGNETIC INTERFERENCE

Man-Made Sources
- RF transmitters
- Automotive Ignitions
- Electric motors
- Arc welders
- Computers
- Fluorescent lights
- Relays
- Neon signs
- High-voltage power lines
- Switches
- Dimmers

Natural Sources
- Electrostatic discharge
- Lightning

TABLE 2—VICTIMS OF ELECTROMAGNETIC INTERFERENCE

- Computers
- Medical equipment
- TV's
- Radios
- Electronic control equipment
- Ordinance (explosives, etc)
- Telephone equipment

Coupling paths

We've already seen that for EMI to occur there must be a path between the source and the victim. That path is called a coupling path. Usually, the task of locating the coupling path or paths responsible for the transmission of the EMI is the most difficult aspect of solving the problem. That is the case, because there may be a number of paths contributing to the problem. Often, the EMI may persist even though you have eliminated one or more paths. The only solution in those cases is to keep searching until all coupling paths are found.

A further complication that multiple coupling paths presents is that it makes it difficult to determine if eliminating a suspected path has actually done any good. If two or more paths contribute equally to the problem, eliminating only one path may provide little apparent improvement.

In order to discuss the various ways in which EMI can couple from one system to another, it is necessary to define a few terms.

When dealing with conducted interference, there are two varieties that we are concerned with. The first variety is *differential-mode interference*. That is an interference signal that appears between the input terminals of a circuit. The other variety of conducted interference is called *common-mode interference*. A common-mode interference signal appears between each input terminal and a third point; that third point is called the *common-mode reference*. That reference may be the equipment chassis, an earth ground, or some other point.

Let's look at those types of interference a little more closely. In Fig. 2-*a* we show a simple circuit consisting of a signal source, V_S, and a load, R_L. In Fig. 2-*b* we show what happens when differential-mode interference is introduced into the circuit by an outside source (more on that in a moment). As is shown, an interference voltage, V_D, appears between the two input terminals, an interference current, I_D, flows in the circuit. The result is noise at the load. If, for instance, the load is a logic gate in a computer, and the amplitude of V_D is sufficiently high, it is possible for the gate to incorrectly change states. It is possible that such an occurrence would alter the results of any computations being performed at the time—a rather undesirable situation.

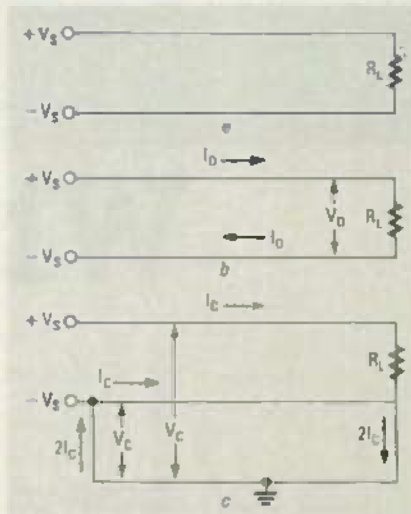
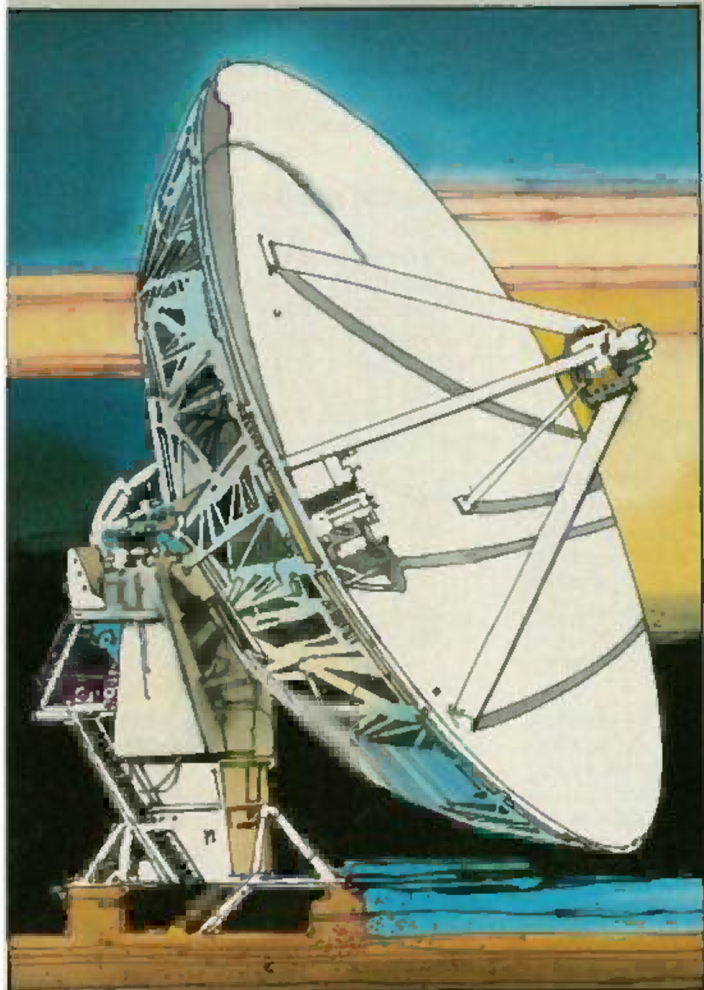


FIG. 2—TWO TYPES OF INTERFERENCE. In differential-mode interference (*b*) the noise voltage appears between the inputs of the circuit. In common mode interference (*c*) the noise voltage appears between each input and a third point called the common-mode reference.

Figure 2-*c* shows what happens when a *ground loop* is added to our circuit. Ground loops, which are undesirable current paths through a grounded body (such as a chassis), are usually caused by poor design or by the failure of a component. In the presence of an interference source, common-mode currents, I_C, and a common-mode voltage, V_C can appear, with the ground loop acting as the common-mode reference. The common-mode cur-



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rent flows on both input lines, and has the same instantaneous polarity and direction (the current and voltage are in phase), and returns through the common-mode reference. The common-mode voltage between each input and the common-mode reference is identical.

Coupling itself can take place in one of several ways. Some of those include field-to-cable coupling, cable-to-cable coupling, and common-impedance coupling. Let's look at those types of coupling one at a time.

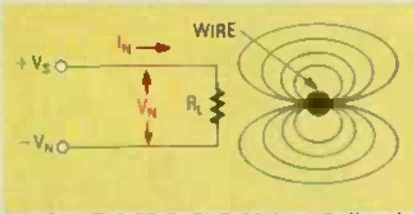


FIG. 3—FIELD-TO-CABLE COUPLING. If a circuit is placed within a time-varying electromagnetic field (such as that generated by a current carrying wire), the field will induce a current and voltage in that circuit.

The principle behind field-to-cable coupling is the same as that behind the receiving antenna. That is, when a conductor is placed in a time-varying electromagnetic field, a current is induced in that conductor. That is shown in Fig. 3. In that figure, we see a signal source, V_S, driving a load, R_L. Nearby there is a current carrying wire (or other conductor). Surrounding the wire is an electromagnetic field. The presence of the field causes the circuit to act as a loop antenna. As such, an interference current, I_N, and and interference voltage, V_N, are induced in the circuit. The magnitude of the induced interference signal is roughly proportional to the frequency of the incoming field, the size of the loop, and the total impedance of the loop.

Cable-to-cable coupling occurs when two wires or cables are run close to one another. Because any two conducting bodies have capacitance between them, called stray capacitance, a time-varying signal in one wire can couple via that capacitance into the other wire. That is referred to as capacitive coupling. Another mechanism of cable-to-cable coupling is mutual inductance. Any wire carrying a time-varying current will develop a magnetic field around it. If a second conductor is placed near enough to that wire, that magnetic field will induce a similar current in the second conductor. That type of coupling is called inductive coupling. In cable-to-cable coupling, either or both of those mechanisms may be responsible for the existance of an interference condition.

Figure 4 shows how cable-to-cable coupling works. Figure 4-*a* shows two lengths of cable (or other conductors) that are running side-by-side. Though there is no

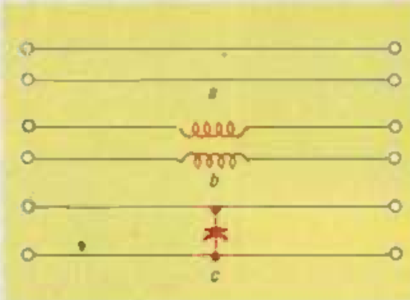


FIG. 4—CABLE-TO-CABLE COUPLING can occur via either inductive coupling (*b*) or capacitive coupling (*c*).

physical connection between the two cables, the properties we have just described make it possible for the signal on one cable to be coupled to the other. Mutual inductance, as shown in Fig. 4-*b*, makes the cables behave as if a poorly wound transformer were connected between them; stray capacitance, as shown in Fig. 4-*c* makes the two cables behave as if there were a coupling capacitor between them.

Either or both of the above-mentioned properties cause the cables to be electromagnetically coupled such that a time-varying signal present on one will cause a portion of that signal to appear on the other. The "efficiency" of the coupling

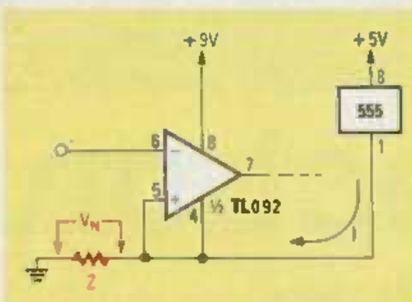


FIG. 5—BECAUSE THE GROUND return does not have an impedance of zero, the current from pin 1 of the 555 will cause a noise voltage to be generated. That voltage will appear in series with the input to the op-amp.

increases with frequency and inversely with the distance between the two cables. One example of cable-to-cable coupling is telephone "crosstalk," in which several phone conversations can be overheard at once. The term crosstalk is now commonly used to describe all types of cable-to-cable coupling. Sometimes it is also used to describe any type of induced interference, though such use is incorrect.

Common-mode impedance coupling occurs when two circuits share a common bus or wire. In Fig. 5 we show a circuit that is susceptible to that type of coupling. In that figure a TL092 op-amp and a 555 timer share a common return or ground. Since any conductor (including a PC-board trace) is not ideal, that ground will have a non-zero impedance, Z. Because of that, the current I from pin 1 of the 555 will cause a noise voltage, V_N, to develop; that voltage is equal to I × Z. That noise voltage will appear in series with the input to the op-amp. If that voltage is of sufficient amplitude, a noise condition will result.

Curing EMI problems

Electromagnetic interference problems can be cured in three ways: through filtering, shielding, and isolation.

Filters are used to eliminate conducted interference on cables and wires, and can be installed at either the source or the victim.

Figure 6 shows an AC power-line filter. The values of the components are not critical; as a guide, the capacitors can be between .01 and .001 µF, and the induc-

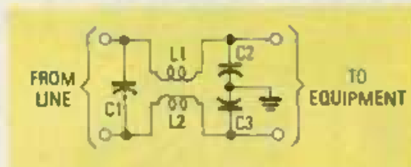


FIG. 6—THIS AC LINE FILTER is designed to eliminate both common-mode and differential mode interference currents.

tors are nominally 6.3 µH. Let's see how that filter does its job. Capacitor C1 is designed to shunt any high-frequency differential-mode currents before they can enter the equipment to be protected. Capacitors C2 and C3 are included to shunt any common-mode currents to ground. The inductors, L1 and L2, are called common-mode chokes, and are placed in the circuit to impede any common-mode currents.

Shielding is used to reduce the amount of electromagnetic radiation reaching a sensitive circuit. Shields are made of metal and work on the principle that electromagnetic fields are reflected and/or attenuated by a metal surface. Different types of shielding are needed for different types of fields. Thus, the type of metal used in the shield and the shield's construction must be considered carefully if the shield is to function properly. The ideal shield has no holes or voids, and, in order to accommodate cooling vents, buttons, lamps, and access panels, special meshes and "EMI-hardened" components are needed.

Isolation is often the cure for many EMI problems. In general, high-voltage circuits and devices such as power supplies and motors need to be isolated from low-voltage analog and digital circuits.

To be most effective, the above points should be considered during the design of a circuit. If nothing else, such consideration may help eliminate some difficult troubleshooting. In the next part of this article, we'll look at how you can design electromagnetic compatibility into your projects. R-E

Versatile Pulse Generator

This full-featured pulse generator is so easy to build that you have no excuse for not adding it to your workbench!

JOSEPH GIANELLI

PULSE GENERATORS ARE NOTORIOUSLY absent from many hobby-electronics test benches. That's not because hobbyists have no use for them. On the contrary: A pulse generator can be invaluable for testing, troubleshooting and experimenting with digital equipment. Unfortunately, commercial pulse generators are expensive.

We'll show you how to build a pulse generator that's not expensive; it should cost under $80 if you use all new parts. If you have some of the parts on hand, especially the switches and cabinet, you'll be able to build it for much less. The generator features a free-running, square-wave clock output that may be gated, and it also features a pulse output that may be derived directly from the clock circuit, from an external trigger, or from an internal delay generator. In addition, there is a one-shot output that delivers one pulse of the selected width for each depression of a front-panel switch. The polarity of all outputs is selectable by the user.

One special feature of our generator is the inclusion of a fault-detection circuit that lights a front-panel indicator whenever the delay or pulse width is greater than the selected clock rate; output will also be disabled. Reducing either the pulse width or the delay time will extinguish the indicator and restore output.

Our generator is built entirely from CMOS circuits, so power requirements are extremely modest. In fact, battery operation is entirely feasible. A nine-volt alkaline battery should provide about 150 hours of operation. Complete specifications for the pulse generator are given in Table 1.

Circuit description

Referring to Fig. 1, IC1 is a multivibrator used in the astable mode. Its oscillating frequency is determined by resistors R1 and R2, and one of capacitors C1–C5, as selected by the CLOCK RATE or CLK PRT (*P*ulse *R*epetition *T*ime) switch S3. With CLK MODE switch S1 in the FREE RUN position, output will appear continuously at jacks J4 and J5; however, with S1 in the GATED position, output will be inhibited whenever pin 5 of IC1 is brought low. To restore output, a gate signal with a voltage exceeding ½ V_{CC} should be applied; for the present circuit, a seven-volt gate signal will suffice.

Sync-generator IC5-a, half of a 4098 dual monostable multivibrator, is also triggered by IC1's Q output. When S2 is in the DIRECT position, the sync-generator's output is fed directly to pulse-width generator IC3-b. The width of the pulse generated by IC3-b is determined by resistors R5 and R6 in combination with C10 or C11, as selected by the PW switch S6. The width of the pulse may vary from approximately 1 μS to 100 μS. Note that IC1 determines the repetition rate of the pulse generator; IC3-b determines the width of those pulses.

When S2 is in the DELAYED position, the sync generator drives IC5-b, the delay generator, which in turn drives IC3-b. The delay generator uses the same resistor and capacitor values as the pulse generator, so the delay may also vary from approximately 1 μS to 100 μS.

When S2 is in the EXT. TRIGGER position, the clock and delay generators are disconnected from the pulse generator circuit. In that mode, a pulse of the selected width is generated on the leading edge of each pulse applied to J6, TRIGGER INPUT. As with the clock-gating signal, the trigger pulse should have an amplitude exceeding ½ V_{CC}, again seven volts. The sync generator is driven by clock generator IC1, so the sync pulses appearing at J1 will not be synchronized to the external trigger.

When S2 is in the ONE-SHOT position, the clock and delay generators are again disconnected from the pulse-generator circuit. In that mode, a pulse of the se-

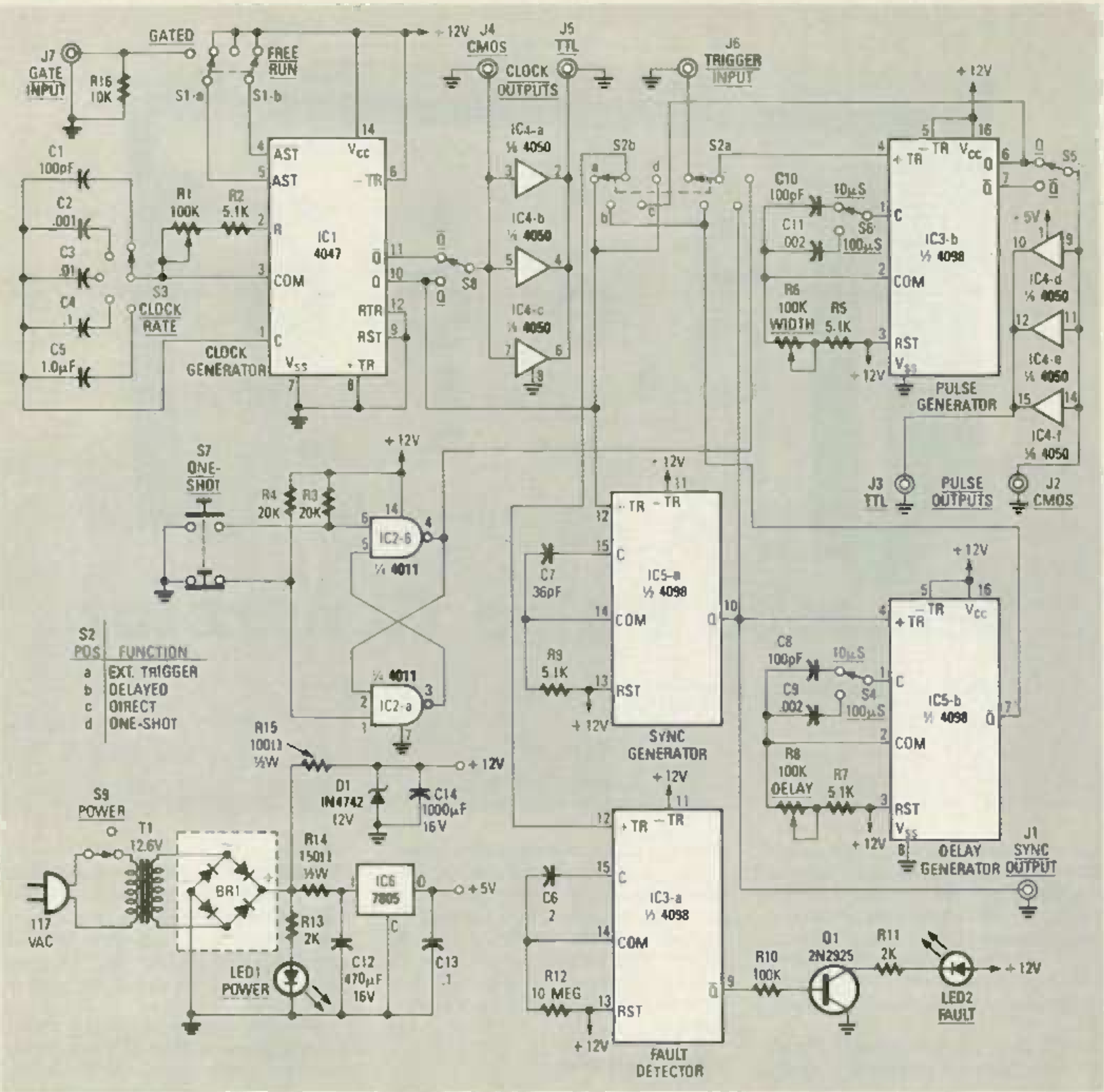


FIG. 1—SCHEMATIC DIAGRAM of the pulse generator. All CMOS components are used, making this a very-low-power device.

lected width is generated each time ONE-SHOT switch, S7, is depressed. Sync pulses are not synchronized to the one-shot output.

The clock output from IC1 and the pulse output from IC3-b are each fed through three 4050 non-inverting buffers wired in parallel. Doing that allows the pulse generator to drive six TTL loads. Separate jacks were used for the CMOS and TTL outputs in lieu of a switch in order to avoid accidentally overdriving TTL IC's with a high voltage. If you don't need to drive TTL circuits, IC4 may be eliminated, as well as the components associated with the five-volt power supply (R14, C12, C13 and IC6). On the other hand, if you work solely with five-volt circuits (TTL or CMOS), the twelve-volt power supply (R15, D1 and C14) could be eliminated, and the entire circuit powered from the five-volt supply.

Switch S2-b connects FAULT detector IC3-a to the output signal selected by S2-a. IC3-a operates in the re-triggerable mode so that, as long as it is receiving trigger pulses, its $\bar{Q}$ output will remain low, which will keep Q1, and hence LED2, turned off.

When S2 is in either the EXT. TRIGGER or the ONE-SHOT mode, IC3-a's TRIGGER input is connected to the Q output of the clock generator, IC1, so the fault detector will remain off. When S2 is in the DELAYED mode, the fault detector's input is connected to the output of the delay generator, IC5-b, and when S2 is in the DIRECT mode, the fault detector's input is connected to the output of the pulse generator, IC3-b. In either case, fault detector LED2 will remain off as long as the delay time, or the pulse width, respectively, does not exceed the clock period.

Two NAND gates in IC2 are set up as a latch to debounce switch S7, and provide dependable triggering in the one-shot mode.

Construction

The pulse generator may be built in any convenient manner, but a printed-circuit

TABLE 1—SPECIFICATIONS	
One Shot	1 TO 100 μs duration
Pulse Output	1 TO 100 μs duration (o and $\bar{o}$)
Pulse Delay	1 TO 100 μs duration
Ext. Trigger	Active on rising edge
Sync. Output	12 volts, 1 μs
Clock Output	2 μs to 400 ms squarewave (o and $\bar{o}$)
Gated Clock	variable burst
Outputs	TTL (5 Volt) AND CMOS (12 Volt)
Fault LED	Lights when pulse delay or width greater than pulse repetition rate.

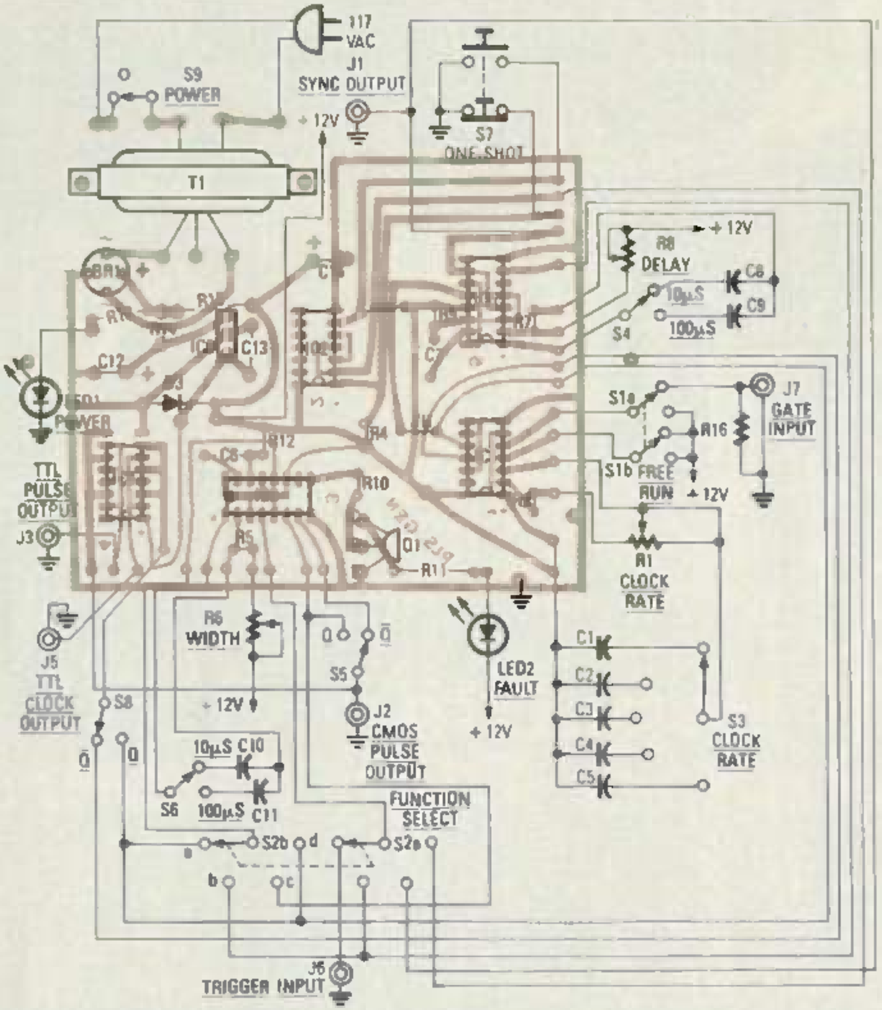


FIG. 2—COMPONENT-PLACEMENT DIAGRAM of the pulse generator. The lines going to +12 volts and ground actually go to a small terminal strip mounted on the front panel. Note that there is one jumper, to avoid using a double sided board.

board simplifies things considerably. Full-size PC artwork is shown in the "PC Service" section of this magazine. alternatively, you may purchase a pre-etched and drilled board; see the Parts List for information.

Whether you buy a PC board or make your own, inspect it carefully before mounting any components. If there are any shorted traces, *carefully* scrape between them with a sharp hobby knife.

When the board is up to snuff, you can start mounting components using the component-placement guide shown in Fig. 2. Mount components in a progression starting with those having the lowest profile: First mount the jumper, then add the resistors and diodes, then the IC sockets, and so on. After each group of a certain height has been inserted, turn the board over, making sure that the components remain flush, bend their leads slightly, then solder and clip those leads. After all components have been mounted, check the board carefully for solder bridges between adjacent pads and traces. Fix any problems that you find, but don't insert the IC's in their sockets yet. There's more wiring to do.

Now connect all the front-panel switches, potentiometers and BNC jacks to the PC board, as shown in Fig. 2, with short lengths of insulated wire. Note that timing capacitors C1–C5 and C8–C11 mount directly to their associated switches, not on the PC board. The timing capacitors should be mica, metal polyester, or other high-quality types. Resistor R16 similarly mounts on front panel jack J6.

PARTS LIST

All resistors ¼-watt, 5% unless otherwise noted

R1, R6, R8—100,000 ohms, linear potentiometer
R2, R5, R7, R9—5100 ohms
R3, R4—20,000 ohms
R10—100,000 ohms
R11, R13—2000 ohms
R12—10 megohms
R14—150 ohms, ½-watt
R15—100 ohms, ½-watt
R16—10,000 ohms

Capacitors

C1, C8, C10—100 pF, mica
C2—0.001, metalized polyester
C3—0.01 μF, metalized polyester
C4, C13—0.1 μF, metalized polyester
C5—1.0 μF, metalized polyester
C6—0.2 μF, metalized polyester
C7—36 pF, mica
C9, C11—0.002, metalized polyester
C12—470 μF, 16 volts, electrolytic, radial leads
C14—1000 μF, 16 volts, electrolytic, radial leads

Semiconductors

IC1—4047 multivibrator
IC2—4011 quad two-input NAND gate
IC3, IC5—4098 dual multivibrator
IC4—4050 noninverting hex buffer and TTL driver
IC6—7805 5 volt regulator
Q1—2N2925
BR1—bridge rectifier 50 volts, 1.5 amps
D1—IN4742 12V Zener
LED1, LED2—standard red LED

Other components

J1–J7—BNC female connectors
S1—DPDT, miniature toggle
S2—2 pole, 4 position miniature rotary
S3—1 pole, 5 position miniature rotary
S4–S6, S8—SPDT, miniature toggle
S7—SPDT, miniature momentary
S9—SPST, miniature toggle
T1—Transformer 12.6 volts, 0.12 amps, Radio Shack #273-1360

Note: An etched and drilled PC board is available from E²VSI, P.O. Box 72100, Roselle, IL 60172 for $ 11.95 postpaid.

Check over your wiring, and if everything looks OK, apply 117 volts AC power to the pulse generator, and turn on switch S9. With a voltmeter verify that the power-supply voltages are correct, and that +12 volts appears at pin 14 of IC1, and pin 16 of IC2, IC3 and IC5. Also make sure that +5 volts are present at pin 14 of IC4. If everything checks out, remove power and insert the IC's.

continued on page 113

Repairing Compact Disc Players

Compact disc players are the most exciting development in audio in years. In this article we'll show you how those devices work, and how you can repair them when something goes wrong.

JOHN D. LENK

COMPACT DISC (CD) SYSTEMS ARE SIMPLER than VCR's and videodisc players, but they are still complex devices that require topnotch troubleshooting skills if they are to be successfully serviced. But if you have had some experience troubleshooting and repairing video or audio equipment, there's no reason not to try your hand at CD servicing.

Servicing CD players is not difficult, if you follow the procedures outlined in the manuals. Unfortunately, most such manuals assume that you are familiar with how a CD player operates. Because of that, little in the way of theory or background is provided. That is a shortcoming that this article aims to eliminate. By the time we are done, you will know the basics of CD-player operation, and repair.

CD player basics.

In this article we will cover CD players designed to reproduce sound from digital compact discs (digital CD's). The compact disc itself is single-sided, 4.75 inches (120 mm) in diameter, and can be used to store about 60 minutes of program information (in stereo). Just as with phonograph records, the program information on a CD may be music, speech, or any other type of audio. But such discs are not to be confused with conventional analog LP records, or with the so-called "digital" LP's. While in the manufacturing of digital LP's PCM (*P*ulse *C*ode *M*odulation) is used to record the original performance (PCM is also the recording technique in CD), the signal that is put on the LP record and played back at home is analog. The CD's described here are not interchangeable (electrically or physically) with analog LP records, digital PCM records, or videodiscs (even though the operating principles of videodisc players are quite similar to those of CD players).

Let's see how a CD player works. Figure 1 is a block diagram of a typical CD player. First off, unlike a phonograph record, a CD is "played" from the underside. The pickup used is not the familiar me-

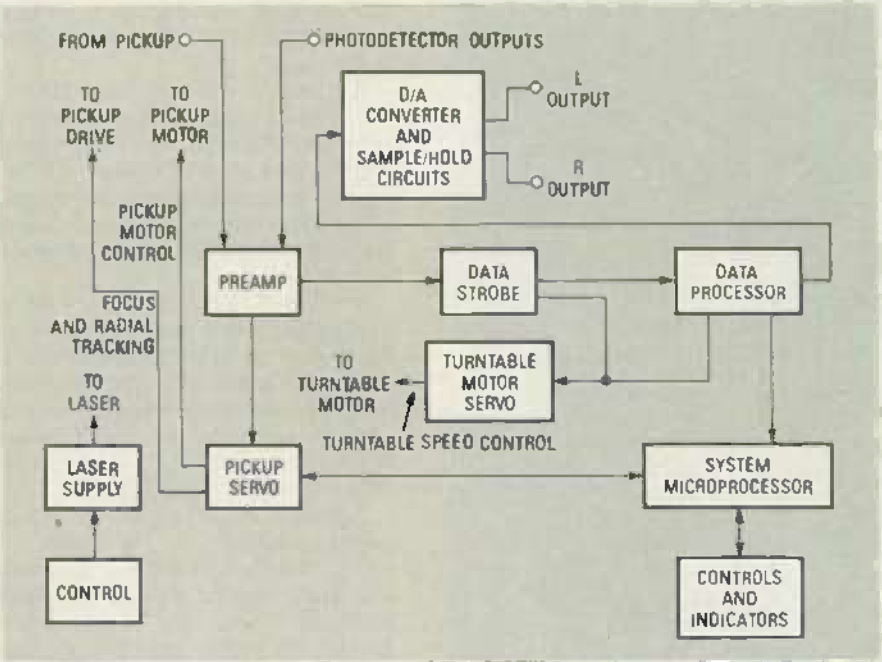


FIG. 1—BLOCK DIAGRAM of a typical CD player. The use of a microprocessor is what makes many convenience features possible.

chanical needle/stylus used in conventional phonographs, but rather an optical system that uses a light beam generated by a laser.

Another important difference is the manner in which information is recorded on a disc. The beginning of a CD "track" is near the center of the disc; as the program plays, the laser beam moves from the center of the disc to its outer edge. Also, rather than a groove, the information is recorded in the form of microscopic pits and flats. Those pits and flats are coded with music or other audio, as well as synchronization and identification information.

The light beam used in the CD optical pickup is focused on the CD surface by an objective lens. As the CD is played, the lens and beam are made to follow the track by a servo-operated pickup motor. The objective lens is part of a pickup assembly. There are two basic types of pickup assemblies, as shown in Fig. 2. In one, the optical system (including the objective lens) is mounted at the end of a rotating arm. The arm and lens are rotated (by the servo drive motor) so that the lens moves from disc center to edge. In the other configuration, the optical system is part of a slide assembly (also called the sled) that is motor driven.

While on the subject of motors, there is also a servo-operated turntable drive motor in all CD players (to spin the disc), and usually a loading motor (or possibly two) to insert and remove the disc from the player.

Although we have already pointed out that the method used in CD's to record information differs from that used in conventional phonograph records, perhaps we should point out the significance of that difference. Phonograph records store information in a continuous groove cut into the surface of the disc. The storage technique is analog: that is, the amplitude or depth of the groove is a direct representation of the audio signal. A conventional phonograph reproduces the audio signal via a mechanical pickup, called a needle or stylus, that detects the shape of the groove and is in direct physical contact with the surface of the disc.

On the other hand, the audio signals stored on a CD are in a high-density digital format. Further, a CD player's pickup never comes into physical contact with the disc surface. The first point means that the signal recorded on the disc is an extremely accurate representation of the original audio signal. The second point means that the problem of deteriorating sound quality over time, caused by the record wear that is unavoidable with a mechanical pick-up system, is eliminated. Also, mechanical pickup systems themselves introduce noise, such as clicks and pops, during playback; such noise is not generated by the CD playback system.

The laser beam is generated by a small low-power semiconductor diode made of aluminum-gallium-arsenide (AlGaAs). The laser beam is focused on the surface of the disc by the objective lens. That lens focuses the beam into a spot slightly less than 1 μm in diameter. Light is then reflected from the pits and flats back through the lens and optical system into infrared photodiodes. The signal from the photodiodes is used to reproduce the digitally-recorded information.

The groove on an LP record contains two signals—the stereo sum- and difference-signals—that must be simultaneously read and reproduced by conventional turntable pickup systems. The CD carries left and right channel information separately, but interlaces it on a single track. The nature of the information—that is, whether it is left or right channel, changes at fixed intervals. The player is programmed to keep step with those changes and thus maintains a high degree of isolation between the two audio channels. Realistically, channel separation of better than 90 dB is possible.

Signals are recorded in PCM form. During the recording process, the audio is sampled 44,100 times per second, (over twice the usual 20-kHz audio range). The composition (frequency, level, etc.) of each separate signal sample is then converted into a 16-bit (place) binary number. That process involves quantization. That is, the maximum signal amplitude is divided up into 2^{16} (65,536) gradations. The real level of the audio signal is then rounded to the nearest quantized value.

The use of the 16-bit system and the high sampling rate allows for an extremely accurate digital representation of the original analog signal. In theory, the dynamic range of the 16-bit system is almost 98 dB, although most CD manufacturers claim about a 90- to 95-dB dynamic range.

Figure 3-*a* shows a track of pits and flats. The length of the pits and flats determines the information contained on the track. The pits and flats can vary in length from about 1 to 3 μm. That variation in length is used to convey the information in the signal. Since the pits reflect less light than the flats, the CD player's optical pickup can differentiate between the two. Figure 3-*b* shows the analog signal that is recovered from the track shown in Fig. 3-*b*.

Optical pickup systems

Figure 4 shows the basic elements of the optical pickup (also called the optical readout) used by most slide-type CD players (the most popular type). The laser beam developed by the laser diode is applied to the reflective surface of the disc through an optical system (a series of lenses, prisms, gratings, and possibly mirrors). The beam is then reflected back through the optics to photodiode detectors (typically 6 diodes). The detector produces an output that corresponds to the audio stored on the disc, as well as tracking and focus signals.

In the system shown in Fig. 4 the disc spins in a horizontal plane. In many CD

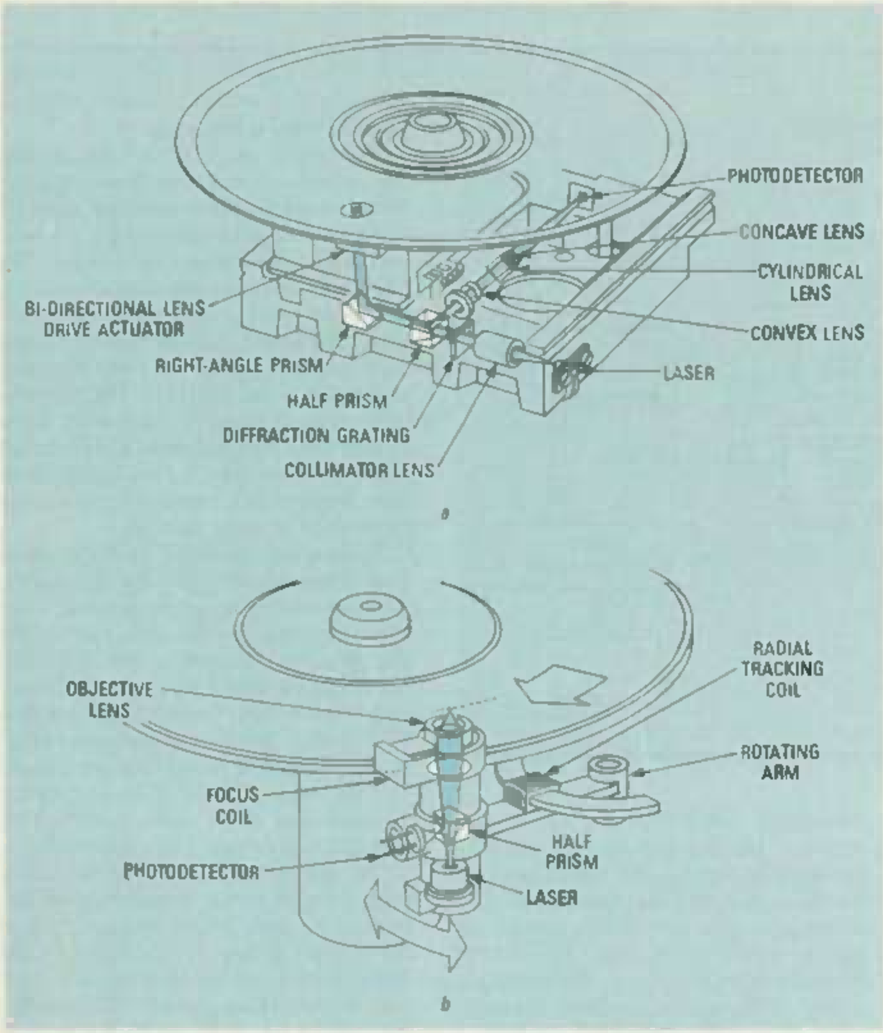


FIG. 2—CD PLAYER PICKUP SYSTEMS. Most CD players use either the slide (or sled) system shown in *a* or the rotating arm pickup shown in *b*.

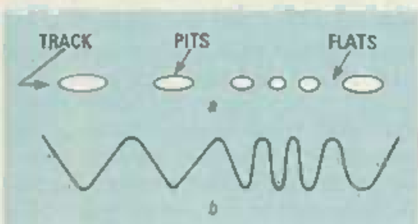


FIG. 3—THE LENGTHS OF the pits and flats (*a*) are used by the player to recover the original audio signal (*b*).

players. the disc spins vertically. Either way, it is essential that the laser beam follows the track of pits and flats as the optical pickup is drawn across the disc by the pickup motor, regardless of any possible disc eccentricity. That is called radial tracking, and usually involves a radial-tracking coil operated by a tracking servo to move the lens (and beam) as necessary.

The radial tracking system uses the 3-beam principle shown in Fig. 5. The 3-beam technique uses two sub-beams to detect tracking errors, and the main beam detects the audio signal. The sub-beams are produced by routing the laser beam through a glass diffraction grating, which creates several images on the same object. The two sub-beams are located ahead of and behind the main beam. After being reflected by the disc, each beam is routed through the optical system to corresponding photodetector diodes. The error signal from the two sub-beams is converted into an electrical signal, and then fed to an error-signal amplifier.

As long as disc tracking is precise, the error-signal amplifier output is zero. However, if even the slightest radial-tracking error is detected, the input differential between the two error signals (right and left) produces an output. That output is fed to the radial-tracking servo and coil; those move the objective lens (at right angles to the track) as necessary to correct the position of the main beam.

In rotating-arm systems, the radial tracking coil moves the entire arm and pickup as necessary to restore proper tracking. In most slide-type systems, the radial tracking coil moves the optical system (lenses, etc.) in relation to the remainder of the pickup assembly to restore tracking. A few players use a third system in which the tracking coil operates a rotary mirror placed between the laser and lens so that the beam is bent 90° when reflected by the mirror. The tracking signals cause the tracking coil to rotate the mirror (slightly) and direct the beam back to the track.

For service, it makes little difference which type of optical system is used since you must replace the entire pickup assembly as a package in the event of failure. Possible exceptions to that are the drive motor, drive belt, or a few gears. Optics are rarely replaceable, or even adjustable, in most CD players.

In addition to radial tracking, the optical pickup also provides for automatic focusing of the beam to compensate for vertical movement of the disc. The focusing system moves the objective lens (toward, or away from, the disc) if the laser beam is not focused precisely (within $\pm 1 \mu m$) on the pits and flats.

Automatic focus (or AF) uses the astigmatism principle. In the simplest of terms, the main laser beam is detected by four equally-spaced photodiodes, shown in Fig. 6. (Those same diodes also reproduce the audio signal.) If the main beam is properly focused, the beam spot is round, and all four diodes receive the same amount of light (and output signals of the same strength). If the beam is not properly focused, the beam spot is elliptical, and the four diodes receive different amounts of light (and produce different outputs). The outputs from the four diodes are summed by an error amplifier; the output of that amplifier is the focus error. That error (if any) is fed to a focus coil or actuator that moves the objective lens as necessary to correct the focus.

Signal processing

The block diagram of Fig. 1 shows the sequence of signal processing within a typical CD. We will discuss each of those circuits later in this series. For now, let's quickly run through the sequence.

The photodiode output is very low, so it is first fed to a pre-amp where it is amplified. From there it is fed to a data strobe circuit that is used to differentiate between the logic-highs and logic-lows in the signal. The data strobe also extracts and separates the sync signals from the music and other audio. (Those sync signals are encoded along with the music at the time of disc manufacture; they make it possible for the CD player to reproduce audio at selected points on the disc track.)

The next stage is the data processor. That stage has many functions, including demodulation of the signal data, error detection and correction, and overall control of the signal processing circuit.

All CD player circuits include some provision for interleaving of signal data. When a CD is recorded, the music or other audio is interleaved before recording on the disc to provide error correction.

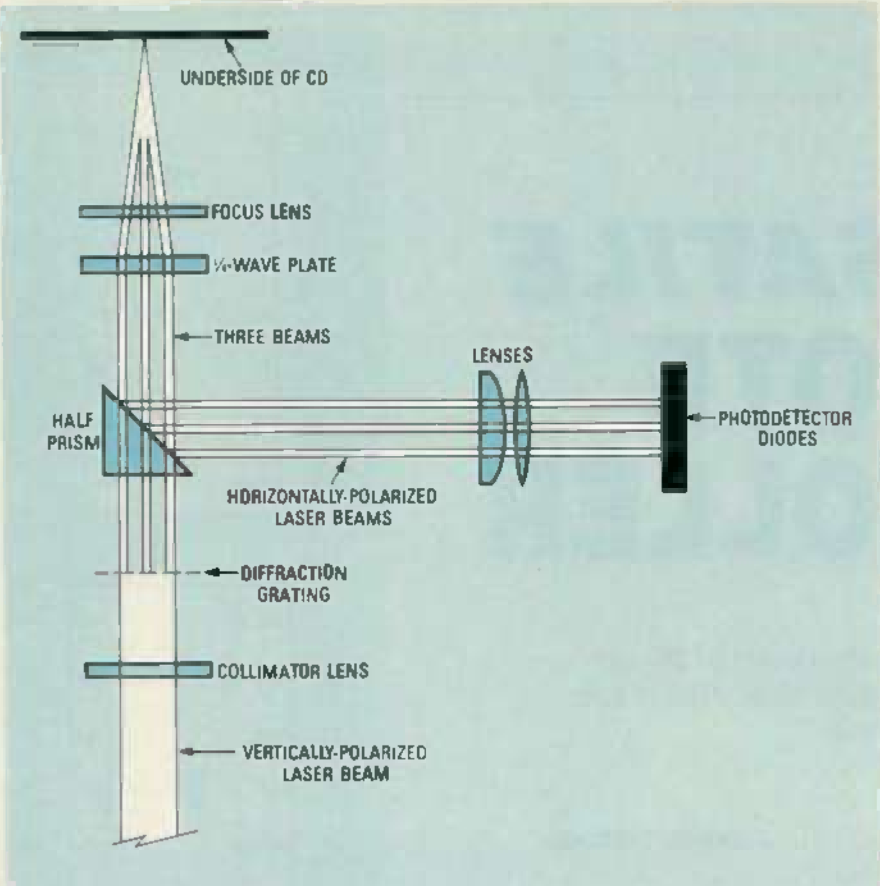


FIG. 4—BASIC ELEMENTS of a CD optical pickup system. In the system shown here the disc spins in a horizontal plane.

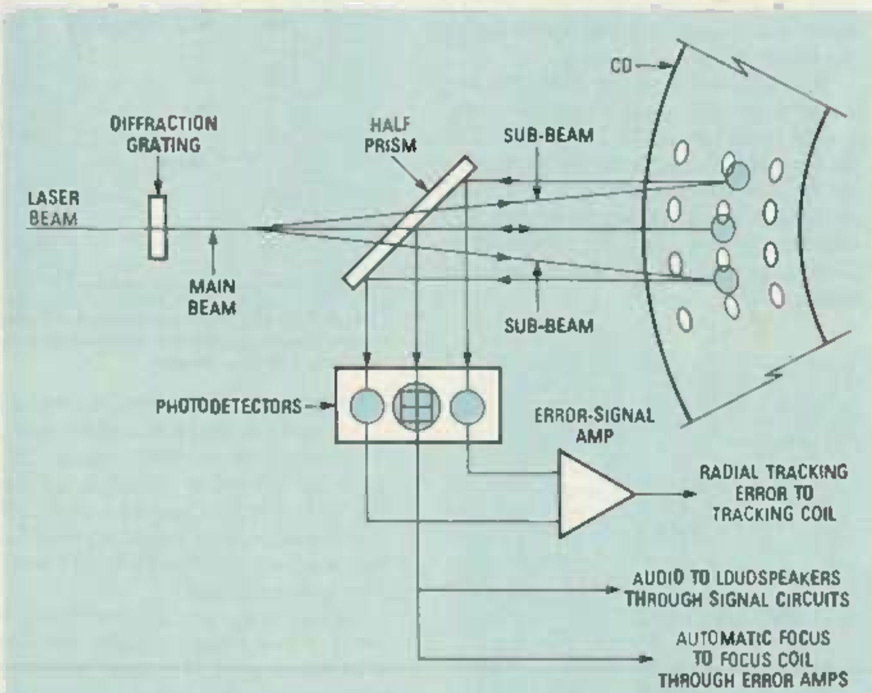


FIG. 5—A DIFFRACTION GRATING splits two sub-beams from the main laser beam. The sub-beams are used to make sure that the player is tracking properly.

The error correction method is called CIRC or *C*ross *I*nterleaved *R*eed-Solomon *C*ode, and involves both parity bits and interleaving. We will not go into CIRC here since that topic is beyond the scope of this article. But you must have some knowledge of interleaving to understand how a CD player works.

In the most basic of terms, interleaving involves dividing the audio to be recorded into a series of random sections, and then lining the sections in a new, fixed, order before recording. During playback, the

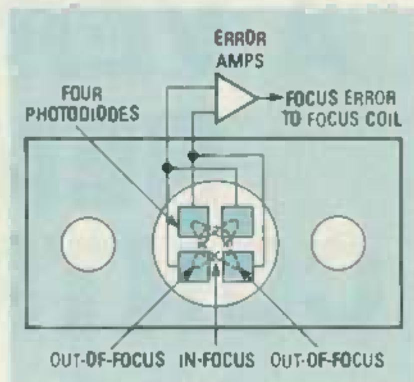


FIG. 6—FOUR PHOTODIODES are used to make sure that the beam is correctly focused.

sections are rearranged by the opposite process to recreate the original music or other signal. The playback arrangement processing is done by temporarily storing the data in RAM and then retrieving the data in the original order.

With interleaving, the effects of dropouts in the audio (from any cause) are greatly minimized. That is true if even a relatively large part of the signal is lost. That's because such a loss is distributed over various smaller gaps in the recreated, final, audio signal. It is a relatively simple task for the digital signal-processing circuitry to "fill in" a small section of missing information when the data on either side of the gap is present.

The D/A converter follows the signal-processing circuits. The D/A converter transforms the digital signal back into an analog signal. The converted analog signal is then restored to pure two-channel audio by a sample-and-hold (S/H) circuit, and applied to the left and right stereo outputs.

Before we move on, let's look a little more closely at the D/A converter. Earlier we mentioned that the original audio is converted to 16-bit digital form for recording on a CD. Such discs, however, can be played back with almost no loss in dynamic range on players that use 14-bit D/A converters. The advantage of the use of such a converter, as opposed to a 16-bit converter, is cost. Thus you will find that many consumer CD players make use of 14-bit D/A converters.

Before one attempts to repair a CD player, it would be helpful to know how that player is supposed to operate in the first place. In the next part of this article we'll see how the various features and functions found on a typical CD player normally operate. R-E

A VERSATILE REMOTE CONTROLLER

Adding remote control to any circuit or device is not as hard as you might think. This article shows you how its done.

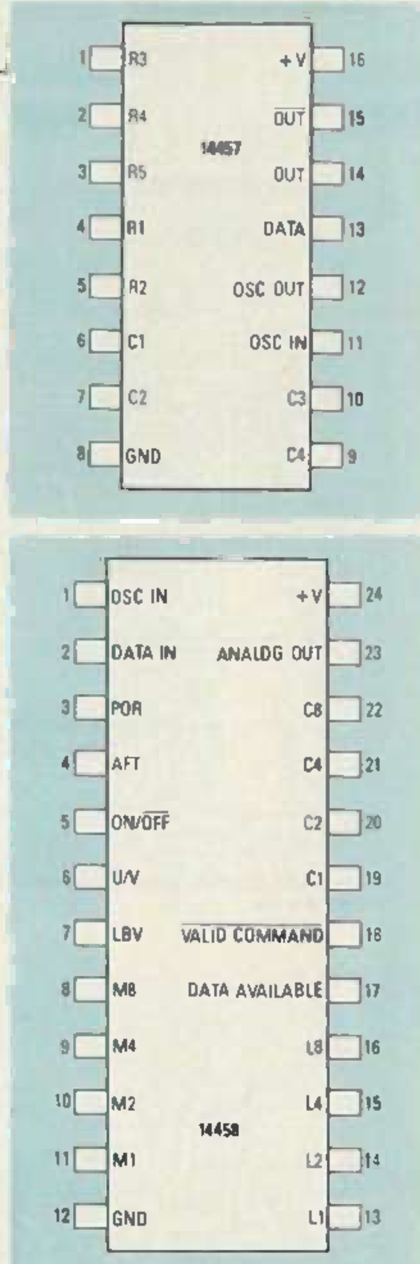
J. DANIEL GIFFORD

Part 2

LAST TIME WE BEGAN to look at the receiver half of our remote-control system. Let's continue that discussion now.

The output from either the ultrasonic or infrared pickup must be amplified before being input to the 14458. One suitable amplifier design is shown in Fig. 10. That circuit takes the signal from either type of pickup, amplifies and conditions it, and clips its amplitude between 0 and 5 volts, producing at its output an exact duplicate of the signal applied to the transmitting LED's or transducer. Other amplifier designs could be used, as long as they have a high-impedance input and extremely high gain. However, the amplifier in Fig. 10 meets that requirement and uses some of the inverters already available.

As discussed earlier, the 14458 has two output ports, one eight-bit port for data, and one four-bit port for commands. The data port is actually two four-bit ports, one for the *M*ost *S*ignificant *D*igit (MSD) and composed of the outputs M1 through M8, and one for the *L*east *S*ignificant *D*igit (LSD), composed of the outputs L1 through L8.



THESE TWO IC's form the heart of a versatile remote control system that can be added to almost any circuit or device.

When data is transmitted, the first digit sent is routed to the MSD outputs, and the second digit to the LSD outputs. Both digits are latched in simultaneously and followed, after a 0.1 second delay, by a 0.8 millisecond positive pulse on pin 17 (DA). The data and the DA pulse may be used in any manner necessary.

Without any special connections, the 14458 is configured to receive two digits as a full data word. If desired, the receiver can be converted to accept a single digit as a full data word by connecting pin 9 (M4) to +V and pin 6 (U/V) to ground. In single-digit mode, the first data digit transmitted will be latched into the LSD outputs and followed by the DA pulse.

The command transmission situation is

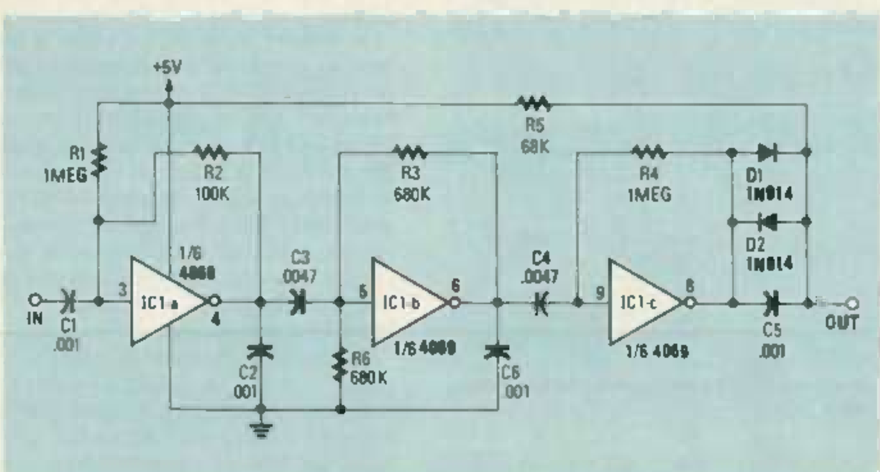


FIG. 10—THIS INPUT AMPLIFIER is ideal for use with the receiver. It can accept the output from either the infrared or ultrasonic pickup.

Ordering Information

The following are available from Circuit Specialists, PO Box 3047, Scottsdale, AZ 85257: 14457/14458 transmitter/receiver pair, $17.00 postpaid; 455-kHz ceramic resonator (Mallory CU455), $8.50 each, postpaid.

Also, the following are available from Dick Smith Electronics, PO Box 8021, Redwood City, CA 94063; telephone number 800-332-5373: Photodiode (catalog number Z-1950), $.60 plus shipping and handling; a matched pair (receive/transmit) of ultrasonic transducers (catalog numbers L-7050 and L-7052), $2.95 each plus shipping and handling. Note that this supplier requires a $10.00 minimum order.

somewhat more involved. If the function bit in the data stream is a 1, the four-bit code is identified as a command, and is routed to the command port. Once the digit is latched into the port, there is a 0.1-second delay and then a negative 0.8-millisecond pulse appears on the $\overline{\text{VC}}$ output, pin 18. All 16 commands and the $\overline{\text{VC}}$ pulse may be used as necessary; however, four of the commands are also internally decoded by the 14458 to control two specialized outputs.

When the key corresponding to command 09 or OFF is pressed, pin 5 on the 14458, ON/OFF, is driven low. That pin is also set low when the IC is powered up, and is driven high when any data word is transmitted. If the 14458's power supply remains uninterrupted, that pin can be used to turn the controlled device on and off. When the ON/OFF pin goes low or off, the rest of the 14458 goes into a standby mode, with commands being ignored until a data word is transmitted.

The other three commands decoded by the 14458 all control one output, pin 23, ANALOG OUT. That output provides a variable voltage between 0 and 5, with a total of 64 steps between the two extremes. When the 14458 is powered up, the voltage is at 0. When the ANALOG UP KEY (command 07) is pressed, the voltage at the ANALOG OUT pin begins to step upwards at a rate of 10 steps per second, until the key is released or until the maximum of 5 volts is reached. The ANALOG DOWN key (command 06) operates in the opposite manner, stepping the voltage at the ANALOG OUT pin down at a rate of 10 steps/second until either the key is released or 0 volts is reached.

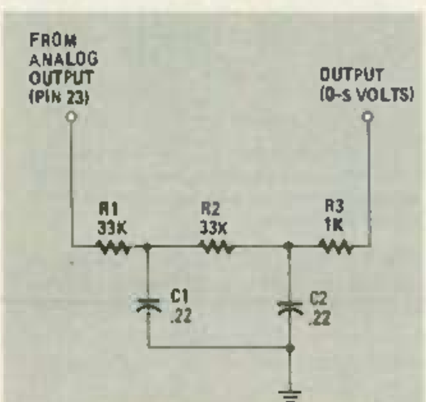


FIG. 11—THE LOW-PASS FILTER used to obtain a smooth DC signal from the ANALOG OUT output. An active filter and/or voltage follower can also be used.

The MUTE key (command 08) when pressed once forces the ANALOG OUT voltage to 0, and when pressed again, returns it to its previous level. The ANALOG UP key will also return the voltage to its previous level and, if held down, continue to increase it.

The ANALOG OUT signal is pulse-width-modulated, and must be passed through a low-pass filter (Fig. 11) in order to obtain a smooth DC signal. If more than a few milliamps of output current are needed, an op-amp voltage follower should be added. The ANALOG OUT signal is intended to control a TV's volume, but can be used for any purpose.

There are two basic types of commands, toggle and continuous. The only difference between the two is that with the toggle type, the command is only sent once (with one $\overline{\text{VC}}$ pulse) no matter how long the key is held down, while with the continuous type, the command is retransmitted (each time with a $\overline{\text{VC}}$ pulse) every 0.1 seconds as long as the key is depressed. OFF and MUTE are examples of toggle-type commands; ANALOG UP and ANALOG DOWN are continuous types. There are twelve uncommitted commands, two of which are toggle-type and ten of which are continuous.

The 14458 also has three specialized outputs intended for TV control that are probably of little use otherwise. All three are controlled by the data sent to the data port.

Pins 6 (U/V) and 7 (LBV) are used to switch between tuners and bands in a TV set. When the data at the data port is between 14 and 83, the U/V pin will be high; it is low otherwise. If the data is between 02 and 06, the LBV will be low; it is high otherwise. When the data is between 7 and 13, both pins will be low.

The third specialized TV output is different in that it may have other uses. Pin 4 (AFT) is used to disable a TV's automatic fine tuning circuit briefly each time the channel is changed. Each time new data is entered into the data port, that output will

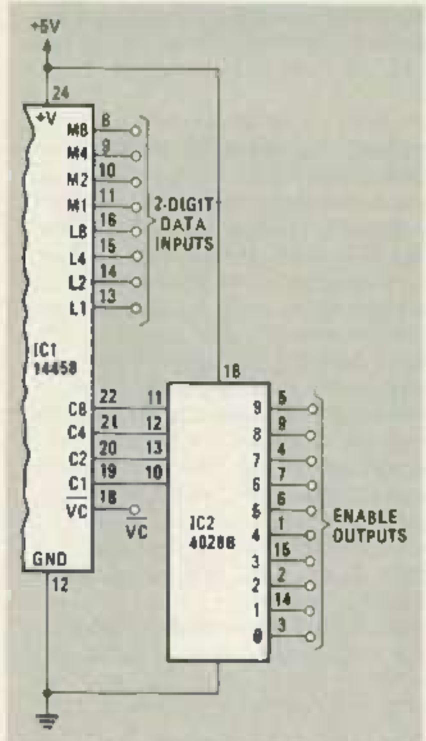


FIG. 12—THE OUTPUTS and decoding scheme for the receiver used in the 20- and 26-key systems. Each enable output is used to activate one output device.

drop low for 0.4 seconds. That could be used as an alternate to the DA pulse, or as a countering or resetting signal to it. The only problem is that four other commands (00, TOGGLE 1; 01, TOGGLE 2; 02, CONT 1; 03, CONT 2) also cause that pin to drop low, which could interfere with such reset functions.

Decoding and Interfacing

The most difficult part of using a remote-control system built with the 14457 and 14458 is interfacing the receiver to the system under control. Since the idea here is not to tell you how to build a specific sort of remote-controlled device, we will not discuss specific sorts of interfacing. Instead, let's look at a universal system that can be used to decode the 14458's commands to control functions remotely. It is up to you to provide the final link between these decoders and the device you want to control.

If the 10-key transmitter is used, no decoding is needed as none of the commands are accessible. The only step necessary would be to interface the data port (either one or two digits) to the security system or other device. Note that although no direct OFF control is possible with that configuration, the OFF output can be driven high by transmitting any data word. The OFF output (and the 14458) could be reset by the controlled device by pulsing the POR input low.

With the 20- or 26- key transmitter, ten commands are available and must be decoded by external circuitry. Since the command codes fit the ten BCD digits (0000-1001), a 4028B BCD-to-10 line decoder can be used to generate ten separate enable lines, one for each command (Fig. 12).

Basically, what that decoding scheme does is use the appropriate enable line to enable or activate the interface circuit associated with the command, and then uses the VC pulse or pulses to clock the circuit. If the 32-key transmitter is used, there are 16 commands, so a 4514B hex-to-16 line decoder must be used to generate the required number of enable lines (Fig. 13). Table 2 shows the relationship of the commands to their respective enable lines.

With that basic approach, an interface circuit can be devised to interface the enable and VC lines to control the proper function on the controlled device. If necessary, more than one enable line can be used to control different aspects of one output device. Let's look at four basic interface circuit types.

The simplest type is used to generate a pulse output when it is selected and clocked by the VC pulse (Fig. 14). Two 4001B NOR gates are used, one to invert

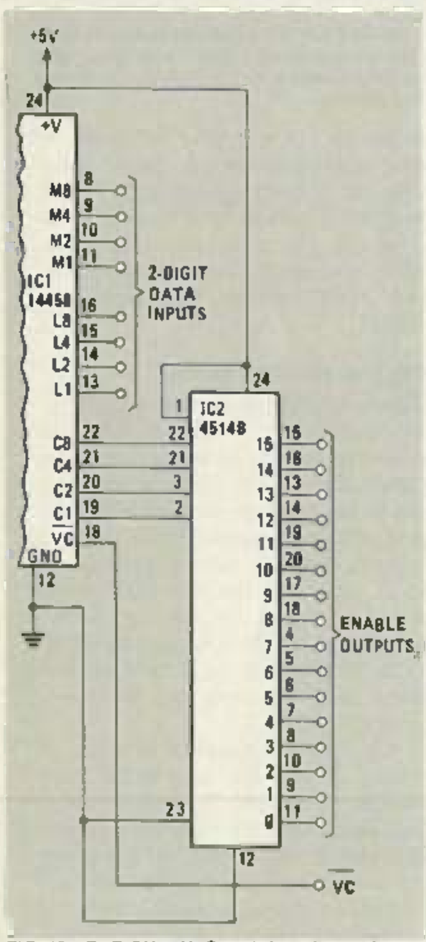


FIG. 13—THE OUTPUTS and decoding scheme for the 32 key system.

TABLE 2—ENABLE DECODER OUTPUTS

Output	Command
00	TOGGLE 1
01	TOGGLE 2
02	CONT 1
03	CONT 2
04	CONT 3
05	CONT 4
06	ANALOG DOWN*
07	ANALOG UP*
08	MUTE*
09	OFF*
10	CONT 5
11	CONT 6
12	CONT 7
13	CONT 8
14	CONT 9
15	CONT 10

*also internally decoded by the 4458

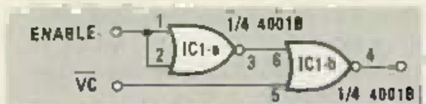


FIG. 14—THIS INTERFACE CIRCUIT outputs a pulse that can be used to control a device.

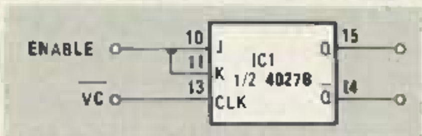


FIG. 15—THE ONE-BUTTON alternate-action interface circuit.

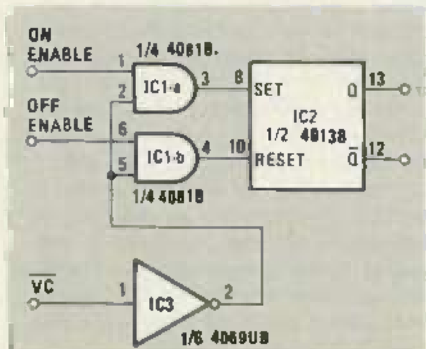


FIG. 16—THE TWO-BUTTON alternate-action interface circuit. Either a 4013B or 4027B type flip-flop may be used.

the enable line signal, and the other to act as a gate that will pass the VC pulse (in inverted form) when the correct enable line is high. The pulse will be an exact mirror of the VC pulse, 0.8 milliseconds wide, and positive in polarity. A third OR gate could be added to re-invert the pulse's polarity, and if a longer pulse width is desired, a 4528B monostable or 555 timer can be added to the output.

The basic on-off type of control is a one-button alternate-action decoder (Fig. 15). A 4027B JK flip-flop has its J and K inputs tied together and to the correct enable line, and its CLK input tied to the VC pin. If the enable line is low, a pulse on the VC pin will have no effect on its outputs. If the enable line is high, the pulse will cause the outputs to change states. That type of output device should be used with a toggle-type command to keep it from changing states more than once per key press.

A more positive such control is a two-button alternate-action decoder (Fig. 16). Either a 4013B or a 4027B flip-flop may be used in that circuit, since only the SET and RESET inputs of either are used. One enable line is used, via a 4081B AND gate, to allow the VC pulse to reach the SET input and drive the Q output high (and the Q output low, of course); another enable line and AND gate are used to similarly allow the VC pulse to reach the RESET input and drive the Q output low. Note that the VC signal is inverted in that circuit. The advantage of the two-button control is that it is impossible to mis-set the flip-flop if the correct button is pressed. Repeated pressing of a button or (in the case of a continuous command) repeated VC pulses will have no effect on the output; only pressing the opposite button will alternate the outputs.

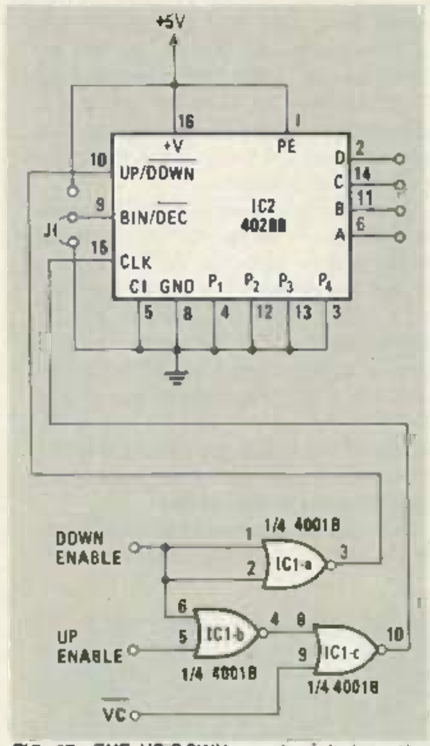


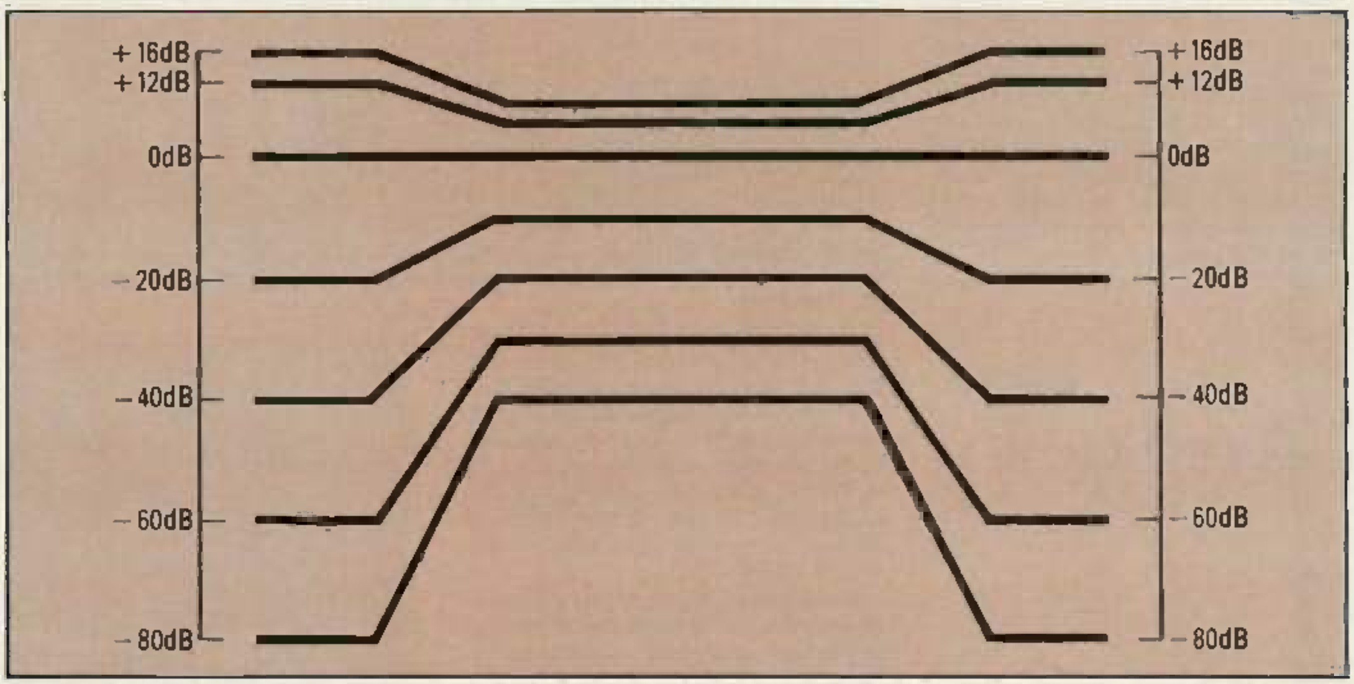
FIG. 17—THE UP/DOWN counter interface circuit. The 4029B can be set to count in either BCD or binary format, or can be replaced by a 4510B/4516B counter.

The last and most complex decoder is an up/down counter controlled by two enable lines (Fig. 17). One is used to activate the counter in the up-counting mode; the other is used to activate the counter in the down-counting mode. In both cases, the VC pulse is used to clock the counter in the desired direction.

(Continued on page 113)

ALL ABOUT

Audio Companding



You can build a professional-quality compander for your hi-fi system using circuits designed around Signetics' NE570 compander IC.

TOM PASK

IF YOU'RE LOOKING FOR WAYS TO IMPROVE your hi-fi system, don't overlook companders. They can be used to reduce noise from your tape recordings and to bring back the dynamic range that is lost when recording and broadcast engineers compress their audio signals. Companders also are used in cordless telephones, speaker-phones, and wireless microphones, and as signal-level controllers in electronic organs, MODEM's, and mobile telephone equipment.

In this article we will explain the fundamental theory of companders, discuss basic applications, and we'll also present a circuit, complete with PC-board patterns, that you can use to experiment with the Signetics NE570 family of IC companders.

Basic compander theory

The compander is a versatile, low-cost, dual-channel gain-control device primarily used for audio noise reduction. The word compander is actually a contraction of the two words *COM*pressor and ex*PANDER*, and they indicate the compander's complementary tasks: compressing and expanding the level of an audio signal, which could be music, speech, or tone-encoded computer data. Signals are compressed before transmitting or recording so that all components of the signal are above the inherent noise level of the transmitting or recording medium, but below the saturation level of that medium. Signals then undergo complementary expansion at the receiving, or playback device to restore their natural dynamic range, and to improve the ratio of the signal to the noise that entered in the transmitting or recording medium.

For example, assume we have a 1000-Hz signal at a level of 2.5 volts P-P combined with a 6000-Hz signal at a level of 1.0 volt P-P. (See Fig. 1-*a*.) On an oscilloscope the 6000-Hz signal would seem to "ride" the 1000-Hz signal, but for clarity, we have shown them separately. The 0.5 volt P-P high-frequency noise signal is not part of the original signal; it's noise that's introduced in the recording or transmission medium: tape hiss, for example.

In Fig. 1-*b* we see what happens when an across-the-board gain of three is applied to those signals. The level of the 6000-Hz signal is greatly increased with respect to the noise signal, but the 1000 Hz signal is clipped, due to the 6-volt P-P dynamic range of our example transmission channel.

That is clearly unacceptable, and Fig. 1-*c* shows the remedy. There the 1000-Hz signal is left as is, and the 6000-Hz signal is amplified by a factor of two. Now the signal-to-noise ratio of both input signals has been increased with no clipping. That is the essence of *compression*.

By contrast, *expansion* restores all components of a signal to their original levels. Feeding the signal represented in Fig. 1-*c* through an expander complementary to the compressor that produced that signal would result in the original signal shown in Fig. 1-*a*. The result is a clean, undistorted signal with a high signal-to-noise ratio and a dynamic range like that of the original signal.

Compander components

The basic compander consists of a current-controlled variable-gain cell (Δ-G), a full-wave averaging rectifier and voltage-to-current converter, (hereafter referred to as the rectifier), and an operational amplifier. The block diagram of the NE570, NE571 and SA571 is shown in Fig. 2-*a*; that of the NE572 is shown in Fig. 2-*b*. Note that although the figure shows only one channel for each type of device, the IC's contain two identical, independent channels.

The NE570 and NE571 have quite similar operating characteristics, but those of the NE570 are somewhat better than those of the NE571, and include wider supply range, lower distortion, lower DC output shift, etc. The SA571 has the same electrical characteristics as the NE571, but operates over a different temperature range. The NE570/1 devices differ from the NE572 in that the latter has an additional buffer inserted between the rectifier and the Δ-G cell that allows separate programming of attack and delay times, which cannot be set independently with the NE570/1 devices.

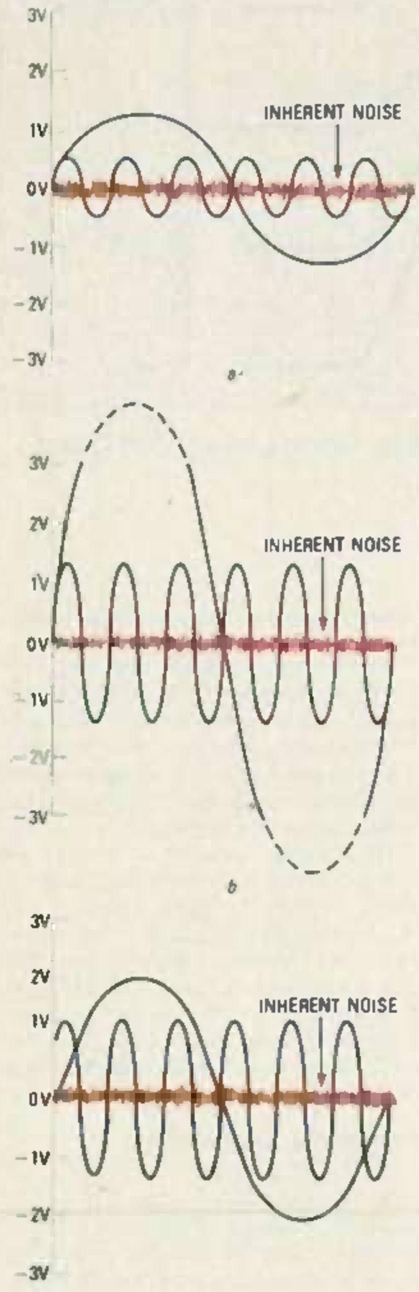


FIG. 1—BASIC COMPANDER ACTION is compared with straight amplification. The input signal (a) is amplified by a factor of three (b) and companded by a factor of two (c).

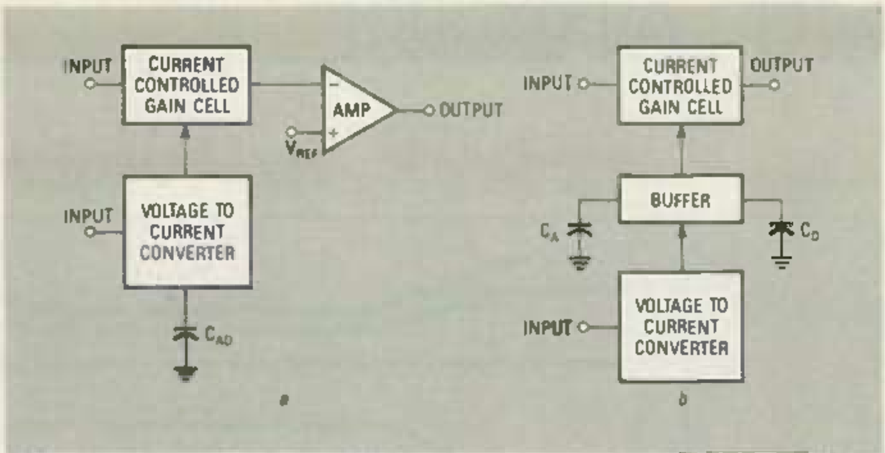


FIG. 2—SIGNETICS' NE570, NE571 and SA571 are shown in *a*, and the NE572 is shown in *b*. The latter has no output buffer, but allows attack and delay times to be set independently by capacitors C_A and C_D, respectively.

However, that buffer leaves no space on the chip for an output op-amp, so circuits requiring additional drive capability will need an additional outboard op-amp. If high fidelity audio or separately programmable attack and decay times are needed, the NE572 should be used with an external low-noise op-amp like the NE5534. We will restrict our discussion to the NE570/1 devices.

The functional blocks mentioned above are assembled in different ways according to whether we need the compression or the expansion function. But in either case, an operational amplifier provides the main signal path and output drive, and the rectifier converts the AC input voltage into a DC current that controls the gain of the op-amp.

Compressor theory

As shown in Fig. 3-*a*, the compressor may be thought of as an op-amp with a variable feedback resistor, R_F. When the input signal increases above a preset crossover level (0 dB), R_F decreases in value, and that causes the gain to decrease. As the input signal decreases below the crossover level, R_F increases in value, and that causes the gain to increase. In fact, as shown in Fig. 3-*b*; the Δ-G cell and rectifier are simply placed in the feedback loop of a standard inverting op-amp circuit and take the place of R_F. The equation for voltage gain in such a circuit is

$$A_V = -R_F/R_{IN}$$

Referring again to Fig. 3-*b*, the compressor's gain is described by this equation:

$$A_V = \sqrt{\frac{R_1 R_2 I_B}{2R_{IN}V_{IN(avg)}}}$$

Resistors R1 and R2 are internal to the compander IC, and have values of 10K and 20K, respectively. The bias current I_B must be limited to 140μA, and V_{IN} (avg) equals 0.9 × V_{IN} (rms).

Sample compressor application

Since the compressor is a feedback controlled system, its stability must be maintained for all input conditions. You must bias the DC level of the output pins at approximately half the supply voltage. If that isn't done, the positive or negative peaks may be clipped, causing distortion. To allow for maximum voltage swing, the op-amp is biased by resistors R_{DC} and R4 as shown in Fig. 4. The equation describing the output bias level is:

$$V_{OUT}(DC) = V_{REF}(1 + 2R_{DC}/R4)$$

V_{REF} is biased internally to a level of +1.8 volts.

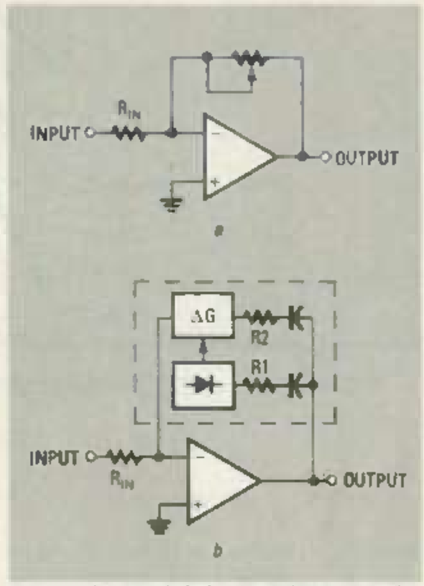


FIG. 3—THE BASIC COMPRESSOR may be thought of as an op-amp with a variable feedback resistor. The components in the dashed box (*b*) correspond to R_F in (*a*).

Note that the value of C_{DC} must to be large enough to shunt any AC flowing through that point to ground. Capacitors C_{F1} and C_{F2}, which should have fairly large values, are used in the Δ-G and rectifier circuits to prevent DC bias currents from flowing between those circuits. The input capacitor, C_{IN}, is also used for AC coupling; it preserves the DC bias on the op-amp.

You must plan for the maximum output

PARTS LIST

All resistors ¼-watt, 5%
R1—33,000 ohms
R2—36,000 ohms
R3—12,000 ohms
Capacitors
C1, C4, C5, C7, C8—2.2 µF, 25 volts, tantalum
C2, C6, C12, C13—10 µF, 35 volts, tantalum
C3, C11—200 pF
C9, C10—1.0 µF, 35 volts, tantalum
Semiconductors
IC1—NE570, NE571, or SA571
Other components
S1—SPST, PC-mount

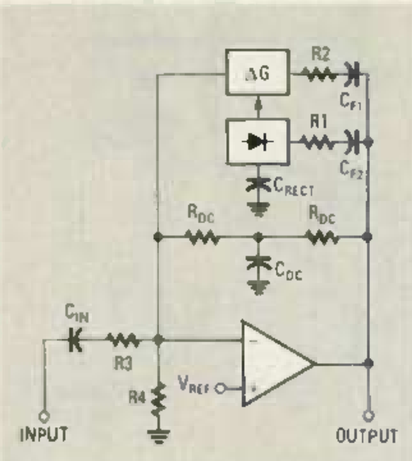


FIG. 4—THE BIASING NETWORK for the compressor. See the text for details on calculating the resistor and capacitor values.

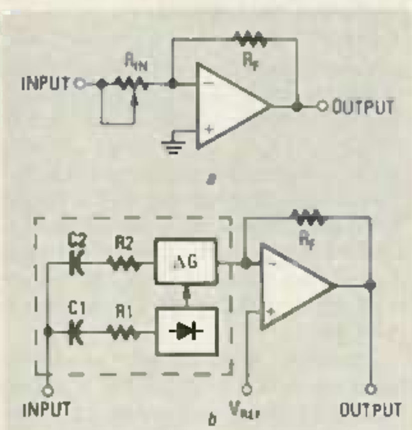


FIG. 5—THE BASIC EXPANDER may be thought of as an op-amp with a variable input resistor. The components in the dashed box (*b*) correspond to R_{IN} in (*a*).

voltage swing because the Δ-G and rectifier cells can handle peaks of only 140 µA and 300 µA, respectively. Use the following formulas to determine the resistor values to use in order to remain below those levels.

$R1 = (V_{OUT(peak)} / 300\ \mu A) - 10{,}000$
$R2 = (V_{OUT(peak)} / 140\ \mu A) - 20{,}000$

Resistors R1 and R2 are reduced by

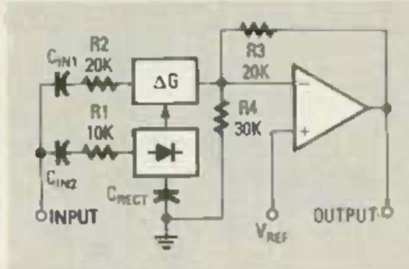


FIG. 6—THE BIASING NETWORK for the expander. See the text for details on calculating the resistor and capacitor values.

10,000 and 20,000 ohms, respectively, because the NE570/1 devices have internal protection resistors with those values.

Rectifier capacitor C_{RECT} controls the attack and decay times of the circuit. It will usually have a value between 1.0 µF and 2.0 µF. A 2.0 µF capacitor gives an attack time of about 3 ms and a decay time of about 13 ms. Note that decreasing C_{RECT} to speed up the attack will cause distortion to increase.

Some applications may be especially sensitive to THD (*T*otal *H*armonic *D*istortion) or low-level tracking errors. Signetics' *1985 Linear LSI Data and Applications Manual* discusses methods of reducing both. Also, some circuit layouts may cause low-level oscillation if the THD trim pin is left unconnected. That is cured by adding a 200 pF capacitor between that pin and ground.

For use in the real world, an input buffer amp may be necessary to match the input impedance of NE570/1 to that of the circuit driving it. In some applications "breathing," noise-pumping, or other strange sounds may occur; they can be reduced or eliminated with pre-emphasis circuitry.

Expander theory

The expander uses the same building blocks as the compressor, but in this configuration the Δ-G cell is inserted before the inverting input of the op-amp, where it functions as a variable input resistance, R_{IN}, as shown in Fig. 5-*a*. When the input signal increases above a preset crossover level (0 dB), the variable resistor decreases in value, and that causes the gain to increase. As the input signal decreases below the crossover level, the variable resistor increases in value, and that causes the gain to decrease. The equation for voltage gain in such a circuit is still:

$$A_V = -R_F/R_{IN}.$$

In fact, in the expander configuration, R_{IN} is replaced by the Δ-G cell and the rectifier as shown in Fig. 5-*b*. Resistors R1 and R2 are still internal to the compander IC and have values of 10K and 20K, respectively; I_B must still be maintained below 140 µA; so the gain equation for the expander is:

$$A_v = \frac{2\ R3\ V_{IN(avg)}}{R1\ R2\ I_B}$$

Sample expander application

As with the compressor application described above, care has to be taken with the expander to avoid clipping. The output should again be biased at one-half the supply voltage. The circuit shown in Fig. 6 is designed to operate from a six-volt power source, so the DC level of the output is biased at three volts.

When using a supply voltage higher than six volts, adjust the output bias level accordingly. To raise the DC output level, it is recommended that the value of R4 be decreased by connecting resistors in parallel with it. Changing R3 would affect the expander's AC gain, and thus would cause a mismatch in a companding sys-

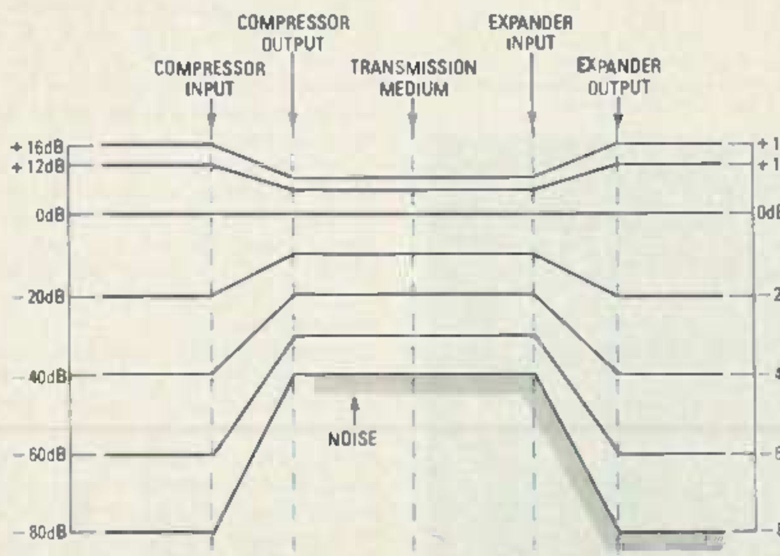


FIG. 7—SIGNAL LEVELS IN A COMPLETE COMPANDER SYSTEM. The compander works on a 2:1 compression ratio and a 1:2 expansion ratio. Noise inherent to the transmission medium is kept below the level of the weakest signal.

tem. In other words, the expansion ratio would be different than the compression ratio. The DC bias of the output can be calculated using this equation:

$$V_{OUT} = V_{REF}(1 + R3/R4)$$

If $R3 = 20K$, $R4 = 30K$ and $V_{REF} = 1.8$, then $V_{OUT} = 2.99$ volts.

The input and output coupling capacitors must be large valued. For lowest distortion, a separate capacitor should be

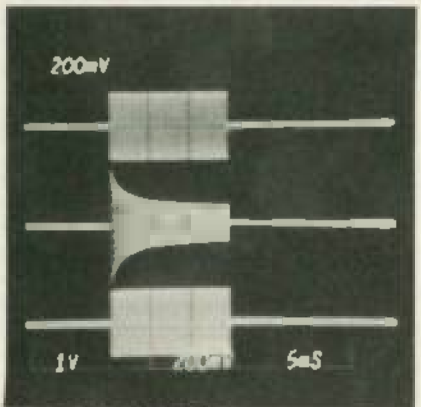


FIG. 8—THE 1S KHZ SIGNAL in the upper trace is fed through the compressor, whose output appears in the middle trace. That signal is restored to its original form, as shown in the lower trace, by the expander.

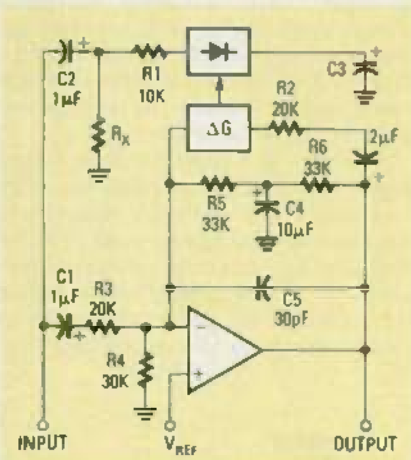


FIG. 9—THE COMPANDER USED AS AN ALC DEVICE. This circuit combines elements of both the compressor and the expander.

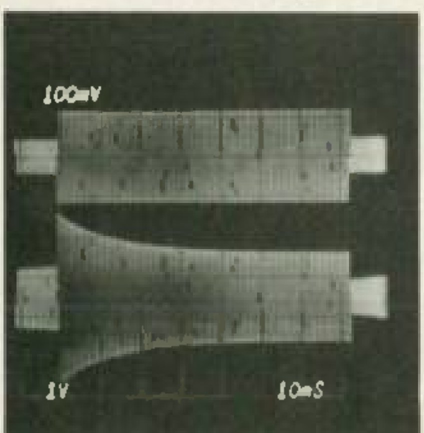


FIG. 10—ALC ACTION is shown here. The upper trace shows the input signal, and the lower trace shows it being processed by the ALC circuit.

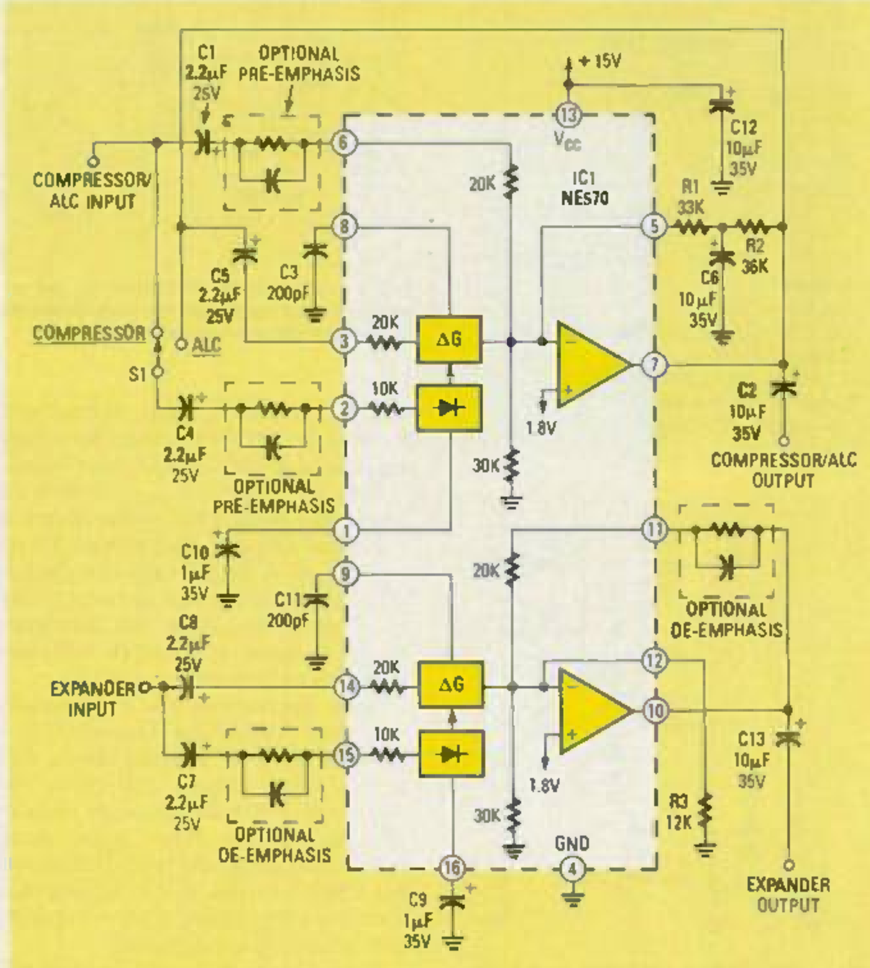


FIG. 11—A COMPANDER CIRCUIT you can build to experiment with compression, expansion and ALC. The pre- and de-emphasis networks may be replaced by jumpers if they are not needed.

placed in series with both the Δ-G cell's input (C_{IN1}) and the rectifier's input (C_{IN2}).

If you anticipate an input signal greater than 2.8 volts peak, which corresponds to an input current of 140 µA, then the value of R2 must be increased. If the input signal is greater than 3.0 volts peak, R1 will also have to be increased. As with the compressor, signal distortion can be avoided by limiting the compander's peak input currents.

The effects C_{RECT} has on attack and delay times, as well as distortion, are the same as in the compressor circuit, so start of with a value of 1 µF to 2 µF for C_{RECT}. In any case, C_{RECT} should have the same value in both circuits of a complete compander system.

An input buffer may again be necessary if the input impedance of the NE570/1 needs to be matched to that of the driving device. Also, de-emphasis would be necessary if the complementary compressor circuit used pre-emphasis, such as that used by high-fidelity tape decks. The distortion trim pin functions as in the compressor, and if not used, should be bypassed with a 200 pF capacitor to ground.

Companding example

In Fig. 7 we see how a complete compression/expansion system affects signals of various levels. Note that the input signals occur over a 96 dB range, and are compressed to a 48 dB range. In other words, compression works on a 2:1 ratio. Signals above the 0 dB line will be halved, and signals below the 0 dB line will be doubled. For example, the +16 dB signal decreases to a value of +8 dB, and the −80 dB signal increases to a value of −40 dB.

The output of the compressor is fed to the transmission medium (be it the airwaves, telephone lines, magnetic tape, etc.) where a low-level noise signal is picked up. The signal is then fed to the expander where it is expanded from 48 dB to 96 dB, that is, at a 1:2 ratio. Here, signals above the 0 dB line are doubled, and signals below the 0 dB line are halved. For example, the +8 dB signal increases to a value of +16 dB, and the −40 dB signal decreases to a value of −80 dB. Note that the noise arising in the transmission medium is kept below the −80 dB level by companding.

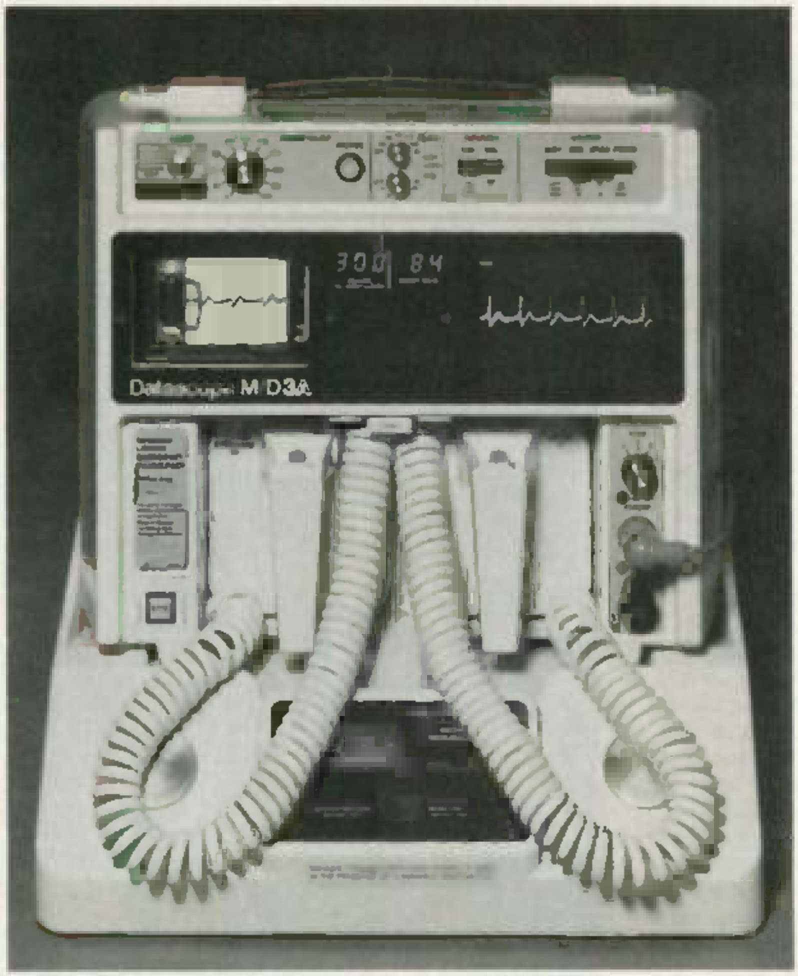
The oscilloscope photo in Fig. 8 shows

continued on page 109

Medical Uses of Electric Shock

Electrical stimulation of the body can be dangerous, but there are some instances where it can save a life.

RAY FISH, Ph.D., M.D.



ACCIDENTAL CONTACT WITH HIGH VOLTAGES or currents can often result in injury or even death. However, there are many instances when deliberate exposure to some type of electrical stimulation is an effective part of treatment for an illness or condition. In this article we are going to look at some of those instances.

Electrical stimulation of the heart

In a healthy heart, muscle contractions are initiated and coordinated by a natural "pacemaker" and "conduction" system that is made up of special muscle cells. While many cells in the heart will electrically discharge, causing a contraction to occur, the pacemaker area of the heart contains cells that spontaneously discharge the fastest. After the pacemaker cells discharge, electrical signals travel throughout the atria (the top half of the heart). The atria are electrically insulated from the ventricles (the bottom half of the heart). The signal from the atria is conducted to the ventricles by a specialized collection of muscle fibers (the AV node and associated fibers) that cause a delay of about a tenth of a second. Thus, after the atria contract to push blood into the ventricles, there is a delay of about a tenth of a second before the ventricles receive the signal to contract. It is the ventricles that produce the real pumping action, giving a pulse that can be felt at the wrist and elsewhere.

When that normal pattern is disrupted, the heart is said to be in fibrillation. When fibrillation is brought on, due to extra pacemaker signals being generated or to an irritation of the heart, the beating of the heart muscle becomes uncoordinated. During fibrillation the exposed heart can be seen to writhe like a bag of worms, rather than contracting in a useful manner. If the ventricles beat normally but there is atrial fibrillation, about 20% of the efficiency of the heart is lost because blood does not enter the ventricles as well as it should. In addition, the fibrillation signals passing through the AV node usually stimulate the ventricles to contract at a rate of about 170 beats per minute, a condition not well tolerated by most individuals. While many people have atrial fibrillation which cannot be stopped, the rate of the beating of the ventricles can be controlled by medication that slows conduction of impulses through the AV node and decreases the ventricular contraction rate (the effective heart rate).

Ventricular fibrillation, if not treated within minutes, is fatal. About 350,000 Americans die each year from disruptions in cardiac rhythm, usually ventricular fibrillation. Most of those electrical disturbances take place during or within a few days of a myocardial infarction (heart attack). Many of the people who die do so needlessly. Though the heart muscle has been damaged by a heart attack, if the electrical disturbance is corrected, the person might live for many more years.

One way to stop fibrillation of the atria and ventricles is to apply an electrical shock to the chest. That shock is administered via large paddles (as you've doubtless seen on TV or at the movies) using a machine called a defibrillator. When that electrical shock is applied, all muscle cells in the heart are depolarized, as if they had just discharged. The first cells to recover are those in the pacemaker area of the heart; they send signals to the conduction system, which causes organized contraction of the heart muscles.

Figure 1 shows an electrocardiogram of a patient in ventricular fibrillation. The region labeled A shows irregular, nonrepeating voltage fluctuations. A defibrillating shock of about 1,000 volts is applied at B. That causes the electrocardiogram amplifier to overload. For a period the electrocardiogram shows a signal with an elevated baseline, then the amplifier saturates again (C). After a few seconds the heart begins to beat slowly (D), though not in a normal manner.

A relatively small number of people have recurrent episodes of cardiac rhythm disturbances (arrhythmias) that are not as-

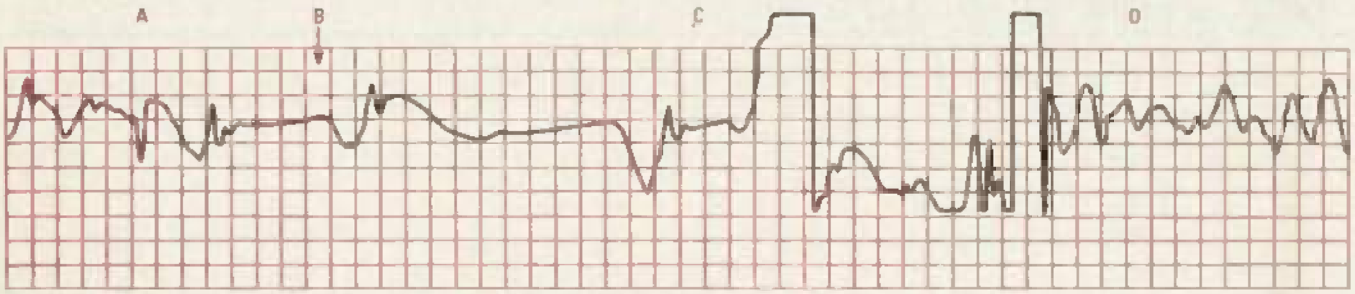


FIG. 1—ELECTROCARDIOGRAM of a patient with ventricular fibrillation. At point *b* defibrillation (the applying of a voltage) is performed. A heartbeat, although abnormal, slowly begins to appear after several seconds (*d*).

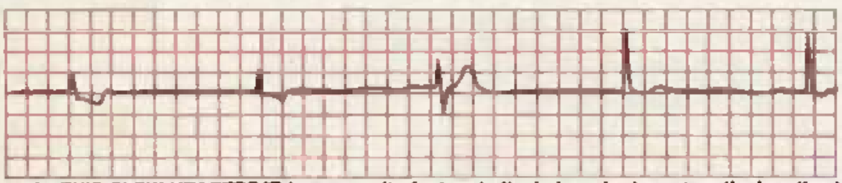


FIG. 2—THIS SLOW HEARTBEAT is the result of a heart attack. In order to restore the heartbeat to normal, a pacemaker had to be implanted. Differences in the waveform are due to the different locations of electrodes used to take the reading.

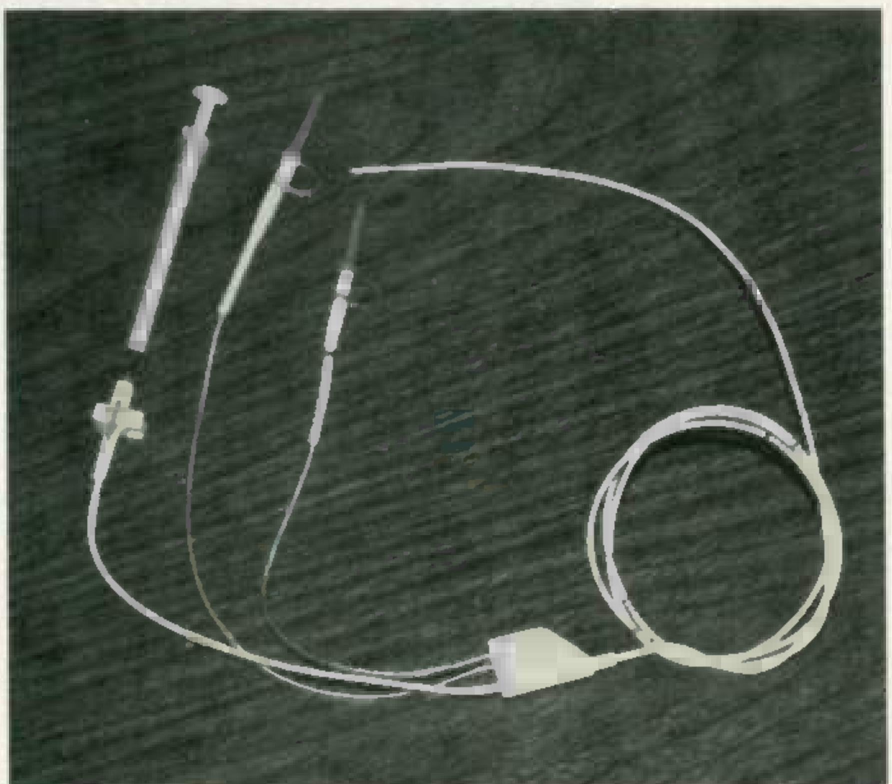


FIG. 3—A PACEMAKER CATHETER, such as the one shown here, is inserted into the body so that the electrodes at its end contact the heart muscle.

sociated with heart attacks. Many of those disturbances are corrected by electrical shock, or defibrillation. A few dozen people with recurrent potentially-lethal arrhythmias have been treated with surgically implanted defibrillators. When a fatal rhythm is recognized by such a unit, a shock of 30 joules is applied to the heart. That is less than the 300 joules usually applied when the defibrillation shock is administered externally. But then again, the power requirements are less because the shock is applied directly to the heart rather than to the chest wall.

In fibrillation there are too many signals or depolarizations occurring. With a slow or absent heart rate, there are too few depolarizations. Figure 2 shows an electrocardiogram from a patient who has suffered an acute heart attack. The beats are coming much too slowly, about one every 2 seconds. That gives a pulse rate of about 30 beats per minute. It was decided that a pacemaker was needed in that case because drugs would not increase the heart rate, and the patient was in shock. A temporary pacemaker, actually a specially built pulse generator in a small box, was connected to the heart by a catheter with wires built into it. The pacemaker catheter was inserted into a large vein under the clavicle (collar bone) and pushed forward until it reached the heart. (See Figs. 3 and 4.)

Usually when a pacemaker catheter is inserted, the positioning of the catheter is obtained using "fluoroscopy." That technique uses a continuous X-ray source and an image intensifier system that permits the physician to see a real-time image of the catheter working its way to the heart. Because veins branch and turn it is useful to be able to see where the catheter is going and to twist or redirect it when needed.

Because the condition of the patient whose electrocardiogram is shown in Fig. 2 was so acutely poor, there was not time to set up the equipment or wait for the technicians who run it to come to the hospital. Thus the catheter was inserted "blindly." That is, the catheter was inserted in the vein via a large needle and pushed forward until small spikes, caused by the signal from the pacemaker, were seen in the patient's electrocardiogram. The presence of those spikes meant that the catheter was near the chest electrodes used to monitor the electrocardiogram. The catheter was further advanced until the small spikes were followed by heartbeats, as seen in Fig 5. That was electrical confirmation of the fact that the pacemaker had "captured" (was stimulating) the heart. Later, routine X-rays showed that the pacemaker was in a good location. Because of the type of heart attack, that pacemaker was only needed for a few days. In other cases a permanent pacemaker must be surgically implanted in the patient and connected to the heart.

There are several types of electronic pacemakers. An atrial pacemaker can be used if the atria are not contracting often enough, but the natural conduction between the atria and ventricals is normal. A ventricular pacemaker can be used to stimulate just the ventricles. The atria

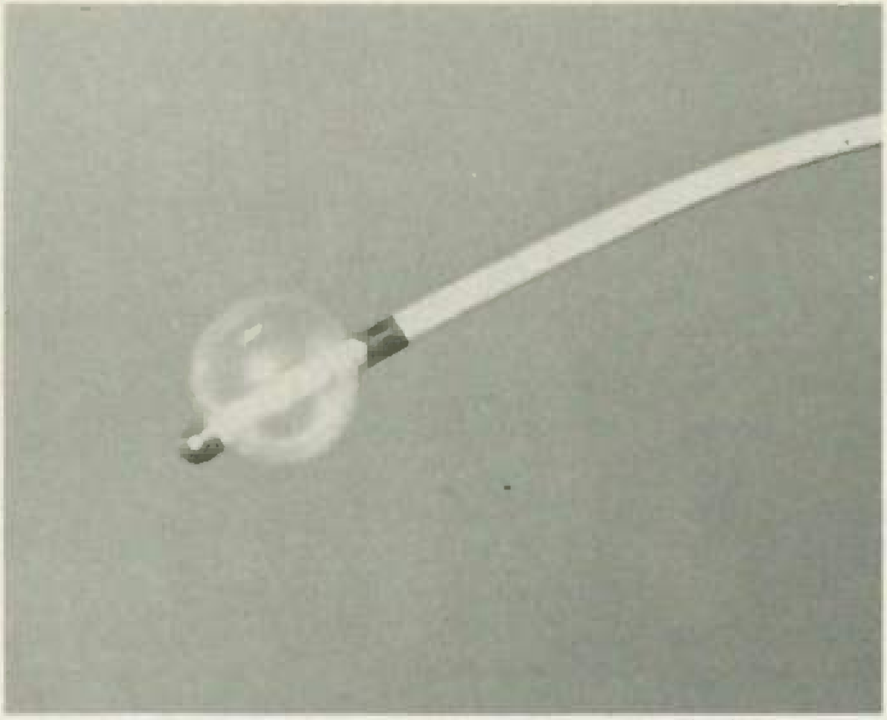


FIG. 4—IF THERE IS ANY CIRCULATION, a balloon at the end of the catheter is inflated so that the catheter tip will be carried to the heart by blood flow.

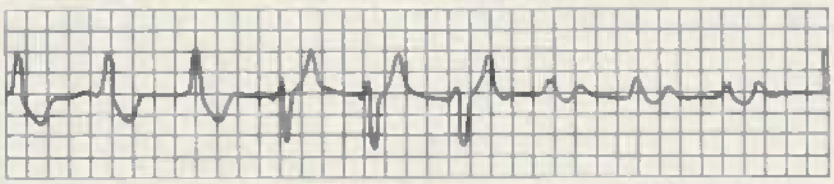


FIG. 5—SMALL SPIKES, which are the output signals from the pacemaker, are followed by heartbeats. This shows that the pacemaker has "captured" the heart.

may be stimulated by backward conduction through the AV node, but the resulting atrial contraction would be at the wrong time to do any good. A sequential pacemaker has two sets of wires: One stimulates or senses the signal from the atria; the second stimulates the ventricles after a delay that simulates the delay normally caused by the AV node. With a sequential pacemaker, the 20% boost in cardiac output provided by the atria is retained.

Different pacemakers operate in different manners. Some work only when needed; those are called *demand pacemakers*. The same wires that stimulate the heart are used to detect heart signals that are spontaneously present. Thus, if the heart is beating on its own, the pacemaker does not fire. If the heart rate gets below the minimum a patient could tolerate, the pacemaker fires.

Some pacemakers fire regardless of spontaneous heart activity. Those are called *asynchronous pacemakers*.

Instead of turning off when a heartbeat is detected, some pacemakers fire within milliseconds of each detected heartbeat (with a maximum rate of firing). In that way externally induced electrical signals cannot trick the pacemaker into shutting off. Units that operate in that manner are called *stimulated pacemakers*.

External pacemakers have controls that allow the physician to program the stimulus current and heart rate. It is also possible to choose whether or not the pacemaker should be inhibited by spontaneous heart activity. With surgically implanted pacemakers that is not possible. To overcome that problem, remotely programmable pacemakers have been developed. The pacemaker contains a radio receiver that detects coded signals sent by a hand-held transmitter that looks something like a calculator or small computer. With such a unit, it is possible to control a wide variety of pacemaker parameters.

If a permanently implanted pacemaker is not functioning, troubleshooting can be difficult. However, there are some tests that can be done to help determine the cause of the problem.

Almost all demand pacemakers contain a magnetic reed switch. Placing a strong permanent magnet near the pacemaker will activate the switch and convert the pacemaker to an asynchronous mode of operation. As long as the magnet is held in place, the pacemaker will fire at a constant rate regardless of the person's spontaneous heart rate. If a magnet is applied and no pacemaker spikes can be seen on the electrocardiogram, either the pulse generator or the electrode wire is defective.

If a pacemaker fails within weeks of being implanted, the problem is usually with the electrode wire. The wire may have dislodged, or the electrical resistance between the electrode and the heart tissue may have increased.

A failure after years of operation is most often due to weak batteries; placing a magnet over the pacemaker may give a relatively slow heartrate when batteries are weak.

When pacemaker spikes are seen on the electrocardiogram, but there is no capture of the heart, the problem might be with the patient or with electrode placement. A chest X-ray may show a break in the electrode wire. The X-ray can also indicate if the electrode has moved or perforated the wall of the heart. Listening to heart sounds may reveal a "pericardial rub" that indicates irritation of the lining of the outside of the heart; the patient may feel pain due to the electrode. If the electrode is in the proper location, loss of capture may be due to chemical imbalances in the patient's blood. Low levels of potassium or calcium can increase the amount of energy needed for electrical capture of the heart.

Further troubleshooting can be done if the pacemaker is a programmable type. Some such pacemakers allow measurements of lead impedance, sensitivity, and output energy.

Stimulating the inner ear

Severe hearing loss can be partially corrected by a new kind of hearing aid, manufactured by 3M (St. Paul, MN), that electrically stimulates the inner ear. Unlike conventional hearing aids that amplify and filter sound, those new hearing aids perform a spectrum analysis and use the resulting signals to stimulate certain portions of the auditory nerve.

The human ear is shown in Fig. 6. Normally sound travels through the air to the eardrum. The eardrum vibrates and those vibrations are transferred to three small bones. Those bones in turn cause vibration of fluid in a snail-shaped structure called the cochlea. Sound causes a membrane, called the basilar membrane, in the cochlea to vibrate at various places. Which portion of the membrane vibrates depends on the frequency of the sound present. Specialized receptor cells along the membrane transmit signals to fibers of the auditory nerve. Thus the ear acts as a real time "spectrum analyzer" and transmits many parallel signals to the brain.

The portion of the basilar membrane that vibrates determines the pitch that is perceived. To a lesser extent the frequen-

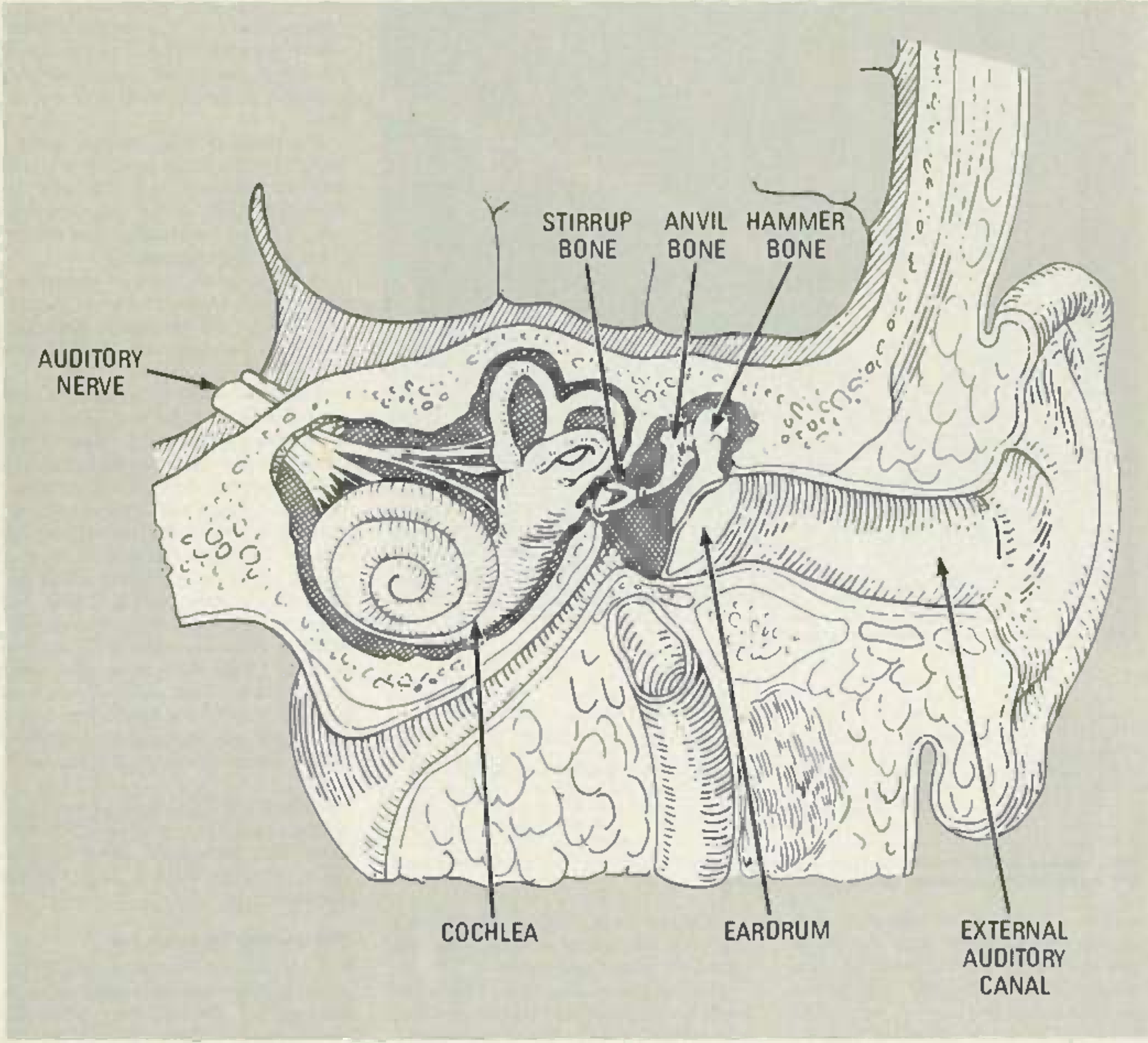


FIG. 6—THE MAJOR STRUCTURES of the human ear are shown here.

cy of stimulation of the basilar membrane as well as the location of the stimulation influences the perception of pitch; that is more important at lower frequencies.

Surgery and conventional hearing aids can correct many hearing problems that are caused by damage to the structures of the outer ear (ear canal) and the middle ear (the eardrum and three bones). But if the cochlea (inner ear) were damaged, there was little that could be done until recently. Clinical trials of cochlear implants began in 1972. Since then hundreds of people have had electrode arrays inserted into their inner ears.

The earliest cochlear implant, or prosthesis, used a single electrode. Such a device allows the user to recognize differences in a sound's intensity and duration, but allowed only low frequency sounds to be recognized. Single electrode devices allow users to recognize some environmental sounds and make lipreading easier.

Multiple channel cochlear implants contain spectrum analyzers and may have 16 electrodes. The stimulating voltage on each electrode is determined by the amplitude of sound in a certain frequency range. Information about the timing and amplitude of signals in various frequency ranges is preserved. Some users of multiple channel cochlear implants are able to understand speech in a limited manner. One study reported 70% recognition of vowels and 30% recognition of consonants without lipreading. Persons with cochlear implants can hear with sensitivity approaching normal. Although the sound is distorted, doorbells, car horns, and other sounds can be heard almost as well as by a person with normal hearing.

A typical cochlear prosthesis consists of two electronic assemblies—one outside of the head, and one that is surgically implanted. The external electronics package detects sound, performs spectrum analysis, and transmits signals to the implanted electronics.

The surgically implanted internal electronics package detects the transmitted signals and converts them so that they can be perceived by the auditory nerve. Some systems use a rigid electrode that is inserted directly into the auditory nerve. More commonly, however, a flexible electrode array is inserted into the cochlea and made to lie along the basilar membrane, which is then made to vibrate by the electrodes in response to the transmitted signals. That vibration is detected by the auditory nerve as normal. Which frequencies cause which electrodes to vibrate can be varied to adjust for differences in perception from patient to patient. R-E

DESIGNING WITH DIGITAL IC'S

This month we learn about counter circuits and how they work.

JOSEPH J. CARR

Part 7

BEFORE WE GET TO our topic for this month, let's clear up an error that appeared in our last installment (September 1985). Among the circuits that we looked at then was a shift register called a pseudo-random sequencer. Due to a mix-up, an incorrect schematic was shown for that circuit (Fig. 15 in that issue). The correct schematic is shown here in Fig. 1.

Actually, that circuit can serve as a good introduction to this month's topic—counters. Remember last time we said that the output of the pseudo-random sequencer only *appears* to be random. Instead its output repeats every $2^n - 1$ times, where n is the number of stages in the circuit. Because of that, the shift register can be thought of as a counter.

A counter is defined as a sequential-state circuit. That is, it has n different states into which it can go, and it enters those states in a predetermined sequence. You can use a counter to divide an input signal frequency by n, or to produce a single output pulse for every n input pulses.

Let's stop for a moment and define a few terms that are used when talking about counters. The *modulo* of a counter refers to the number of different states that a counter sequences through. For instance, the modulo of a hexadecimal, or base-16 counter is 16. The modulo of a binary counter is two.

The *coding* of a counter tells us which states it will pass through, and in what sequence. The coding is particularly important when the counter is *weighted*. In a weighted counter, each parallel output is used to represent a number of counts. To make that a little clearer, let's look at an example.

Figure 2 shows a base-16 counter consisting of four J-K flip-flop stages in series. The relationship between the signals at the four parallel outputs and the input is shown in Fig. 3. Studying that figure reveals that the outputs of that modulo-16 counter are weighted 1, 2, 4, and 8. That is $Q1 = 2^0$; $Q2 = 2^1$; $Q3 = 2^2$, and $Q4 = 2^3$. Thus, an output of 1010 represents a count of $(1 \times 1) + (0 \times 2) + (1 \times 4) + (0 \times 8) = 1 + 0 + 4 + 0 = 5$. A quick check of Fig. 3 will verify that that indeed is the output at T5. That type of weighting is called binary weighting.

A counter is said to be *decodable* if it is possible to continuously monitor the state of the count using relatively simple circuitry. Generally, for a counter to be decodable it should use a standard weighted code such as binary or BCD (more on BCD in a moment). The counter of Fig. 2 is decodable because the state of the count is always available at the parallel outputs.

A counter can also be *resettable* or *presettable*. A resettable counter is one that can be forced into an all-zeros state. In the counter of Fig. 2 that is done by tying the active-low $\overline{CLR}$ pins on the flip-flops together to form an active-low reset line.

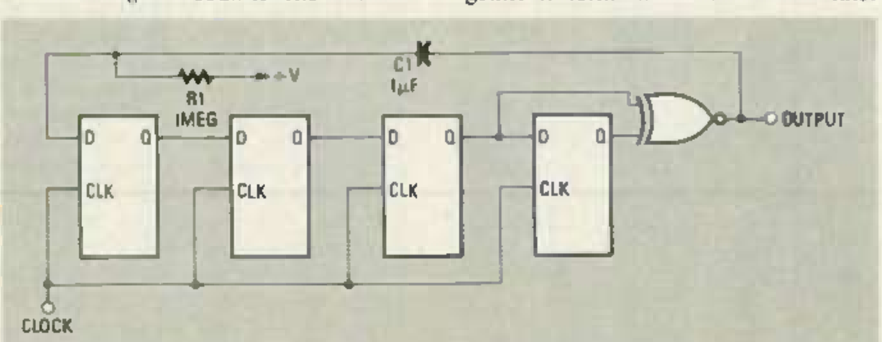


FIG. 1—A PSEUDO-RANDOM sequencer. Due to an error, the schematic shown in the Sept. issue for this circuit was incorrect. The correct circuit is shown here.

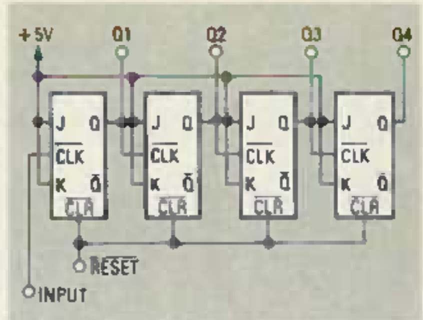


FIG. 2—A FOUR-STAGE ripple counter. The outputs of the counter are weighted 1, 2, 4, and 8.

Bringing that line low momentarily forces all the outputs to go low simultaneously.

A presettable counter is one that can be forced into a desired state. That is done by placing the desired state on a set of preset inputs called "jam" inputs. A pin called PRESET ENABLE, or something similar, controls the preset function.

The reset line can be used to form a decimal (or base-10) counter. In Fig. 4, a NAND gate has been added to our base-16 counter. That gate is placed there to detect the unique output state that follows the tenth count (i.e. both Q2 and Q4 are high simultaneously). When those two outputs are high, the output of the NAND gate goes low forcing the reset line, and in turn Q1–Q4, low.

The outputs of that counter are still weighted 1248, but the output states run only from 0000 to 1001 (0 to 9 in base 10). That coding is called *Binary Coded Decimal*, or BCD.

Let's consider at a typical BCD counter, for instance the 7490. That TTL IC is designed as a bi-quinary counter; that is, it has divide-by-two and divide-by-five sections that are cascaded (pins 12 and 1 shorted) to form a divide-by-ten counter. The reset pins (2 and 3), which are normally strapped together in decimal operation, are active-high. Thus those pins are normally grounded. If it is necessary reset the counter to zero (0000_2), then pins 2 and 3 are momentarily brought high. That will clear the flip-flops, thereby forcing the outputs to 0000_2. Another set of terminals (6 & 7) resets the 7490 to 9_{10} (1001_2). The 7490 is now considered the classic decimal counter, although for certain applications other devices may prove to be a better choice.

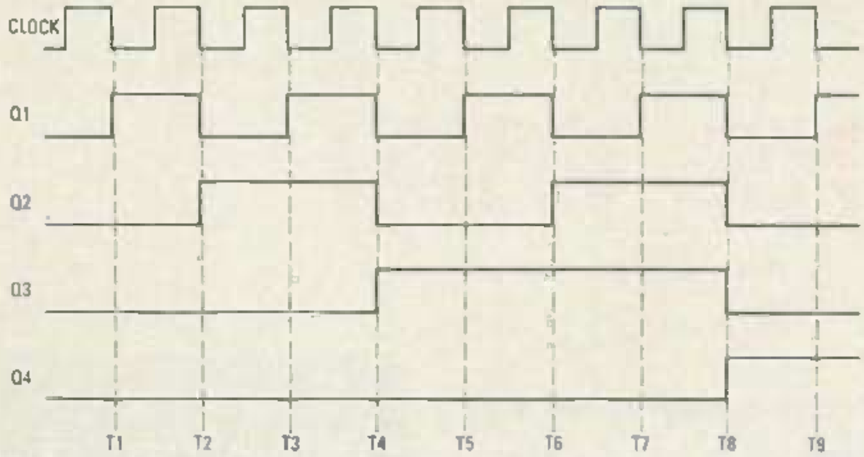


FIG. 3—THIS TIMING DIAGRAM shows the relationship between the clock signal and the signal at the four outputs for the circuit of Fig. 2.

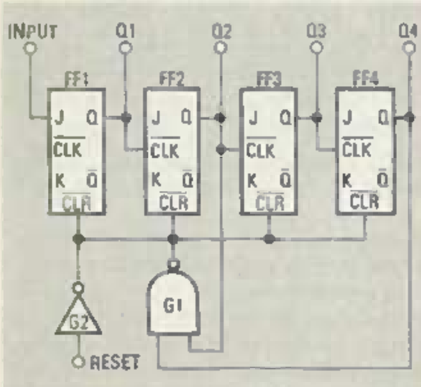


FIG. 4—A BINARY-CODED-DECIMAL counter. This counter resets after the count reaches 1001.

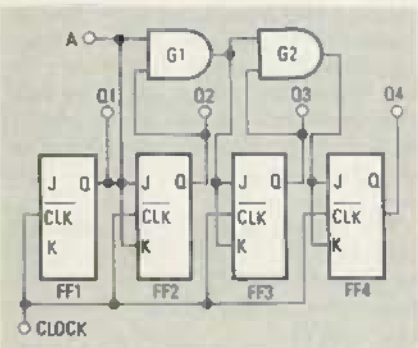


FIG. 5—IN A SYNCHRONOUS COUNTER all outputs change state simultaneously. This counter has two major advantages over the ripple counter—speed and freedom from glitches.

Synchronous counters

Counters such as the hexadecimal (base-16) and decimal (base-10) circuits discussed thus far suffer from one major problem: speed. Those counters are called ripple counters because they are connected in cascade such that the output of one stage drives the clock input of the succeeding stage. Thus, a change in the input must ripple through the entire chain before it brings the outputs to their final state. In addition, propagation delays in the circuit can cause glitches to appear in the count.

Those problems are eliminated in a second type of counter, called a *synchronous* counter. In that type of counter, all of the counter stages are driven directly from a single input, and all outputs change simultaneously.

Figure 5 shows a synchronous counter circuit. The most obvious features of that circuit are the two AND gates and the fact that all four clock inputs are tied in parallel to form a common clock line. One of the AND gates is connected so that both Q1 and Q2 must be high before flip-flop FF3 changes state. In a similar manner, Q2 and Q3 must be high before FF4 changes state. When a pulse is received on the clock line, all flip-flops that are "scheduled" to change states do so simultaneously, no matter how many stages the counter has.

Some common TTL synchronous counters include the 74160 (BCD with direct clear input), 74161 (hexadecimal with direct clear input), 74162 (BCD), and 74163 (hexadecimal).

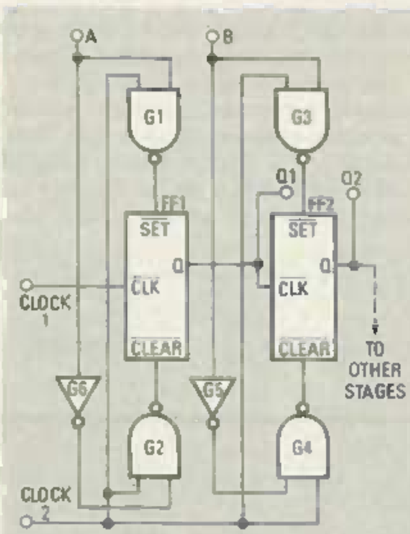


FIG. 6—THE COUNT'S STARTING POINT can be preset using jam inputs A and B. This type of counter is called a presettable counter.

Preset counters

Most counters increment from 0000$_2$. A preset counter is one that can be made to increment from another value. That is done by loading the value of the starting point into the counter via a set of jam inputs.

Figure 6 shows a portion of a preset counter circuit that uses the jam input method to preset the flip-flops of the counter. Although only two stages are shown here, the same technique is used in the succeeding stages.

The preset count value is applied to the jam inputs, labeled here as A and B. For sake of this discussion, let's consider only the A input (which drives FF1). The data at A is applied directly to one input of NAND gate G1, and through an inverter to one input of G2. The remaining inputs of G1 and G2 are connected together to form clock line number 2 (CLOCK2).

In order to understand the operation of CLOCK2 and the A jam input, let's review the rules governing a two-input NAND gate:

- If either input is low, then the output is high.
- Both inputs must be high for the output to be low.

The rules above tell us that CLOCK2 is active-high: let's see why. When CLOCK2 is low, both outputs G1 and G2 are kept high. The output of G1 controls the active-low $\overline{\text{SET}}$ input on FF1, while the output of G2 controls the active-low $\overline{\text{CLEAR}}$ input. Thus, a low on CLOCK2 keeps $\overline{\text{SET}}$ and $\overline{\text{CLEAR}}$ high, and therefore inactive.

Let's consider circuit action for two situations: when A is low and when A is high. The first situation implies that we are forcing the circuit's Q1 output low. Let's see if that is what happens.

If a low is applied to A, then the input to G1 is low, and the input to G2 is high (due to the inverter). When CLOCK2 goes high, the output of G1 is high (keeping $\overline{\text{SET}}$ inactive) and the output of G2 is low (activating $\overline{\text{CLEAR}}$). Since $\overline{\text{CLEAR}}$ is now active, the flip-flop's output Q goes low. Therefore, Q1 is forced low whenever the A jam input is low and CLOCK2 is active, and that is how the circuit should operate.

Now let's see what happens when the input at A is high, which implies that we are forcing Q1 high. In that situation, the input to G1 is high and the input to G2 is low. When CLOCK2 goes high, therefore, the output of G1 is low, and the output of G2 is high. That renders $\overline{\text{CLEAR}}$ inactive, and $\overline{\text{SET}}$ active, so the flip-flop's output, and circuit output Q1 is high. In other words, if A is high when CLOCK2 goes high, then Q1 is forced high, and that is how the circuit should operate.

In a multi-stage cascade counter, there will be one jam input for each bit of the counter. All bits will be preset simultaneously when CLOCK2 goes high. After

(Continued on page 110)

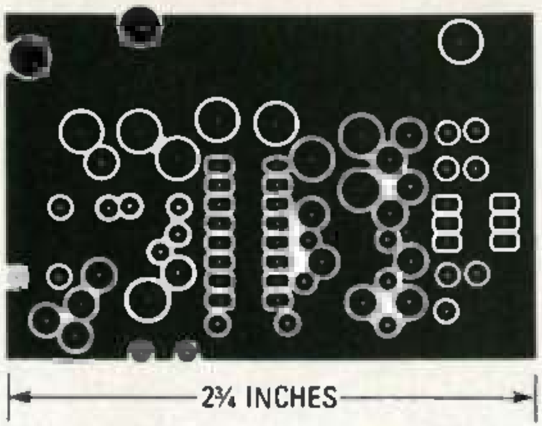
PC SERVICE

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!

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

An optional step, once you're satisfied that the artwork is clean, is to take a little bit of mineral oil and carefully wipe it across the back of the artwork. That helps make the paper transluscent. Don't get any oil on the front side of the paper (the



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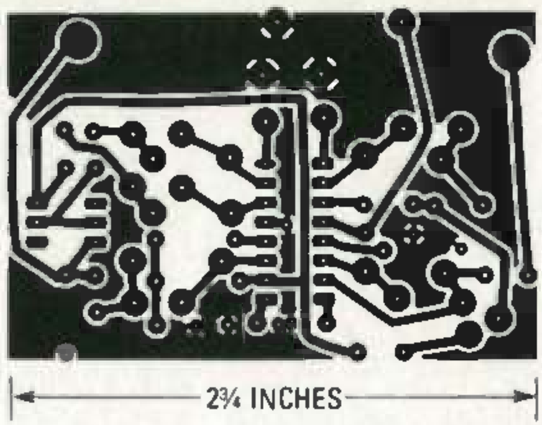

SOLDER SIDE for the audio compander PC board.

PC SERVICE

side with the pattern) because you'll contaminate the sensitized surface of the copper blank. After the oil has "dried" a bit—patting with a paper towel will help speed up the process—place the pattern front side down on the sensitized copper blank, and make the exposure. You'll probably have to use a longer exposure time than you are used to.

We can't tell you exactly how long an exposure time you will need because we don't know what kind of light source you use. As a starting point, figure that there's a 50 percent increase in exposure time over lithographic film. But you'll have to experiment to find the best method to use with your chemicals. And once you find it, stick with it. Don't forget the "three C's" of making PC boards—care, cleanliness, and consistency.

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

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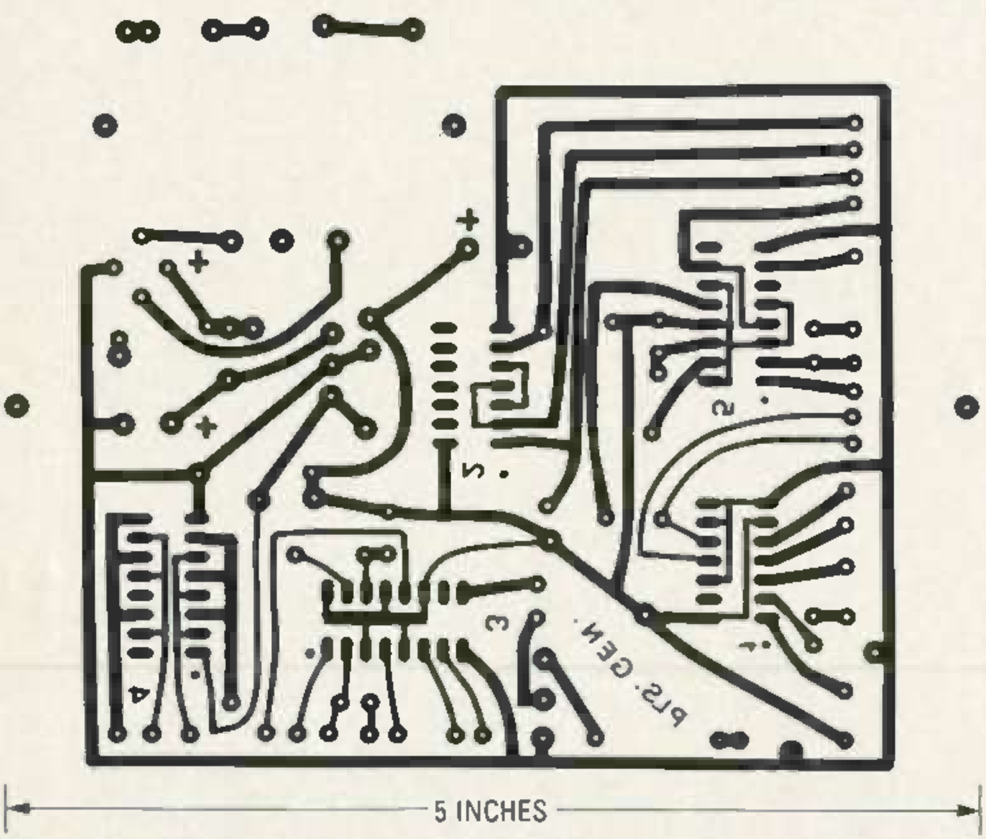

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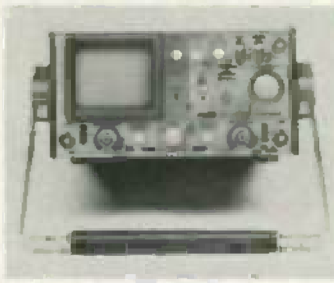

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GLOSSARY OF COMMONLY USED SATELLITE-TV TERMS

For those readers unfamiliar with satellite-TV terminology, we have included the following glossary of commonly used terms. You'll notice that satellite-TV technology has not only caused the development of "a language of its own." In many cases, existing words and phrases are given new meanings. In such cases, we will deal only with the definition related to satellite TV.

Active component—A device whose output is dependent on a source of power other than the input signal.

Aperture—The diameter of an antenna dish.

Apogee—The point in an elliptical satellite-orbit that is farthest from the earth's surface.

Audio subcarrier—Subcarriers of satellite video-signals that are modulated by audio. The frequency range can be from 5–8 MHz but is usually 6.2 or 6.8 MHz.

Az El mount—A dish mount whose position is changed by two separate adjustments (in azimuth and elevation.)

Azimuth—The angular displacement of a dish in a horizontal plane with respect to true north (measured in a clockwise direction).

Baseband—The frequency band occupied by the modulating signal. For example, baseband-video signals occupy a band from 0 to 4.3 MHz.

Block downconverter—A device that converts an entire band (for example the 3.7–4.2 GHz C-band) down to a lower band of frequencies.

Boresight point—The area of maximum signal strength of a down-link signal. The center of the transponder "footprint."

C band—A band of downlink frequencies having a range from 3.7 GHz to 4.2 GHz. This band also includes uplink signal frequencies from 5.92 to 6.42 GHz.

Cassegrain antenna—An antenna that uses a subreflector at the focal point to reflect the received signals to a feed located at the dish's apex (center).

CATV—Abbreviation for *C*ommunity *A*ntenna *T*ele*V*ision. Now generally used to mean cable TV.

Channel—A band of frequencies used for carrying video and/or audio signals, data, news, etc. Bandwidth depends on the amount of information to be transmitted. Channel frequencies are specified in the U.S. by the FCC.

Chroma—An abbreviation of chrominance. Color signals. A reference to a combination of hue, purity and saturation.

Circular polarization—A form of polarization of electromagnetic signals (such as from a satellite) in which the electric field of the signal is made to assume helical form, either clockwise or counterclockwise.

Clarke belt—The orbital path followed by geosynchronous satellites named after Arthur Clarke, noted sicence-fiction writer who made the original suggestion about the possibility of geostationary satellites. The orbit is 22,300 miles.

C/N—Carrier-to-noise ratio—The ratio of the satellite-signal carrier strength to the power of the received noise, measured in decibels.

Color Edging—Extraneous colors that appear along the edges of video pictures, but that don't have any color relationship to those areas.

Color subcarrier—A subcarrier (3.58 MHz) of a composite-video signal. Also called chrominance subcarrier.

Decoder—Device for unscrambling video signals which have been encoded.

Dish—A device that reflects received satellite microwave signals to a feedhorn. Sometimes incorrectly referred to as an antenna.

Dish illumination—The area of a dish as seen by the feedhorn.

Dithering—The process of equalizing the video signal. The 6-MHz satellite signal is shifted up and down the 36-MHz satellite transponder spectrum to distribute the energy of the video signal. The purpose is to reduce the interference that any terrestrial microwave transmitter could cause to the satellite transmission.

Downconverter—The part of a satellite receiving system that converts the downlink signals to a 70-MHz intermediate frequency that is used by the receiver. Although it is sometimes part of the receiver, it is more often externally mounted directly at the LNA so that inexpensive coaxial cable can bring the signal to the receiver.

Downlink signals—The signals that are transmitted from a satellite's transponder to earth.

Dual feedhorn—A waveguide feed system designed for both vertically and horizontally polarized signals.

Dual orthomode coupler—A dish-mounted device that allows reception of both vertically and horizontally polarized signals.

Earth station—A station equipped with transmitting equipment for the production of uplink signals, and also a complete receiving system for picking up downlink signals. Sometimes used synonymously, but incorrectly, with TVRO.

EIRP—An abbreviation for effective isotropic radiated power. The energy level of a transmitted signal expressed in dBW.

Elevation—The vertical angular displacement of a dish with the earth considered as a horizontal frame of reference.

Encoding—The scrambling of a signal to prevent viewing of a program by non-subscribers.

F/D ratio—The ratio of the focal length of a dish to its diameter. A method for indicating the depth of a dish.

Feedhorn—The entrance to the waveguide used to channel signals from the focal point of the dish to the LNA. See Horn.

Figure of merit—A quality factor comparing dish gain to system noise and written as G/T where T is the system noise in °K and G is the gain of the dish in dB.

Focal length—The distance from the center of the dish to its focal point.

Focal point—The point at which all the signals reflected by a dish join or cross.

Footprint—The area covered by downlink signals transmitted from a satellite.

Frequency coordinator—A test procedure that is part of a site survey to determine interference-signal levels.

Frequency reuse—A method that allows two different TV channels to be broadcast simultaneously on the same transponder by vertically polarizing one channel and horizontally polarizing the other. Another method of frequency reuse is to space satellites about 4° apart. A TVRO pointed at one satellite will not detect any signal from the other satellite, even if it is operating at the same frequency.

Geodetic north—A reference to the non-magnetic poles. Also called true north.

Geostationary—Geosynchronous. Fixed relative to the Earth. A satellite in the Clarke belt is geostationary.

Global beam—A broad pattern of signal radiation from a satellite that covers one third the Earth's surface. Used by INTELSAT satellites.

G/T—A figure of merit that describes the capability of a TVRO system to receive a signal from a satellite. The ratio (in decibels) of the gain of an receiving system to the noise temperature of the system.

Horn—A type of waveguide with a flared end. Its shape is selected so as to provide a better impedance match between the feed and open air. See Feedhorn.

Hyperboloidal subreflector—The secondary reflector used in a Cassegrain antenna system.

Impedance—The algebraic sum of resistance and reactance. Represented by the letter Z.

Isolator—A device that allows the transmission of signals in one direction while blocking or attenuating them in the other.

Ku Band—Also K band. A band of frequencies that extends from 11.7 to 12.7 GHz. The band is separated into two portions: 11.7–12.2 GHz (fixed satellite services—intended for point-to-point services) and 12.2–12.7 (for broadcasting satellite service or DBS).

Line amplifier—An amplifier inserted in any part of the transmission line following the downconverter to compensate signal losses caused by long lengths of coaxial cable or the insertion of passive devices such as splitters. Line amplifiers are also used when the signal must drive a number of television receivers.

Look angle—The positioning angle of a mount that permits a dish to focus on ("see") a satellite.

Low-noise amplifier—Abbreviated as LNA. A wide band, non-tunable amplifier that accepts satellite signals from an antenna probe and delivers them to a downconverter.

Luminance signal—Also known as a brightness signal. The monochrome portion of a color television signal.

Microwaves—Generally considered to be RF waves in the frequency range of 3 GHz to 30 GHz.

Multiple LNA's—A pair of LNA's with one used for the amplification of vertically polarized signals, the other for horizontally polarized signals.

Noise—Any unwanted disturbance (can be mechanical or electrical).

Noise factor—The ratio of output S/N to input S/N.

Noise figure—The ratio of output noise level to input noise level.

Noise temperature—Noise of a component expressed in degrees Kelvin, ordinarily used with reference to an LNA. The thermal noise that the LNA adds to the TVRO system.

Path loss—Also known as space loss. The attenuation of a signal as it travels through space.

Perigee—The point in an elliptical orbit that is closest to the earth.

Petallized dish—A receiving dish that is shipped in sections "petals" and assembled at the installation site.

Polar mount—A support for a dish that permits simultaneous movements in azimuth and elevation.

Polarization—A property of a radiated electromagnetic wave that describes the direction of its electric field.

Prime focus feed—An arrangement in which the entrance to a section of a waveguide is positioned at the signal focal point.

Reception window—An imaginary rectangle in front of a dish defining the limits of dish movement for reception from a satellite.

Remodulation—The process of modulating the recovered (demodulated) baseband signals in a satellite receiver.

Satellite receiver—A component used for tuning in a selected satellite transponder. It may contain one or two downconverters, or none. The receiver recovers the original baseband signals and delivers them to a remodulator. The receiver can also supply the DC operating voltages for an external LNA and downconverter.

Scalar feed—A series of concentric rings positioned at the mouth of the feedhorn that act as an aid in picking up reflected signals from the dish.

Slot—The longitudinal position of a satellite in geosynchronous orbit.

S/N—Signal-to-noise ratio. Ratio of the magnitudes of a signal to that of the noise. Usually expressed in decibels.

Spherical dish—A dish whose surface is a section of a sphere.

Splitter—A device with one input that provides two or more outputs to allow multiple receiver hookups to one antenna. Can be passive (an antenna coupler) or active, providing gain.

Thermal noise—Noise that occurs in all transmission media and communications equipment as a result of random electron motion (which is a function of temperature). Thermal noise sets the lower limit for the sensitivity of a receiving system.

Translation frequency—The 2220-MHz (2.2-GHz) frequency difference between an uplink and a downlink signal.

Transponder—A receiver-transmitter combination that receives (uplink) signals, and retransmits the signals on a different (downlink) carrier frequency.

Unguided wave—A broadcast wave.

Uplink—The signals transmitted from an earth station to one or more geosynchronous satellites.

Video inversion—A type of encoding or scrambling used in which the transmitted downlink video signals are inverted.

Voltage standing wave ratio—Abbreviated as VSWR. An indication of the amount of signal energy accepted by a load or reflected to the source. The best VSWR is a ratio 1:1.

VTO—*V*oltage *T*uned *O*scillator. In a TVRO, the local oscillator in an externally positioned downconverter whose operating frequency is changed by a DC voltage delivered from the in-home satellite receiver.

Waveguide—A transmission line made from a hollow conducting tube (rectangular or tubular) through which electromagnetic waves propagate.

Wind load survival—The amount of wind pressure tolerated by a dish.

DESIGNER'S NOTEBOOK

ROBERT GROSSBLATT
CIRCUITS EDITOR

An expandable keyboard encoder and display circuit.

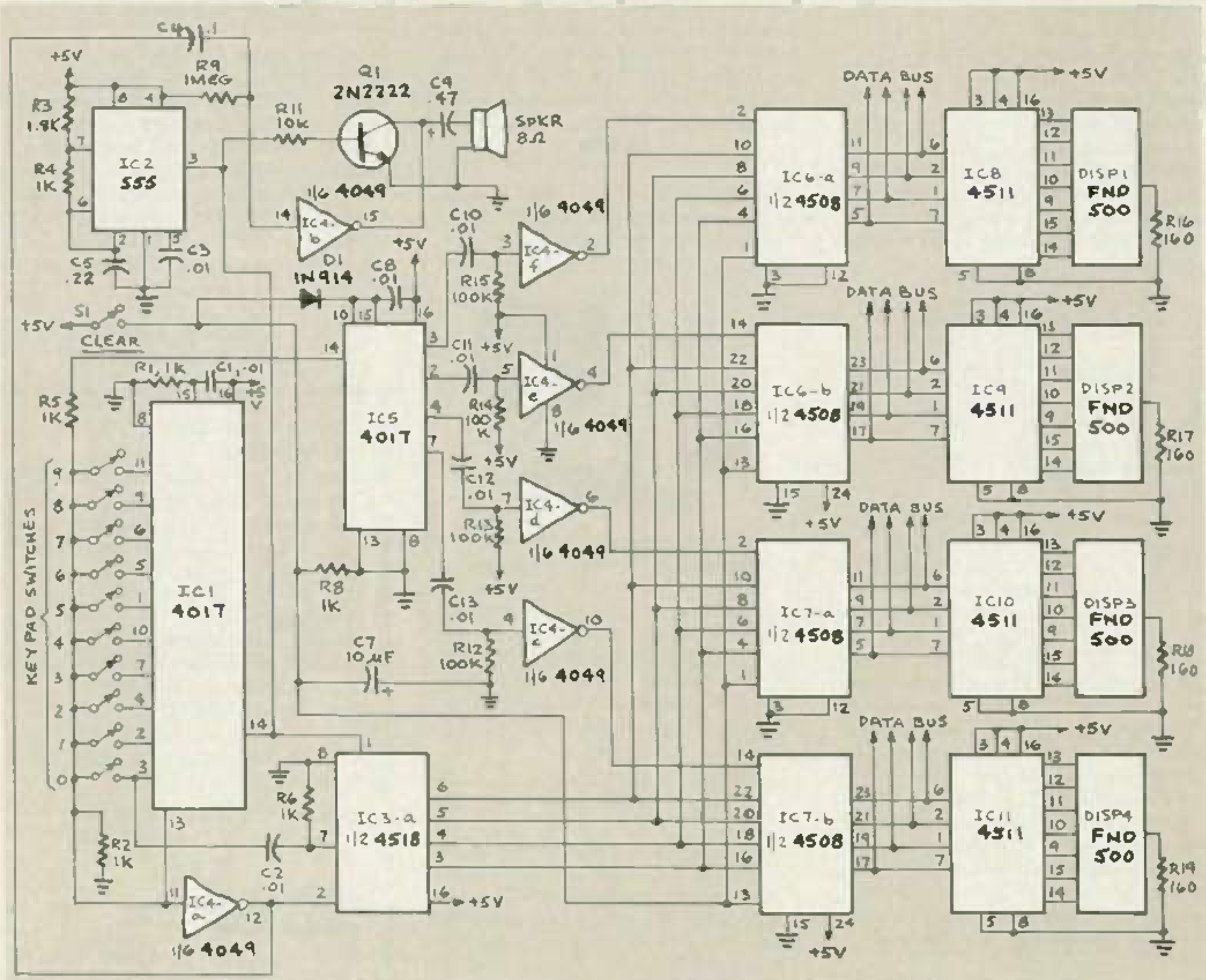
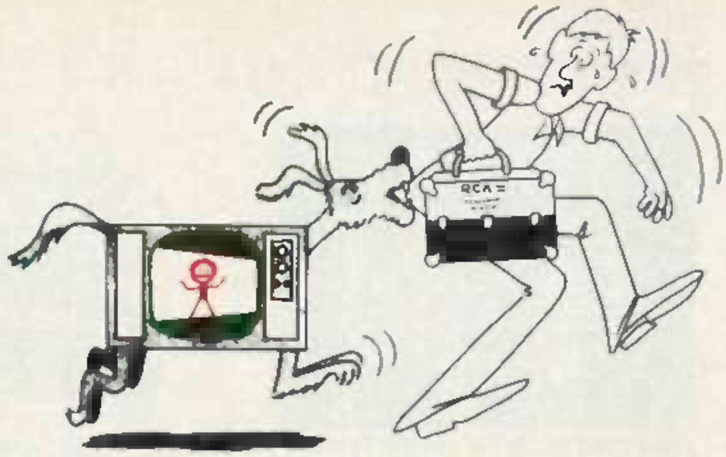


FIG. 1

A FEW MONTHS AGO IN THE "DRAWING Board" (see **Radio-Electronics**, April 1985), we spent some time talking about memory, and actually built a circuit to demonstrate the use of the 5101 CMOS memory IC. Unfortunately, we goofed. We mentioned a keyboard encoder that could be used with that memory circuit, but neglected to tell you where to find it. Sorry about that.

The circuit I was referring to appeared in the "Drawing Board" columns in the February through April, 1983, issues of **Radio-Electronics**. The schematic of that circuit is shown in Fig. 1.

How Many Times Do You Intend To Let "THE SAME DOG" Bite You ?



★ How many times have you worked all day long trying to diagnose the hi-voltage / LV regulator circuit of a set that is in shut down only to eventually find that a **shorted** video, color, vertical, tuner, AGC, or matrix circuit was causing the set to shut down and, to find that the hi-voltage / LV regulator circuit was working flawlessly all the time?

★ How many times have you spent the day looking for a **short** that was causing the set to shut down, only to eventually find that an **open** vertical, video, matrix circuit or, an **open** HV multiplier was to blame?

★ How many times have you worked all day on the same TV set, only to find out that the set's **flyback** transformer was defective?

★ How many **flyback** transformers have you replaced only to find that the original flyback was **not** defective?

★ How many horiz output transistors and Sony SG 613 **SCRs** have you destroyed while simply trying to figure out whether the flyback was good or bad?

★ How many times have you been deceived by your flyback "ringer"? Can you even count the number of hours that your "ringer" has caused you to waste?

★ How many times have you condemned a flyback, only to find that a shorted scan derived B + source was causing the flyback to "appear" as though it were defective?

★ How many hours have you wasted, working on a TV set, only to find that the CRT had a dynamically shorted 2nd anode (to primary element)?

★ How many new sweep transformers have you unknowingly destroyed because a short existed in one of the scan derived B + sources?

★ How many times have you said to yourself, "I could fix this - - - -thing if I could only get it to fire up long enough to lite the screen? - - - without blowing an output transistor or a fuse."

★ How many additional bench jobs could you have gotten, had you been able to give an accurate, "on the spot" estimate on sets that were either in shut down or, not capable of coming on long enough for you to analyze them?

If you had been using our all new Super Tech HV circuit scanner, you would have had an accurate evaluation concerning all of the above in about one minute, at the push of **just one** single button.

It's true! Push just one test button and our HV circuit scanner will (1) Accurately prove or disprove the flyback, (2) Check for any possible shorts in any circuit that utilizes scan derived B +, (3) Check the scan derived power supplies themselves for shorted diodes and / or electrolytic capacitors, (4) Check for primary B + collector voltage and, (5) Check the horiz output stage for defects.

Our HV circuit scanner works equally well on sets with integrated or outboard HV multipliers. It will diagnose any brand, any age, solid state TV set including Sony. The only exceptions are sets which use an SCR for trace and, another for retrace (I.e., RCA CTC 40 etc.). Our scanner will not work on these sets.

In plain English, our HV circuit scanner is even easier to operate than a "plain vanilla" voltmeter.

First off, when you're using a scanner, **you do not** remove the flyback in order to check it. In fact, you don't even unhook any of the wires that are connected to the flyback! All you do is:

(1) Remove the set's horiz output device, plug in the scanner's interface plug, then make one single ground connection. That's all you do to hook it up.

(2) If the primary LV supply is functional and, assuming that the emitter circuit of the horiz output stage has continuity, the scanner will tell you that it is ready to "scan" by illuminating the "ready" light, which is the white button on the test / run switch.

(3) Press the spring loaded (test) side of the test / run switch and the scanner will "look" for any type of a **short** that might exist anywhere on the secondary side of the flyback, including the HV multiplier, any circuit that relies on flyback generated B + and, including the flyback itself (both primary and all secondary windings). It will simultaneously check for a shorted LV regulator device HV multiplier, or an open or "partially" open safety capacitor.

If a short or, an "excessive load" exists on one secondary winding, all other secondary windings will have "normal" output voltage in spite of the short. Only the shorted winding itself will have zero volts on it. This makes shorted scan derived B + sources incredibly easy to isolate. During this test, the 2nd anode voltage is being limited to approx 5 kv by the scanner.

If a short is present, the red "flyback" light will either lite, or flash (at various speeds), depending on which type of a short exists. If no shorts exist, the "flyback" light will be green.

Assuming that the "flyback" light is green, no **shorts** exist and, it is now time (and safe), to begin looking for **open** circuits which might be causing the set to shut down due to flyback run-a-way. It only stands to reason that if no shorted conditions exist, then one (or more) circuits will have to be open, otherwise, the TV set would be working!

(4) Now that you know that no **shorts** exists, push the "run" side of the test / run switch (the side that latches). Provided all of the other circuits in the TV set are functional, the scanner will now put a picture on the set's CRT screen that has full vertical and horiz deflection, normal audio, video and color.

Keep in mind that during this test, your scanner is:

(1) Circumventing all horiz osc/driver related shut down circuits.

(2) Limiting the set's 2nd anode voltage to approx 20-25 kv,

(3) Substituting the set's horiz osc/driver circuit and, as a result, eliminating any need that the set might have for an initial start up or B + resupply circuit for the osc/driver.

Wait about 15 seconds for its filaments to warm up, then look at the CRT. Any circuits that are **"open"** will now produce an obvious symptom on the screen. Because the scanner has circumvented all of the set's shut down features, you can now use your old reliable "symptom to circuit analysis" technique to troubleshoot the problem, I.e., if the picture has no blue in it - - - repair the blue video or blue matrix circuit. If the picture has only partial vertical deflection - - - repair the vertical circuit, and so on. The scanner has effectively removed all of the stumbling blocks that would normally prevent you from diagnosing the problem. I.e., start up and shut down features, and allowed you to repair the TV set by using conventional techniques.

When you're using a scanner, all start up, shut down, dead set problems are easy to solve. You don't need anyone to tell you just how difficult these problems can be for those who don't have a scanner!!

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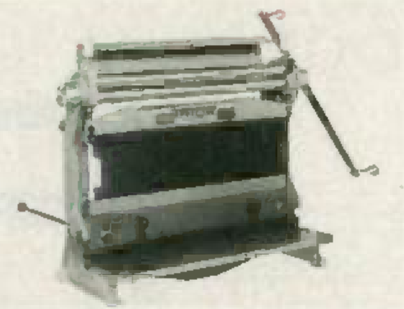

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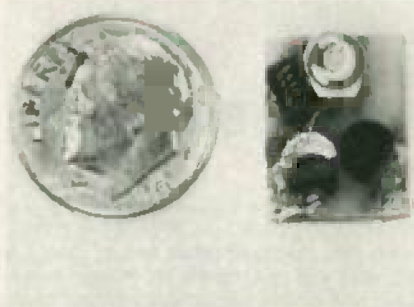

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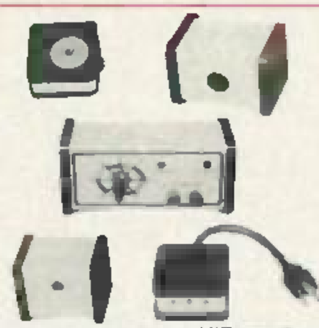

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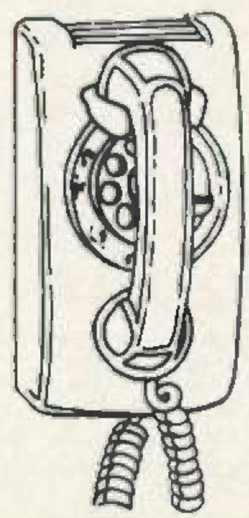

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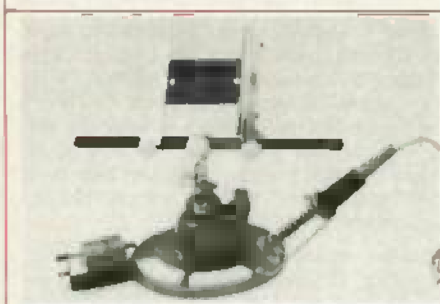

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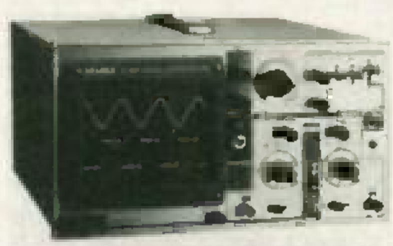

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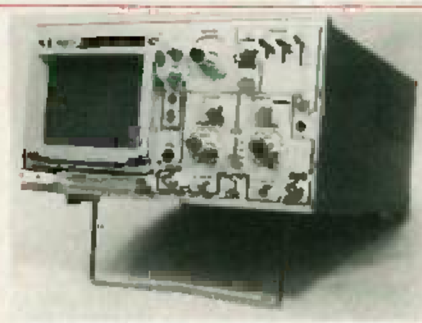

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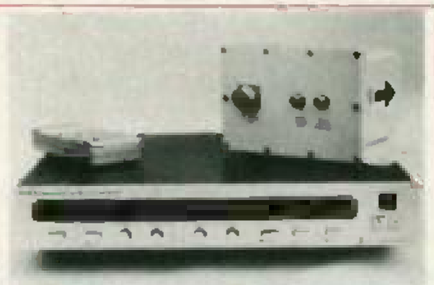

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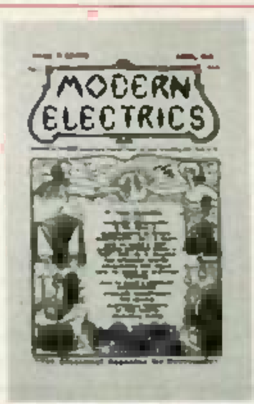

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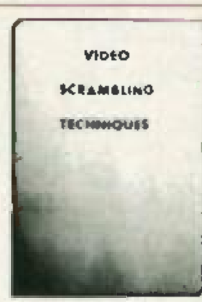

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CIRCLE 284 ON FREE INFORMATION CARD

Let's begin by looking at the major functions of the keyboard encoder. A 555, IC2, is set up to oscillate at a frequency of about 2 kHz. That signal is used to drive Q1 and SPKR, which provides an aural key-press indication. The 2 kHz signal also drives IC1, a 4017 decade counter, whose 1-of-10 outputs appear on pins 1–7 and 9–11. When one of the switches is pressed, the output from the 4017 is fed through IC4-a to the ENABLE input of IC3-a. Since IC3-a is also fed by the 2 kHz clock signal, that IC "freezes" at the current count, and its BCD output is presented to the inputs of the 4508 dual four-bit latches.

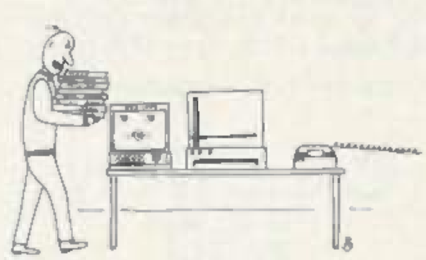
The output from IC1 is also fed through resistor R5 to IC5, another 4017, which acts as a digit selector. Each time IC5 is clocked, its output increments by one, and that provides a signal to strobe the "frozen" BCD value into the appropriate latch IC. Since we're only driving four digits, the Q4 output of IC5 (pin 10) is fed to that IC's RESET input (pin 15).

After the BCD data has been latched in IC6 or IC7, the data is presented to a 4511 seven-segment display decoder/driver. The output of that IC is fed to the displays. So the value of the first key pressed will appear in DISP1, with following entries appearing in DISP2, DISP3, and DISP4; and the next entry will appear in DISP1, and so on.

Note that we use only one resistor for current limiting in each display. Since different digits have different numbers of "on" segments, not all digits will glow with equal brightness. If that bothers you, just insert one resistor between each 4511 output and each FND500 input. That's seven resistors per display, and 28 total. You may use any low-current, common-cathode seven-segment LED for DISP1–4; you could also use discrete LED's, if desired.

Capacitors C1 and C8 provide a power-on-reset function, and IC4-b is used to turn the speaker *off* after about 1/10-second. The 4508 latches are three-state types, and that allows the corresponding lines from each digit (labeled "Data Bus") to be connected together and tied to any external data bus—such as our memory-demonstration circuit.

If you're interested in displaying more digits (as many as ten), simply duplicate the group of components IC4-f, IC6-a, IC8, and DISP1, as well as C10 and R15. To add another digit, connect the capacitor to the Q4 output on IC5, and drive its RESET input with the Q5 output. You could increase the number of digits beyond ten by driving an additional 4017 from the CARRY output of IC5. **R-E**



"One more stunt like this, and I'll cut your modem cord!"

ROBOTICS

Ultrasonic vision

MARK J. ROBILLARD
ROBOTICS EDITOR

FOR A ROBOT TO EXHIBIT EVEN A modicum of intelligence, it needs some type of feedback mechanism between the "thinking" part and the "doing" part. Without some type of feedback, the "thinker" can't adjust the actions of the "doer" in response to changes in its environment.

The most useful form of feedback for human beings is visual. Machine vision, however, is limited by current technology in its ability to resolve details and in its ability to estimate distances.

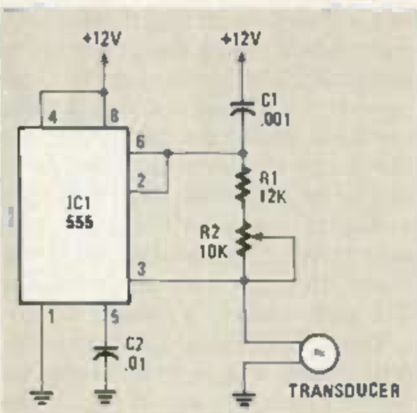


FIG. 1

There are several dozen companies now selling machine-vision systems to industrial manufacturers. Those systems are generally used to inspect finished goods. There are a few companies selling devices that will help a mobile robot get around in a cluttered room. With that type of vision, a robot can see what it is gripping, where it is going and where it has been.

Human beings have a crude, built-in distance measuring system that makes use of the eyes as well as stored knowledge of how

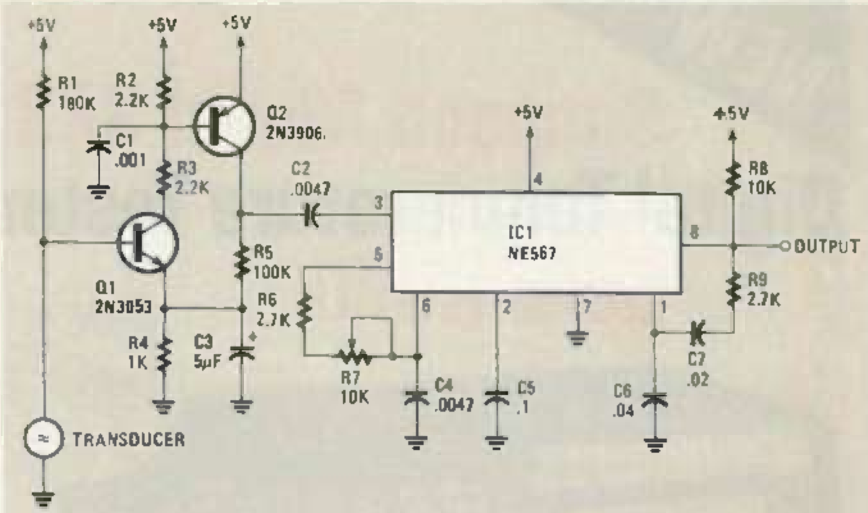


FIG. 2

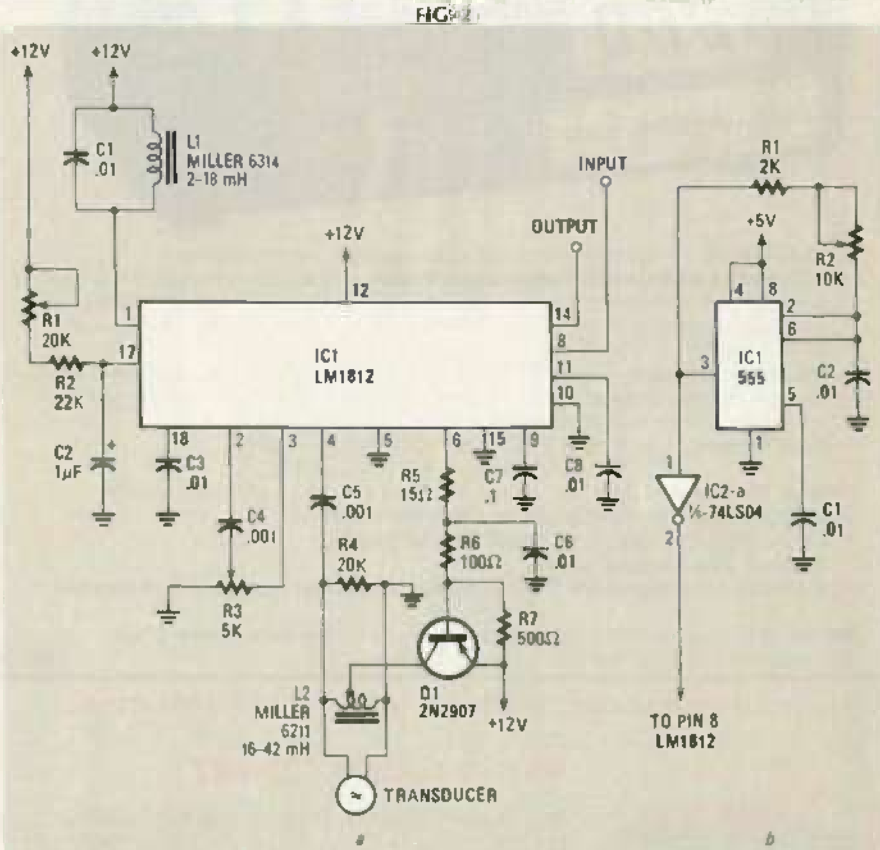


FIG. 3

an object looks at different distances. We then compare the known image to the one we are presently encountering and *voilà*—we obtain a rough estimate of the object's distance. That is the method used by systems that inspect parts on a finished-goods assembly line. We could apply that method to a robot system, but that would require auto-focusing lenses and complex image-analysis algorithms in the controlling electronics. However, there is a simpler and more economical way to obtain distance information: *ultrasonic ranging*. That method is frequently more accurate than light-wave systems.

Ultrasonics theory

In a typical ultrasonic ranging application, an ultrasonic transmitter starts a timer as it emits a short burst of 40-kHz sound waves through its transducer. Those sound waves spread out as they travel through free air. When they strike an object in their path, some of the sound is deflected back toward the transducer, which now acts as a receiving device, like a conventional audio microphone. The received sound waves are sent to a discriminator circuit that stops the timer.

The value in the timer is proportional to the length of time it took the sound waves to travel to the object and return to the origin. We can determine the distance (D) from the period measured by the timer (T) by using the classic formula, $D = V/T$. V here stands for velocity, and is simply the velocity of sound waves in air, about 13,080 inches per second. Basically that's all that's needed to measure distance. So let's look at some practical implementations of both transmitters and receivers.

Ultrasonic circuits

A simple 40-kHz transmitter is shown in Fig. 1. The 555 is a very inexpensive eight-pin timer IC configured as an astable multivibrator oscillating at a frequency of 40 kHz. (That frequency can be adjusted by potentiometer R2.) With a twelve-volt supply, the 555's output will swing about ten volts, which should be enough to drive common transducers. Any 40-kHz oscillator could be substituted for the circuit shown in Fig. 1. In fact, it would be quite simple to generate a 40-kHz signal with a computer, and drive a transducer with that signal through an open-collector TTL gate (such as a 7406).

The receiver portion of the system is only a little more complex. In the circuit shown in Fig. 2, the received signal is amplified by a discrete transistor amplifier, and then applied to a tone-decoder NE567. That IC, a phase-locked-loop contains its own internal oscillator that must be adjusted to match the transmit frequency. The NE567 has a comparator that will send the output high when it detects an incoming signal equal in frequency to its internal oscillator.

The circuit shown in Fig. 3-a uses a single IC specially developed by National for use as an ultrasonic transceiver. Using such a device allows you to use a single transducer for both transmit and re-

continued on page 108

DRAWING BOARD

ROBERT GROSSBLATT
CIRCUITS EDITOR

Clever hexadecimal display circuits

I HAVE TO TAKE MY HAT OFF TO YOU people out there. I've been telling everybody here that you are the smartest readers of this magazine, and you've proven me right once again. A few months ago I asked you to come up with a circuit that would drive ordinary seven-segment LED's and give hexadecimal outputs (Ø through 9 and A through F) for binary inputs. To tell the truth, I expected no more than a couple of letters. Boy, was I wrong!

So far I've gotten ideas from over 100 of you, containing such a variety of circuits that it took me weeks to sort through them all. Obviously, many of you are interested in how to display hex values, so I'm going to take a month off from our discussion of the Z80 and devote this month's column to reporting some of the solutions. But before I go any further, let me remind you that I can't mention everybody's name or describe everybody's solution. Basically, the solutions I've received fall into three categories:

- A. Using special display IC's.
- B. Using elaborate decoding logic.
- C. Using PROM's for decoding.

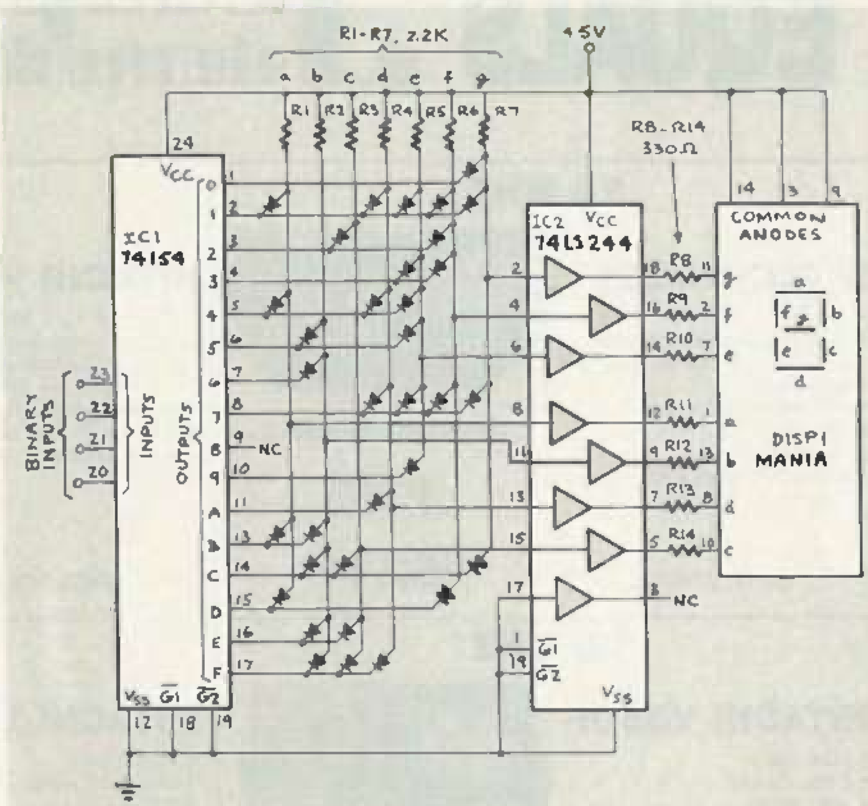


FIG. 1

Dedicated IC's

There are several dedicated IC's that do the job, and, to tell the truth, I was somewhat surprised that more of you didn't suggest that solution. One person who did was Michel Peloquin from Canada. He suggested using the Motorola MC14495, which is a display decoder/driver that does just what we need: It decodes four-bit binary data into the correct output to drive seven-segment, common-cathode LED displays. Using that IC is no more complicated than using a 4511, or other common devices. The MC14495 is a CMOS device, so it may be used with supply voltages ranging from 4.5 to 16 volts DC. In addition, it has built-in current-limiting resistors, making the MC14495 an elegant solution to our problem.

So, you may well ask, if the MC14495 is so wonderful, why not use it? There is no problem when buying it in large quantities. But trying to find it in hobbyist quantities is murder. None of the regular mail-order houses advertise it, and when you do find it, the price is too steep to make using the 14495 worthwhile.

A special thanks to Bob Milton for letting me know about the Fairchild 9368, another one-IC solution. The 9368 also drives seven-segment, common-cathode displays, but has no built-in current limiting resistors. However, it is easily available, and costs just over $3.00 in small quantities.

Gates-only solutions

I was really impressed by some of the gates-only designs you sent in. Doing a gates-only solution to a *continued on page 101*

STATE OF SOLID STATE

ROBERT F. SCOTT
SEMICONDUCTOR EDITOR

Surface-mount technology comes of age.

PRINTED-CIRCUIT BOARDS WERE WIDELY used before semiconductors began to appear in consumer-electronics products. Components were almost invariably mounted on the top of the board, with terminal leads protruding through holes to the underside of the board where components were interconnected. That technique remained an international standard as semiconductors replaced vacuum tubes.

With the advent of digital watches, business-card calculators, and portable personal computers, engineers were hard-pressed to cram more circuitry in less space. In addition, the DIP with its increasingly high pin-counts suffers from inductance, resistance, and capacitance problems that adversely affect processing speed.

One solution to those problems is *surface-mount technology*, or SMT, which makes it possible to mount both discrete and integrated semiconductor devices directly on the surface of the PC board. Cost savings are effected due to a reduction in the number of plated-through holes, improved board yields, and higher component density. Components can even be mounted on both sides of the board with little increase in volume. Using SMT, Texas Instruments has achieved space reductions between 46 and 60% over circuits previously assembled on PC boards with discrete components.

Surface-mount transistors

Several semiconductor manufacturers are now producing

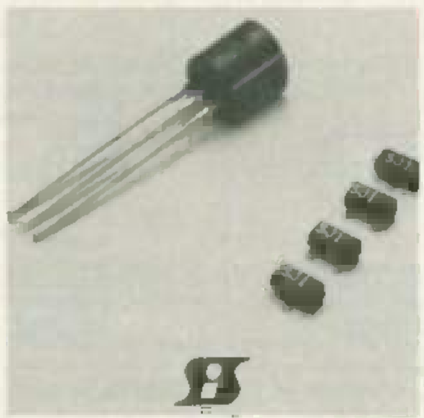


FIG. 1

transistors in the SOT-23 package—a subminiature three-lead package one-fourth the thickness of the common TO-92 package. In Fig. 1 we see four such SOT-23 devices (made by Siliconix) laid out beside a standard TO-92 device.

The SOT-23 package was originally introduced in two different heights, but Ferranti Semiconductors has introduced what they call their "optimum profile" package. Ferranti believes that their package eliminates the need for both standard and low-profile packages. The space between the device and the PC board allows for proper cleaning and also allows traces to be run beneath the device, while still permitting the device to be epoxied to the surface of the board. (Since there are no through-the-board leads, surface-mount components must be epoxied to the board before they are soldered. Soldering is usually accomplished by a solder-reflow process.)

Ferranti offers a number of devices for SMT, including both NPN and PNP transistors, ranging from general-purpose, low-noise, and switching devices, to medium-power, high-frequency, and high-voltages types. Also included is a line of switching, Schottky, Zener, and varactor diodes.

Other SOT-23 devices made by Ferranti is the FMMT38 family of NPN Darlington transistors that feature high breakdown voltage (V_{CEO}), and HFE ratings between 1000 and 10,000 at 500 mA and 5 volts (pulsed). Applications range from audio driver and output stages to drivers for lamps, relays, and hammers.

The 6-page "SOT-23 Transistor and Diode Selection Guide" lists key parameters of more than 250 devices for hybrid and SMT applications. Further information on the "optimum profile" package and copies of the selection guide are available from **Ferranti Semiconductors**, 87 Modular Ave., Commack, NY 11725.

A line of fifteen small-signal FET's is now being offered in SOT-23 packages by Siliconix. The devices, available in one P-channel and four N-channel configurations, are characterized as general-purpose amplifiers, low-noise amplifiers, low-leakage amplifiers, high-frequency amplifiers, and high speed analog switches. Prices are approximately 36 cents each in 5000-piece quantities.

Surface-mount IC's

As shown in Fig. 2, surface-mount IC's are currently being offered in three SMT packages. These are SOIC (*S*mall *O*utline *I*ntegrated *C*ircuit), the PLCC (*P*las-

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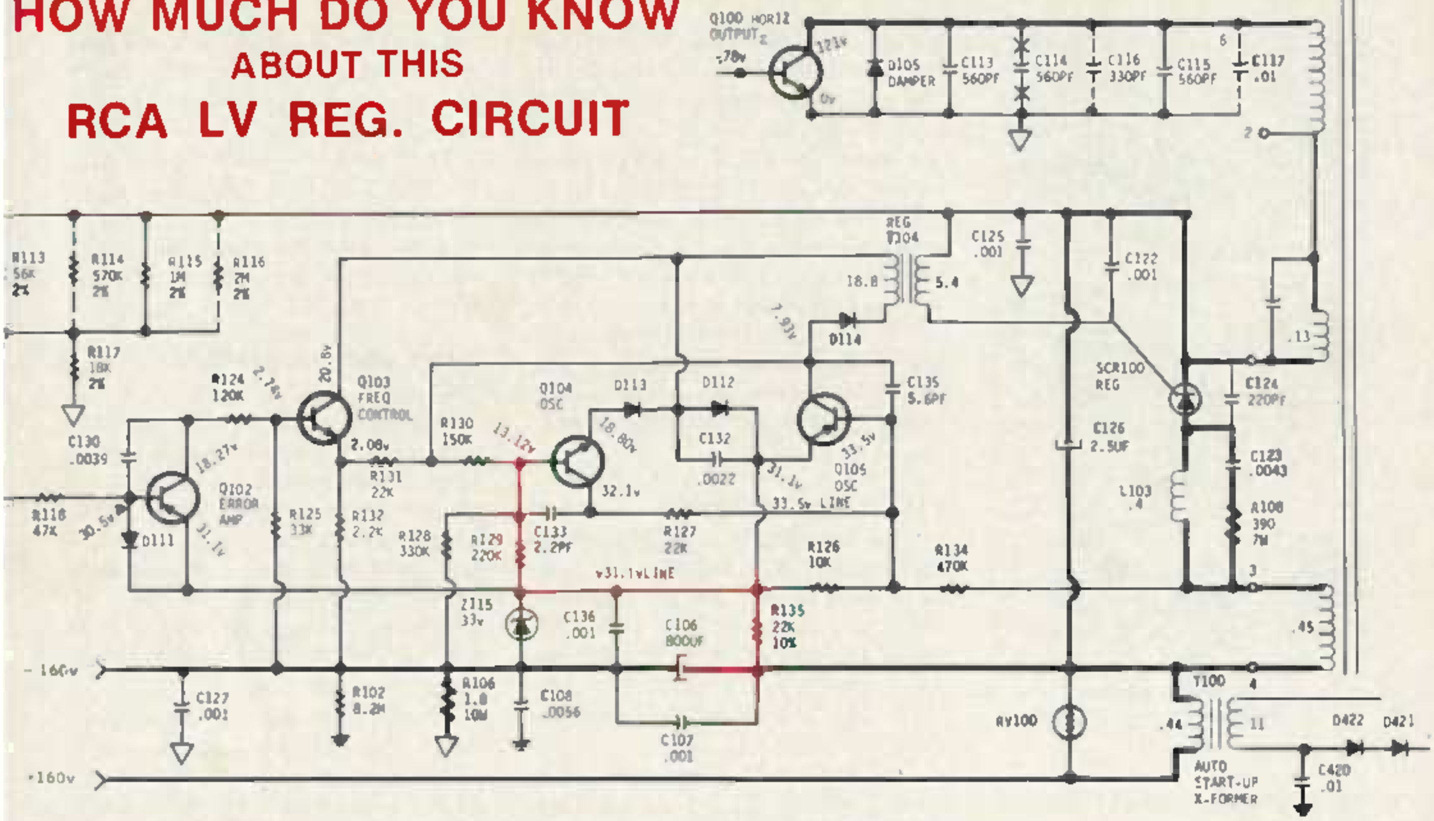
HOW MUCH DO YOU KNOW ABOUT THIS RCA LV REG. CIRCUIT



Typical of RCA CTC 85 thru 108 LV Regulator Circuits

Schematic by Diehl Engineering

How many of these questions can you answer ?

(1) Every circuit has a beginning and an ending. Where does this circuit begin ?

(2) Specifically, what is the purpose of this circuit ?

(3) What turns it on ? What turns it off, or does it ever really turn off ?

(4) Does this circuit have a shut down feature ? If so, which components are involved ?

(5) What would happen if Q103 were to become shorted E to C ?

(6) What purpose does Z115 serve ?

(7) What would happen if D114 became shorted ?

(8) What purpose does C126 serve ? What will happen if C126 becomes open ?

(9) Is the winding between terminals 3 and 4 of the flyback a primary or a secondary winding ?

(10) What purpose does C117 serve ? Exactly what does it do, and exactly how does it do it ?

(11) Exactly what do resistors R113, 114, 115, 116, and 117 do ? What happens if they change value ?

(12) What occurs that causes this circuit to produce an initial start up pulse ?

(13) Why does this entire circuit become shorted and begin to destroy horiz output transistors if the regulator SCR becomes shorted ?

(14) There is exactly one safe and practical method of circumventing this LV regulator circuit for test purposes. This technique does not involve a variac. Instead, you must disconnect one wire then connect a jumper wire from terminal #4 directly to ______. Which wire do you disconnect and where do you connect the other end of your jumper wire ?

(15) If SCR100 is shorted, this circuit will still "eat" horiz output transistors even if you are using a variac. Why ?

(16) Why does this circuit use a floating ground ?

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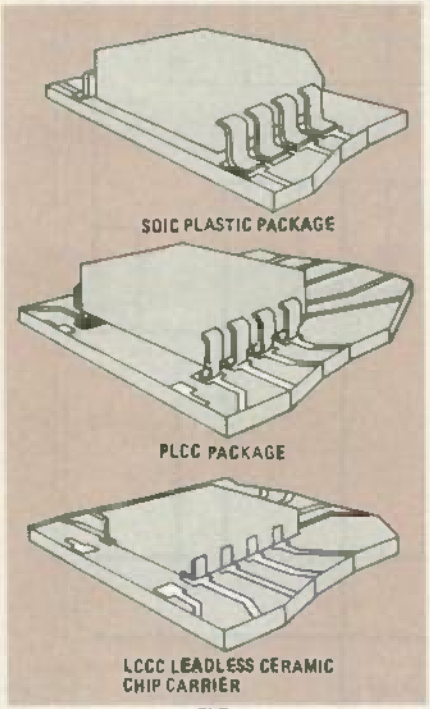

FIG. 2

tic *L*eaded *C*hip *C*arrier) and the LCCC (*L*eadless *C*eramic *C*hip *C*arrier).

The SOIC has leads on two sides. Its "gull-wing" leads are bent outward; they lie parallel to the mounting surface. The SOIC comes in 8-, 14-, 16-, 20-, and 24-pin versions. The PLCC is intended to house devices requiring 20 to 68 pins. The PLCC has J-shaped leads spaced equally around the sides of the package. The J-shaped leads are tucked under the plastic body as shown in the middle drawing of Fig. 2. The LCCC is similar to the PLCC but is considerably more expensive and is used mainly in military applications.

PLCC's from Motorola

The MCM63256 and MCM65256 256K (32K × 8 bit) MOS mask-programmed ROM's are packaged in PLCC's, and the rolled-under "J" leads are compliant, thus reducing temperature-coefficient problems. The 32-lead devices measure 0.450 × 0.550 inches.

The MCM63256 is fabricated using Motorola's silicon-gate HMOS process; those new units are available with access times of 150 and 200 nanoseconds. The MCM65256 is designed for low power dissipation, and uses Motorola's complementary HCMOS technology.

Prices of the MCM63256 and MCM65256 will be about $5.65 in quantities of 1000. For more information, contact Motorola, MOS Memory Products Group, PO Box 6000, Austin, TX 78762.

Zener diodes in TO-220 packages

Motorola now has 10- and 50-watt Zener diodes housed in a TO-220 plastic package that can replace more expensive metal-packaged devices. The 10-watt MZT2970-3015 series offers voltages ranging from 6.8 to 200 volts while the 50-watt MZT3305-3350 and MZT4549-4554 families range from 3.9 to 200 volts.

Retail prices for the 10-watt series of Zener diodes, in quantities of 100 and up, range from $0.75 to $0.96; 50-watt units range in price from $1.10 to $1.74.—**Motorola Semiconductor Products**, PO Box 20912, Phoenix AZ 85036. **R-E**

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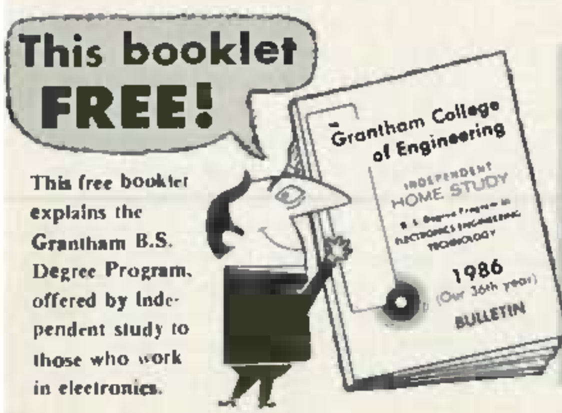

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COMMUNICATIONS CORNER

Communications in the computer age

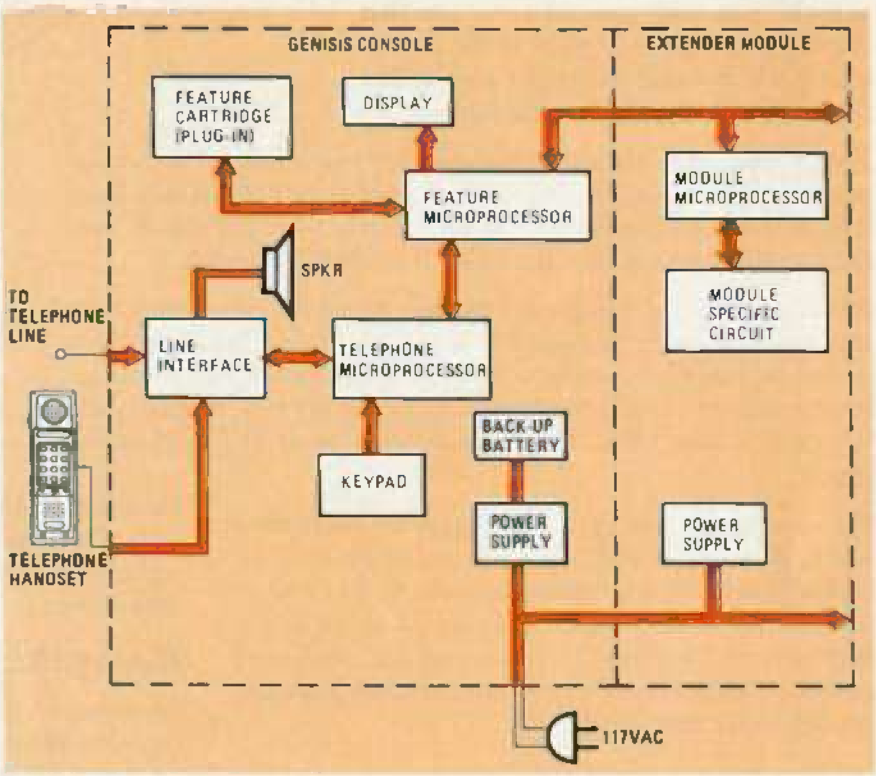
HERB FRIEDMAN
COMMUNICATIONS EDITOR

THE COROLLARY TO THE OLD CLICHE that says something will always rush in to fill a vacuum is that if a need is created, someone will manufacture the required equipment. But it's really amazing to see the product created first and then a need develop simply because the product exists.

While we've come to expect that kind of thinking from the manufacturers of small appliances, and the gizmos and gadgets that fill mail-order catalogs, it's somewhat surprising to see how successful it's been in communications—particularly on the dial-up telephone system.

Have you ever wonder what happened to CB and all those who enjoyed chit-chatting over the airwaves? You'll find many of them on the telephone using a service that connects up to five semi-random callers at once. Simply dial a telephone number (usually long distance), and a computer connects you with four other users that have similar interests.

Already there are phone numbers for teenagers, young adults, and senior citizens. Once connected, if you don't like the group you're in, you can hang up, call in again (another charge), and the computer serves up a different set of callers. That scheme may eventually attract many special-interest groups, like photographers, calligraphers, or even a group out to cut the cost of their telephone bills!



Changes in telecommunications

Since we're in the computer age, what is more natural than to computerize family communications? Unfortunately, there's little that can be done with routine telephone calls, because the voice must move from one point to another. And users usually don't care how many computers there are between the talker and the talkee as long as it's not necessary to shout into the phone.

But as successful salespeople have been taught from the cradle: You don't sell the steak, you sell the sizzle. In other words, if you can't computerize the telephone call, computerize the instrument. Today's telephones use computers to provide services that no one dreamed of only five years ago.

The best example of how to load a home (or business) phone with computerized functions is AT&T's *Genesis* Telesystem. *Genesis* is basically a computerized desk or wall-mounted console whose operating and convenience features can be upgraded by the user with plug-in program cartridges.

If the desired feature is too complex for a pocket-size cartridge, it can be made part of a complete extender module that connects to the base unit. Since the microprocessor and power-supply buses of the console interconnect to the extender unit, the entire system comes under the control of the console's microprocessor.

Figure 1 is a block diagram of the

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R-2000
All-mode receiver.

- Covers 150 kHz – 30 MHz in 30 bands.
- All mode: USB, LSB, CW, AM, FM.
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- Memory scan.
- Programmable band scan.
- Fluorescent tube digital display of frequency (100 Hz resolution) or time.
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- Three built-in IF filters with NARROW/WIDE selector switch. (CW filter optional.)
- Squelch circuit, all mode, built-in.
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- Large front mounted speaker.
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- AGC switch. (Slow-Fast.)
- "S" meter, with SINPO scale.
- High and low impedance antenna terminals.
- 100/120/220/240 VAC operation.
- RECORD output jack.
- Timer REMOTE output (not for AC power).
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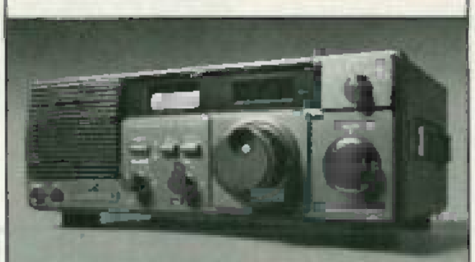
Specifications and prices subject to change without notice or obligation.

R-1000 High performance receiver • 200 kHz-30 MHz in 30 bands • AM, CW, SSB • 3 IF filters • noise blanker • RF attenuator • S-meter • 120-240 VAC • muting terminals • built-in speaker • digital display/clock/timer



R-600 General coverage receiver • 150 kHz-30 MHz in 30 bands • AM, CW, SSB • IF filters • noise blanker • RF attenuator • S-meter with SINPO scale • front mounted speaker • 3 antenna inputs • 100-240 VAC operation • record jack • muting terminals • digital display

Optional accessories:

- VC-10 VHF converter for R-2000 covers 118-174 MHz
- YG-455C 500 Hz CW filter for R-2000
- HS-4 Headphones
- HS-5 Deluxe headphones
- HS-6 Lightweight headphones
- HS-7 Micro headphones
- DCK-1 DC cable kit for 13.8 VDC operation
- AL-2 Lightning and static arrester
- Service manuals are available for all receivers and most accessories.

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

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Genesis system. Notice that two separate microprocessors are provided. The telephone microprocessor handles only actual telephone communications. It converts the keypad entries to pulse or *Touch-Tone* dialing (switch selectable), controls a built-in speaker that is used to monitor the line so that you know when to pick up the handset (automatically disconnecting the speaker), and controls the interfacing to the telephone line.

The feature microprocessor is interfaced to the one for the telephone. It provides 9 controls and the individual convenience features, such as a digital display of the number dialed, a digital clock/calendar/alarm and call timer, and single-touch memory dialing (of which three are reserved for emergency numbers).

As Fig. 1 shows, the power supply also includes a 9-volt transistor-radio type battery as a backup. The purpose of the battery is to keep the telephone "alive" when there's a power failure. If the AC power fails, or the cartridge gets damaged, the telephone still works; the three programmed emergency call buttons will dial, and the remaining nine memories will retain their programming.

If both the power and the batteries fail (highly unlikely), the telephone is disabled, because it needs a local power source to operate. That's one of the prices paid for computerization. Fortunately, the microprocessor also tests the battery.

If the battery's voltage falls below a reference level, the display shows the words BATTERY LOW. And if you wait too long to replace the battery, the display shows the dreaded words BATTERY DEAD.

Notice from Figure 1 that the cartridge that provides the individual communications features is similar in concept to the plug-in game cartridges for home-and-family computers in that the instructions (program) for the microprocessor are in ROM.

The basic feature cartridge, which comes with the unit, provides touch-tone dialing, a call timer, and hold; an clock/alarm, a ringer control, and speaker on-off.

Custom cartridges—which the user can install to replace the basic feature cartridge—can provide three-way calling, call forwarding, and call waiting, an electronic appointment reminder that displays up to 40 messages and even beeps when it's time to do something, and an electronic padlock that can lock out long-distance and operator-assisted calls.

Another module even memorizes and automatically alphabetizes a personal telephone directory. Since there's only one cartridge "slot," it's obvious that the features stack. That is, the upgrade cartridge has the features of the cartridge one level below, plus the upgrades.

If the feature is too large to fit into a cartridge, such as a speakerphone or multi-user dialer, it comes as an add-on extender that attaches to the right side of the the console so that the two form an integral unit. R-E complex logic problem can be a tedious job. And no matter how elegant your solution, there's always another one just a bit more elegant hovering around the corner. But whatever solution you arrive at, if it works, you should be proud of yourself.

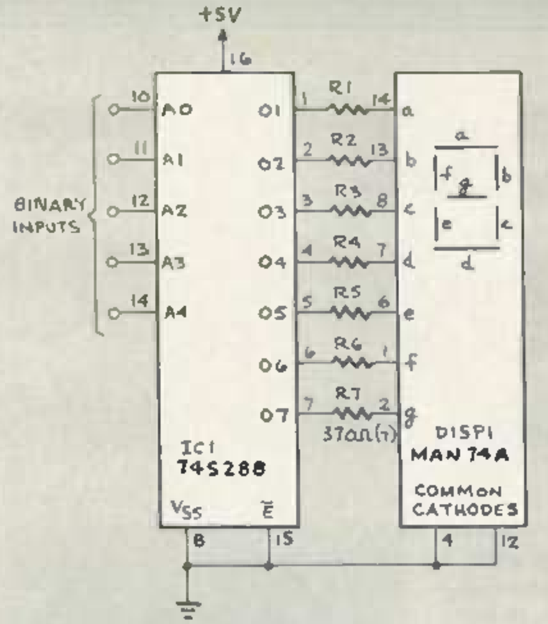
Jeff Davis sent me a complex solution that uses quite a few analog switches to decode every possible state (sixteen in all) of a four-bit binary word. A more elegant solution was sent in by Bob Milton of Canton MI. He did what a lot of you did. He used a standard decoder/driver (like the 7448) to drive the display for inputs from ØØØØ to Ø111, and additional circuitry to drive the display for inputs from 1ØØØ to 1111. The trick is to use the high bit of the input word to disable the display driver IC for inputs greater than or equal to 1ØØØ.

Bob hooked a 7404 inverter to the D input (pin 6) of a 7448, and fed the output to the BLANKING INPUT (pin 4) of that IC. So for any input greater than Ø111, the D input goes high, the 7404 goes low, and the IC is disabled. Then the display LED may be driven with other circuitry. But be careful. Many of you confused turning off the display with three-stating it. In the case of a 4511, for example, a blank display means that the outputs are all low—and that's a far cry from being three-stated!

Since you'll drive the display with additional decoders for inputs above Ø111, you should isolate both driver sections with three-state buffers. If you don't, the operation of the whole circuit is going to be flaky at best and nonexistent at worst.

Many of you went the data-selector and diodes route. That's like building your own PROM, and is a sensible way to solve logic problems when you're short on time, supplies, and patience. Grey Benton of Campbell, CA sent the circuit shown in Fig. 1 as an example of that kind of approach.

Circuit operation is simple. Each four-bit word at the input will cause one and only one of the 74154's outputs to go low. The segments of the display are driven by IC2, a 74LS244 octal buffer whose inputs are held high by 2.2K resistors R1 to R7. Any segment that's tied to a 74154 output through a diode will stay off when that output is selected.



CHARACTER	ADDRESS	CONTENTS
0	0000	11111100
1	0001	01100000
2	0010	11011010
3	0011	11110010
4	0100	01100110
5	0101	10110110
6	0110	10111110
7	0111	11100000
8	1000	11111110
9	1001	11110110
A	1010	11101110
b	1011	00111110
C	1100	10011100
d	1101	01111010
E	1110	10011110
F	1111	10001110

There are both advantages and disadvantages to that sort of design. On the plus side, the format of the display of each digit can be changed simply by adding or removing diodes. In addition, as Grey points out, the circuit can be put together from readily available parts for about 10 bucks—including perfboard and IC sockets. The drawback is that the circuit takes a lot of connections.

The PROM approach

Using a PROM was the most common solution to our problem. That approach is shown in Fig. 2-*a*. The truth table to decode sixteen binary inputs has sixteen entries, as shown in Fig. 2-*b*. For such a small amount of data, a small PROM will suffice. You could burn the code into an EPROM, but the smallest one available is the 1K–by–8 2708. Since we only need sixteen bytes, using a 2708 is like going after a fly with an elephant gun.

The best choice is probably a small bipolar PROM, such as the one most of you mentioned, the 74S288, which has a 32-word × 8-bit memory, costs about $2.00 in small quantities, and is available everywhere. The 74S288 is rather easy to program (as bipolar PROM's go).

Jackson Harris of Helena, MT sent me the truth table shown in Fig. 2-*b*. Burning it in a 74S288 will give you a single-IC decoder/driver for common-cathode displays. But you've still got half the PROM to play with. You could make use of that by burning an inverted truth table in the upper half of the PROM. You would then have an IC that could drive either a common-anode or a common-cathode LED display. Select the one you want by using address input A4 (pin 14) as a selector. Tie it low to drive a common-cathode display, and tie it high to drive a common-anode display.

As you know, the problem with bipolar PROM's is getting them programmed. There are many programming services that will program bipolar PROM's for you. All you have to do is provide them with the code and the cash.

But designing a circuit to burn bipolar PROM's isn't very difficult. All the specifications are given in the data books, and the problem is just complex enough to be interesting.

If you're interested in the subject, I'll spend some time on it. But for now, get ready to roll your sleeves up again because next month we're going to continue our discussion of the Z80. **R-E**

ANTIQUE RADIOS

RICHARD D. FITCH
CONTRIBUTING EDITOR

Dealing with tubes

FIRST OF ALL, I WANT TO THANK EVERYbody who has taken time to write. I only wish that I could answer all your questions and supply all the parts you need to get your radios restored to their original condition. Believe me, I know from first-hand experience how hard it can be. This month's column should help, though. We'll talk about tube substitution and then present some requests for help from readers. But first, let's get to the antique radio of the month.

Antique radio of the month

The Philco *Junior Model 80* shown in Fig. 1 is this month's restoration case history. Its thin-veneered cabinet, four-tube chassis, and ability to receive only the AM broadcast band doesn't qualify it as a top-of-the-line radio. However, it does have a few interesting features, including a superheterodyne circuit, field and bucking coils on the dynamic speaker assembly, and a volume control in the antenna circuit (a common practice in many early radios).

Another interesting feature of the *Junior Model 80* is that it was originally sold with a choice of power transformers, in order to accommodate the power-line voltages available to listeners in different areas. If you come across a *Junior Model 80*, check the specifications on the rear of the chassis to make sure it will run on 117 volts. Otherwise you'll have to hook up an auto-transformer or some other kind of adapter in order to run that old radio.

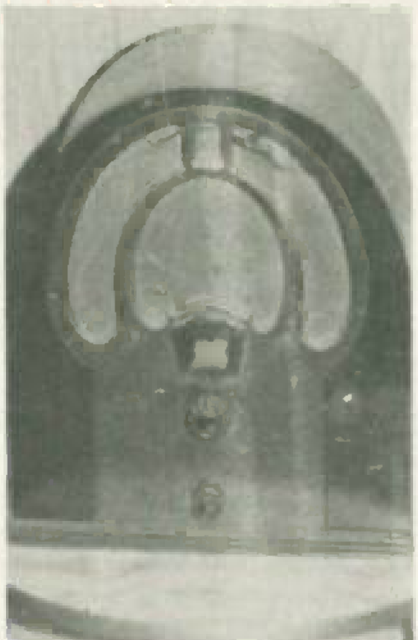


FIG. 1

My *Junior Model 80* plays well now, but it needs a somewhat longer antenna than some antique radios with larger chassis. It had no serious chassis problems; it only needed to be cleaned and aligned. But that's to be expected: Many antique radios must be aligned after restoration because the settings of trimmer capacitors and coils are often disturbed when they are cleaned. The *Junior Model 80*'s veneer cabinet held up well, considering its age of 50 years or more; it only needed minor touching up to complete our restoration and make the Philco Jr. *Model 80* a well-respected member of our collection.

Testing tubes

While it's often easy to find replacements or substitutions for most of the capacitors, coils, and resistors that are used in antique radios, it can be very difficult to do the same for tubes. In the early days of TV servicing, it was convenient to troubleshoot using the substitution method: The service man would carry a large (steamer-trunk sized) tube caddy into a customer's home. The caddy contained at least one sample of every type of TV tube. The tube caddy was often supplied by the tube manufacturer, as tubes were the backbone of the industry in those days. But now, few antique-radio fans enjoy the luxury of having one of every sort of tube available for substitution testing. That is when a tube tester comes in handy.

The problem is that the charts of modern tube testers seldom list tubes from our antique radios. If you do much restoration of antiques, it will be worth the effort to get an antique tube tester, which, by the way, is just as "collectable" as the antique radios we usually consider the primary object of our hobby. We've discussed some antique tube testers in previous columns.

When you buy an antique tube tester, make sure it has operating instructions as well as tube charts. It can be extremely difficult to find someone with a similar piece of equipment, and often the original manufacturer can't help.

There are several types of tube testers available. The most common is the emission tester. The other type, called a mutual conductance tester, is somewhat more expensive and harder to come by. The emission tester is sufficiently

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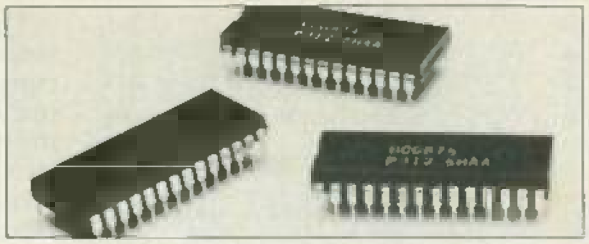

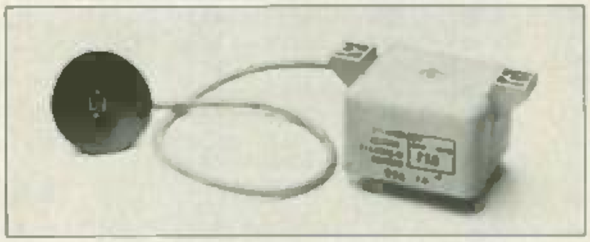

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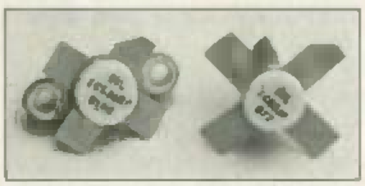

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Philips ECG power transistors are the ideal replacement RF power output devices for fire, police and taxi radios. They are suitable for transmitters and drivers up to 100 Watts RF power. They cover frequencies from the 13 to 30 MHz band to the UHF 806 to 870 MHz band. Most dealers will be happy to learn that Philips ECG replacement RF power transistors are designed to replace units in Asian and European equipment as well as domestic types. So, if it's ECG, it fits and it works... worldwide. Philips offers a selection of over 65 RF transistors that replace literally hundreds of domestic and foreign transistors in a broad range of frequencies.

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accurate for our purposes. It does just what its name implies: it provides an indication of the number of electrons being emitted from the cathode. An emission tester is usually reliable, and can help you rank the quality of several tubes, as well as testing for shorts and opens.

When using a tube tester, stop the test and remove power at the first indication of a short. A tube with an inter-element short should not be used in an antique radio, not even just "to fill a hole." Watch the neon indicator on the tube tester for the slightest indication of leakage. If a hard-to-get tube tests "weak" (or worse, as long as it's not shorted) it can still be used "to fill a hole."

If you don't have a tube tester handy, you can make continuity tests with an ohmmeter, as we've discussed in previous columns; but such tests are limited. An ohmmeter can detect an open filament, but shorts may or may not show up on a cold tube.

Testing tubes

The numbering system of antique radio tubes did little to identify the tubes' functions. Tubes were numbered consecutively, and unless you had an exceptional memory, it was always necessary to keep a tube-substitution guide handy. Later, even when tube numbers began to give some indication of type and function, every radio man kept his substitution guide within arm's reach because the sheer number of tubes made it a necessity.

For those who have forgotten, the numbers for tubes used in antique radios from the later 1930's give some information about the tube in the type number. The first digit(s) indicate the approximate filament voltage. The second part of the tube number consists of one or two letters. Usually, letters near the end of the alphabet (W, X, Y, Z) indicate a rectifier tube. An *S* as the first of two letters indicates that the tube doesn't have a grid cap, or that all elements are attached to pins in the base of the tube. The third part usually indicates the number of elements connected to the pins in the base of the tube. Of course, the number of elements does not necessarily correspond to the number of pins.

Letters at the end of the tube number refer to the type of construction. So, for example, a 25Z5 has a 25 volt filament, is a rectifier, and has five pins connected to tube elements. Earlier tubes (from the 1920's) have a two-letter prefix and three digits. Tubes with the *UY* prefix (like the UY224 or UY227) have five pins, and tubes with the *UX* prefix (like the UX226 and UX245) have four pins.

In Table 1 you'll see a tube-substitution guide; it is by no means complete, but does contain a list of the tubes I most commonly find in antique radios from before the second world war, along with common substitutes. You may want to clip the table and save it for future reference. Tube types marked with a double asterisk (**) are functional equivalents, but their pinouts differ, so some type of adapter must be used. You could also rewire the socket.

TABLE 1-ANTIQUE TUBE SUBSTITUTION CHART

Tube	Sub	Tube	Sub
00A	01A	6F7	unknown
01A	00A 40	6G5	6U5
0Z4	0Y4	6J5	6C5
1V	6Z3	6J7	6K7
12	71A	6K5	6C5
24	35-51	6K7	6U7
26	unknown	6L5	6C5
27	56	6L6	6K6
32	34	6L7	unknown
33	1F4	6N6	6AB6
34	32	6Q7	6B6
36	39-44	6S7	6W7
37	76	6T7	6B6
38	unknown	6U7	6K7
39	44	6V6	6K6
40	01A-12	6X5	6W5
41	42	6Y5	unknown
42	41	6Z4	84
43	unknown	6Z5	unknown
44	39	7A5	7C5
45	2A3	7A7	7L7
47	unknown	7A8	unknown
55	2A6	7B5	7C5
56	27	7B7	7C7
57	58	7G7	1232
58	57	7J7	7S7
59	unknown	7L7	7A7
71A	unknown	7N7	7F7
75	85	7R7	7E7
76	37	7T7	7V7
77	1221	7V7	7C7
78	6D6	7Y4	unknown
80	5Z3-83	12SQ7	12SR7
83	5Z3	12SK7	12SG7
85	75	12SA7	12SY7
89	unknown	25A6	25B6
5W4	5Y3	25L6	25W6
5Y3	5AX4	25Y5	25Z5
5Y4	5Z4	25Z5	25Y5
5Z3	80	25Z6	35Z6
5Z4	5Y3	1232	7G7
6A7	unknown	6SA7	6SB7
6A8	6J8	6SC7	unknown
6B5	unknown	6SF7	6SV7
6B7	unknown	6SK7	6AG7
6C5	6C6	6A7**	6SA7
6D6	78	6Q7**	6SQ7
6D8	unknown	41**	6K6
6E7	6D7	42**	6F6
6F6	6V6	** = with adapter	

Reader's inquiries

Bill Fletcher (3302 Leopold Way, #111, Madison, Wis. 53713) writes looking for the schematic of the General TV And Audio model *337*. Sorry Bill, I can't find that model listed anywhere, but maybe one of our readers can help. Martin Hammond (Box 1854, Huntsville, Ontario, Canada P0A 1K0) is interested in receiving information about antique radio museums and publications for collectors.

David Sharosky (1323 Jackie Lane, Mayfield Hts., Ohio 44124) has a crystal radio he'd like to sell; it has a label that says, "Martian Mfg. Co. Inc. Special, Newark, NJ Pat. Pend." Sounds interesting, Dave. If you weren't so far away I'd come and take a look at it myself. Dave also has a piece of galena he would like to sell.

David G. Weatherly (2300 Carolina Rd., Chesapeake, VA. 23322) wrote to say he has seven tubes from a Majestic model *90* for sale. Dave, if you still have the rest of that Majestic, it is as valuable as the tubes to someone needing parts.

A schematic for a Firestone Air Chief model *4–A–22*, code 5–6–9023 B is needed by Michael Wilhelm (Marine Bks., Box MTM FBPO, Norfolk, VA 23593). Mike, I found some information on that radio in Sams *Photofact 11*.

Finally, one reader wrote complaining about a 1936 Silvertone 4585 console radio that whistled when new tubes were installed, especially when using the volume control. I'm sure others have had that problem; the solution is usually quite simple. Antique radios depend heavily on shielding for proper operation, so be sure to replace all shielding after working on an antique. **R-E**

SERVICE CLINIC

JACK DARR
SERVICE EDITOR

Use a function generator for audio troubleshooting.

I HAVE TO ADMIT THAT THE FIRST TIME I saw a function generator, I was a bit overwhelmed. (Perhaps it's because function generators were bigger and more imposing-looking back then than they are today; see Fig. 1.) However, I had to evaluate a unit, and that made it necessary for me to find out about function generators in a hurry. Doing so, I became so fascinated with the thing that I bought one for myself.

A function generator can be thought of as a very versatile audio-frequency generator. A function generator can produce sinewaves, squarewaves, sawtooth waves, pulses of just about any width and repetition rate, and many have built-in sweep capability.

Using a function generator for troubleshooting is not much different than using an ordinary signal generator; in fact, many times you can use it just the same way you'd use an ordinary signal generator. For example, one traditional application is signal tracing, in which a signal is applied to a low-level audio stage and traced through the inputs and outputs of successive stages, either aurally or with an oscilloscope (or both), until a distorted signal becomes evident. Then it is simply a matter of determining which component(s) are responsible for the distortion.

A triangle wave is very handy for that type of testing since any clipping is immediately apparent on the screen of the scope. The peaks of the wave will flatten out. Just be sure not to overdrive your circuit's input; I've found that 50 millivolts is usually sufficient to drive the low-level stages of most amplifiers. If the first stage is clipping, try reducing the output level of your generator. If the clipping doesn't disappear, you may have found the source of the distortion. Also, keep the volume control cranked up; clipping will be most evident then.

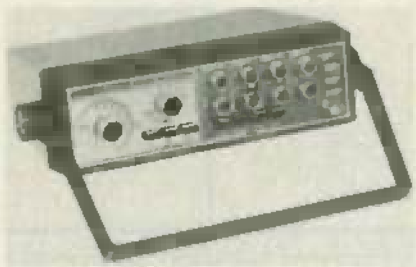

FIG. 1

When you find a stage that is clipping, measure the grid and plate—or base and collector—voltages. Incorrect bias is a very common cause of clipping. If a stage is improperly biased, it won't be able to handle the range of signal that it should. The signal may be driven toward cutoff, saturation, or both; in any case, the signal will be clipped, and distortion will result.

Incorrect bias is often due to a resistor that has drifted off-value. Be sure to check the values of plate and collector load resistors, and in some cases, screen-grid resistors. If the screen voltage is off either way, the gain of the stage could be drastically affected.

Checking bias is best done at a low level of amplification. Bias that is a few tenths of a volt out of spec won't bother a tube circuit too much, especially if the grid is biased at about ten or fifteen volts. However, transistors are usually more sensitive than tubes to bias changes; a transistor that loses a few tenths of a volt may be driven into complete cutoff. That is particularly true of the low-level preamplifier stages. By the way, that's where a precision digital VOM comes in handy. That's what the factory uses to measure the voltages marked on the service literature, and you'll want to use high-impedance, high-accuracy equipment just as they do. Otherwise, your measurements may be so far off that they're meaningless.

In power tubes, distortion may result if the grid bias is off. The best way to see if grid bias is the problem is by inserting a new tube into the circuit. Alternatively, you could use the grid current test function of your tube tester.

Using squarewaves

The squarewave from a function generator can be used to test both low and high frequency response. Apply the squarewave to the amplifier, and examine the output on a scope. Look for any signs of "tilt" on the tops and bottoms of the signal; they should be absolutely flat and parallel to the baseline. If they tilt to the left, the low-frequency response is poor. If they tilt to the right, and the corners are rounded, the high-frequency response is poor. That rounding of the corners is easy to spot. You can also use squarewaves to check the efficiency of the tone controls; rotate them and observe the effect on the scope. In fact, that would be a good place to try out the sweep function of your generator.

To use the sweep function, all you do is feed a small voltage, preferably a 60-Hz sinewave, into

(Continued following Computer Digest)

VOL. 2 NO. 11 November 1985

COMPUTER DIGEST

NEW KIND OF MAGAZINE FOR ELECTRONICS PROFESSIONALS

BUILD THE FIRMWARE CARD

Place an EPROM in the USR Memory of your Timex.

A GERNSBACK PUBLICATION

RAMDISK TECHNOLOGY

Instant-Access Mass Storage.

BUILD THIS MODEM FOR YOUR COMMODORE 64

Part I of a Two-Part Article.

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Vol. 2 No. 11 November 1985

ON THE COVER

The Firmware Card (See page 4) will add an element of additional flexibility to your TIMEX computer. The small amount of time and cost makes the effort well-worthwhile.

COMING NEXT MONTH

A really jam-packed issue you won't want to miss. Learn how your computer can take the drudgery out of designing attenuatrors and pads, How to use PERCOM to double your storage density, how to enhance and tune the 1541 disk drive the easy way, and we'll start a two-part article on building your own modem for your Commodore.

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LETTERS

Hackers

I resent your recent editorials on Hackers. Anybody that tinkers with computers is a hacker, and I've been doing this for years, trying to improve my system. I do not consider myself a moron!—B. G. Jerrolds, Waseca, MN.

Watch my lips. You're not a hacker. You're a computer experimenter. Read some of the mail we received and see if you don't agree with me.

More On Hackers

I'm a hacker and a student of computer science. I do break into other systems but don't crash them. I just look around to see what they're doing and how they're doing it, then quietly leave. All I'm really trying to do is educate myself. Is that wrong?—Monorail Red, Orlando, FL.

And if you were studying interior decorating, would it be all right to break into your neighbor's home just to see how it was furnished?

Still More

I'm a hacker, and I look upon a computer system as a challenge. It's like a puzzle I'm trying to solve. If I can break in, why it simply means I solved the puzzle. What harm is there in that?—R. D. Falcon, Atlanta, GA.

How do you feel about picking your neighbor's front-door lock? That's a puzzle, too.

It Goes On

Did it ever occur to you that we hackers are performing a service? If we can break into a computer system, anybody else can, too! It makes the system operator look again at his security methods. Frank Cheyney, Billings, Mont

Sure, Frank; in the same way that a bank robber helps the bank!

And On

There are some very famous and important heads of business in the computer industry that started as hackers. What do you have to say about them?—Sam Pace, Indianapoilis, IN.

The same thing I say about **all** hackers.

COMPUTER PRODUCTS

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

PORTABLE COMPUTER, the *Bondwell 16*, features a 10-megabyte hard disk drive, 128K RAM memory, built-in voice synthesizer, and bundled software. It also features a 9" non-glare monitor, 91-key detached fullstroke keyboard, with a separate numeric keypad, built-in modem, and a 5¼" floppy-disk drive.

Equipped with the upgraded CP/M 3.0 operating system, the 30-pound computer is better able to use its 128K RAM memory in the application of the five business-software programs bundled with the system: WordStar, MailMerge, CalcStar, DataStar, and ReportStar. The model *Bondwell 16* is priced at $1995.00.—*Spectravideo, Inc.*, 3300 Seldon Court #10, Freemont, CA 94539.

CIRCLE 11 ON FREE INFORMATION CARD

DOT-MATRIX PRINTERS, the Microline model *192* and its wide-column companion, model *193*, (shown in photo), feature three different print modes, a re-inking cartridge ribbon, and user-friendly operation.

Both printers come in standard versions to interface with most personal computers, as well as specially configured IBM-compatible models. (The IBM-configured printers come with free software to work with the IBM-*PC*, *PC Jr.*, and *PX/XT.*) The software provides type styles similar to courier, italic, gothic, and scientific characters.

The Microline model *192* comes with an adjustable pin-feed mechanism, while the model *193* has a tractor feeder.

CIRCLE 12 ON FREE INFORMATION CARD

The model *192* is a compact unit, measuring 14.6" × 10.9" × 3.2.6" and weighs just 9.9 pounds. It is priced at $499.00. The model *193* handles wide-column applications, such as spreadsheets. It prints up to 136 columns at 10 characters per inch, 163 at 12 CPI, and 17.1 at 233 CPI. It can print between 68 and 233 characters per line. It measures 20.6" × 10.9" × 5". It is priced at $699.00.—*Okidata*, 532 Fellowship Road, Mt. Laurel, NJ 08054.

FIRMWARE CARD

Build this and you don't have to store everything above RAMTOP.

MARK W. LATHAM

■From teletext terminals to solar heating controllers people seem to discover new uses for the Timex/ Sinclair 1000 and its upgraded successors. Those who write the software for these applications often forego BASIC and program either partially or completely in machine code. Such programs not only have precise control of the computer and fast execution times, but lend themselves perfectly for placement on a firmware card.

How do you know that your program has been written completely in machine language? If it loads into the BASIC area and then transfers itself above RAMTOP, it probably is. The area above RAMTOP is not the only place to put machine code programs. USR calls can be directed to any location in the 0-32K area.

The firmware card described here lets you place either a 2K or 4K EPROM anywhere in the USR memory area. It can serve as an interface card for custom projects. It fits into Radio Shack's smallest project box and operates much like an Atari game cartridge. Once you plug it in, all that is necessary is to call the program.

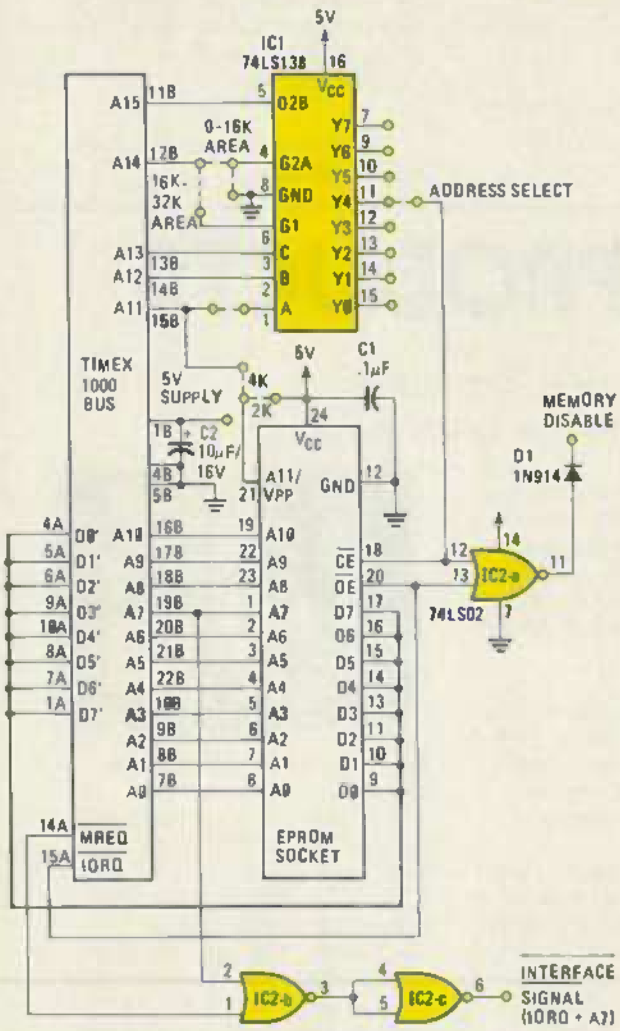


Fig. 1—SCHEMATIC DIAGRAM OF FIRMWARE CARD can easily be modified by cutting certain of the trace lines to suit your needs. See the text for additional information.

Circuit operation

The schematic diagram is shown in Figure 1. The one-of-eight decoder, IC1, reads address lines A11-A15 and provides a decoded output. Just a few jumpers allow this IC to activate the EPROM anywhere in the USR area.

When a 2K EPROM is used, address A11 is jumpered to the decoder's least significant address input, pin 1. The decoder's eight outputs will then each represent a 2K block of memory. Address A14 is jumpered to either pin 4 or pin 6 of the decoder, allowing these eight outputs to activate for addresses in the 0-16K or 16-32K areas, respectively.

For a 4K EPROM, the decoder's pin 1 is left open and A11 is jumpered to the most significant EPROM address pin. With this jumper configuration, the decoder activates only the odd-numbered of the eight outputs, each of which represents a 4K block of memory.

Usually the decoded address signal is ORed with / MREQ (computer's memory request) before being fed to the EPROM's /CE (chip enable). Such a configuration provides for the least power dissipation possible. In this case, however, the decoded address signal is connected directly to /CE, and /MREQ is connected to the EPROM's /OE (output enable). For a rare compromise in power, access time is then extended allowing even the slow 480ns memories to work.

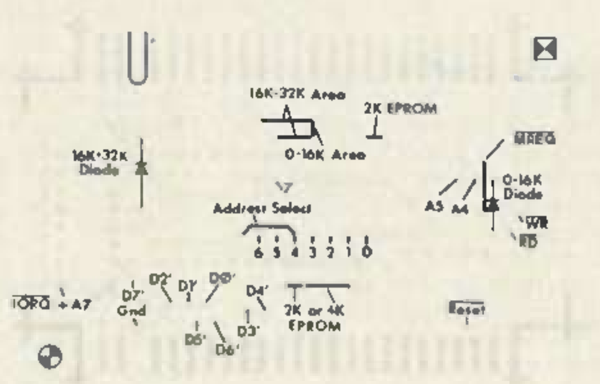


FIG. 2—SIGNAL LOCATIONS are called out on diagram above. Refer to text for further clarification.

Project interface

For those readers who have built custom add-ons such as those described in "Interfacing The ZX-81" (see Radio-Electronics, July-September, 1984) or "Machine Code Development System" (see ComputerDigest, January and March, 1985) the firmware card allows you to interface your project and keep the computer bus too. To separate the display and printer commands from the project's I/O signals, the computer's /IORQ and address A7 have been ORed to provide an interfacing signal. The locations of this and other useful signals on the firmware card is shown in Figure 2.

Memory disable

In order for the firmware card to work properly, it must disable any other memory device working in the same area. A memory disable signal is made by NORing (via IC2a) the decoder's output with /MREQ and then connecting the NOR output through diode D1 to the control line of the memory to be disabled.

As shown in Figure 2, D1 can be placed to disable either the ROM (0-16K) or the RAM (16K-32K) of the computer's internal memories. The firmware card can also disable an external RAMPAK that cannot be manually switched off in the card area. This is done by replacing the /MREQ trace with a 680-ohm resistor and then connecting the 16K-32K diode's cathode to the end of that resistor. The RAM is then plugged in behind the firmware card.

Contruction

The component and solder sides for the firmware card are shown in Figure 3. This circuit board can be made at home or can be ordered from the supplier given in the parts list. The pattern shown includes jumper traces that place a 2K EPROM in the 8K-10K memory area. To change the EPROM size or memory placement, these traces must be broken and wire jumpers used as shown in Figure 2.

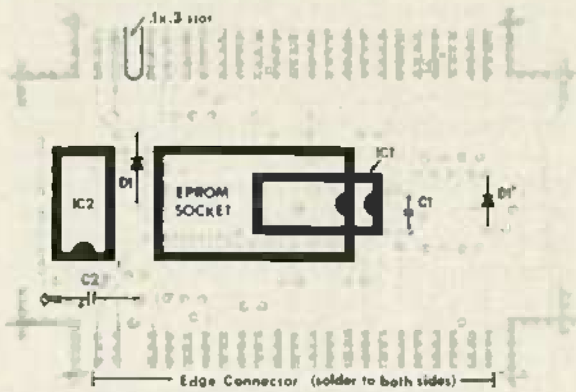


FIG. 4—PARTS PLACEMENT is shown here. Note that IC1 is mounted directly to the board beneath the EPROM. See text.

The parts placement is shown in Figure 4. Note that IC1 is mounted directly to the board under the EPROM. To allow space for this IC, the EPROM socket can be modified on one end, resulting in a U-shaped socket.

Once wired, the firmware card can be placed inside Radio Shack's smallest project case. This case should be sprayed on the inside with aluminum paint and then cut ½-inch up on each side to allow for the edge connectors. On one end of the aluminum cover place adhesive foam. On the other end, two holes should be drilled ¼-inch away from parallel with the two case holes. Plastic ¼-inch spacers and ½ x 4-40 screws thread directly into the board to complete the assembly.

Other uses

The firmware card can provide many other useful functions missing on the Timex computer. A nice accessory, for instance, would be a Reset button that can be made by connecting a normally open, momentary contact switch between /RESET and ground.

The EPROM socket can also hold an HM6116 2K RAM by changing pin 21 from 5V to the /WR signal. This makes the card ideal for writing custom software in the 8K-16K area.

The interface output can also be used to power a piezo element. A little experimentation with short bursts of output commands should result in some unique sounds and musical tones.

PARTS LIST

D1—1N914 or 4148 Switching Diode
IC1—74LS138 One-Of-Eight Decoder
IC2—74LS02 Quad 2-input NOR gate
C1—.1µF Disc or Metalfilm Capacitor
C2—10µF 16V Electrolytic Capacitor
Miscellaneous—Edge connector, 24-pin socket, circuit board, project case, hardware.

An etched, drilled and cut printed circuit board is available for $12.95 (price includes shipping and handling) from WILDONICS, Box 1763, Boise, ID 83701. For custom cards, write.

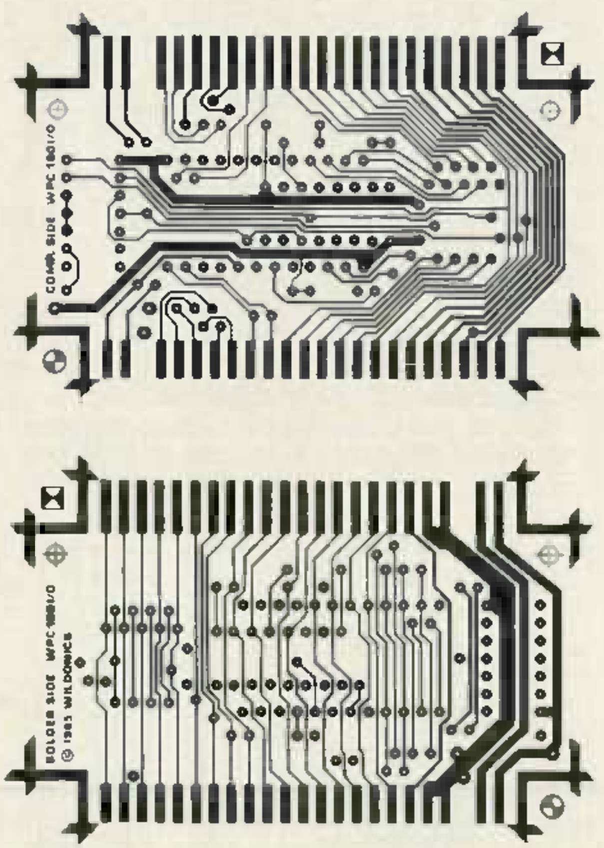


FIG. 3—IF YOU'D LIKE to make your own circuit board, full-size patterns are offered here for both sides. Above is the component side, below, the solder side.

RAMDISK TECHNOLOGY

Instant-access mass storage

Herb Friedman

■While it might appear that the new super-sophisticated programs do more for the same price—giving something for nothing—a super data-crunching program usually requires a great amount of mass storage. Fortunately, since mass storage in the form of double-sided floppies and hard disks now comes cheap, prodigious amounts of mass storage hardware can be squeezed into anybody's computing budget.

Usually, access time is relative to the amount of data stored: The more you store, the slower it is to locate and access specific information. Because a modern, super-sophisticated data base or spreadsheet might require more time to locate specific information it can usually end up running slower than the similar but older and smaller programs designed for 8-bit computers with a modest amount of storage.

The recommended solution to slow data access is usually something with a catchy high-tech name such as *hyperdrive,*, or *superdrive*, or *turbodrive*. Regardless of what it's called, it is actually a portion of a computer's RAM that's been programmed to emulate a disk drive. Usually, the emulation is so accurate that the computer actually sees the RAMdisk as only a disk drive: As far as the computer is concerned, the RAM used for disk emulation no longer exists as free RAM.

The reason why RAMdisk data access is faster than a conventional disk is because to access data on a physical floppy or hard disk the disk must start, come up to speed, and the read/write head must be positioned before it can locate the desired data or an empty space into which new data can be written. A RAMdisk has no such delays because reads and writes are from RAM to RAM: The only delays are those of the applications program and the computer itself as it moves electrical impulses through RAM.

The way in which RAMdisk is used depends on the particular software, the computer and the user. In general, particularly with 64K 8-bit computers, the user employs special software to reserve a portion of conventional memory as a RAMdisk only as large as needed for the disk file. The computer recognizes the RAMdisk the same way it recognizes a physical disk. For example, if the computer has physical drives A: and B: the RAMdisk might be C: or D: or M: or whatever. Once the RAMdisk is established in memory the user can read or write to the RAMdisk, or copy the desired data from a physical drive to the RAMdisk by using the conventional DOS PIP or COPY command. Assuming the RAMdisk was assigned the identifier M:, if the user wanted to browse through a computerized mailing list of customers who purchased TV service contracts for the past 5 years he would copy the data file—assume its filename is CONTRACT.DAT—from the floppy or hard disk to the RAMdisk with the command:

PIP M: = CONTRACT.DAT (for CPM)

or

COPY CONTRACT.DAT = M: (for PC/MS-DOS).

Using an in-memory word processor, a data base editor, or the computer's LIST or TYPE command, the user could browse through the mailing list—move forward and back—without having to wait for the computer to seek and load from the disk.

How it's done

If the computer's RAM were unlimited, one could safely create a RAMdisk equal in size, at least to a conventional floppy disk and all the data of a physical disk could be copied into the RAMdisk.

Figure 1A shows how a RAMdisk is usually established in a 64K 8-bit computer having two 160K floppy disks. The program that establishes the RAMdisk positions it in an area that is not used by the disk operating system (DOS). If the user sets up a RAMdisk of 16K, only 48K of RAM is available to the user because the computer no longer "sees" the 16K of RAM that's been set aside for the disk emulation. If the DOS uses 4K, only 44K total memory is available to the applications program in contrast to a total of 60K which would be available if the RAMdisk wasn't used.

Figure 1B shows the computer's functional system after the 16K RAMdisk is created. The computer sees three disk drives: Two of 160K and one of 16K. As a

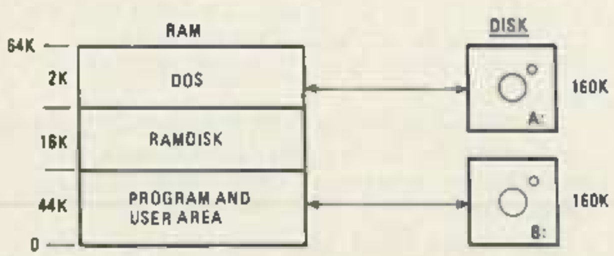


FIG. 1A—IN A CONVENTIONAL 8-BIT COMPUTER the RAMdisk is created from the basic 64K of memory. The memory used for the RAMdisk is no longer available to the applications program.

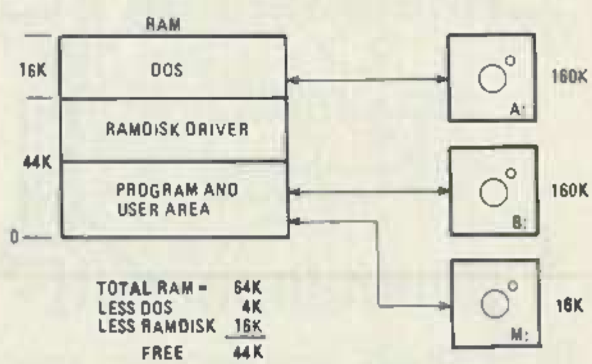


FIG. 1B—IF A 64K RAMDISK is created, the functional computer now has three disk drives, but 16K less RAM.

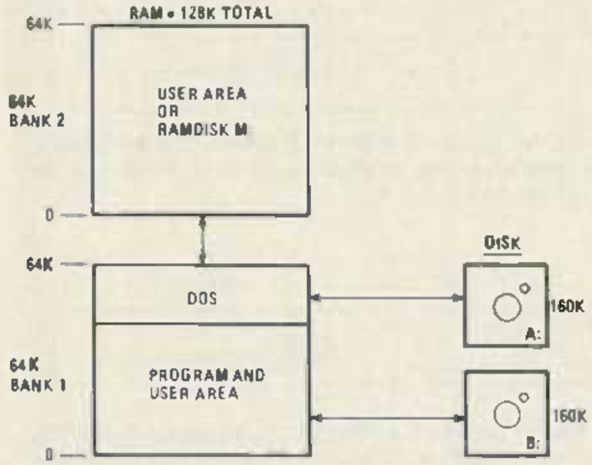


FIG. 2A—SOME OF THE LATEST 8-bit computers provide a second bank of 64K of memory, part or all of which can be partitioned for use as a RAMdisk or as user RAM.

general rule, this configuration lasts until the computer is turned off: The memory utilized for the RAMdisk cannot be reprogrammed for use as conventional RAM.

In a 64K computer, the RAMdisk must be as small as possible; if it is made too large, there might not be sufficient memory left to run the applications program. But if enough memory is left for the applications program, the RAMdisk is usually too small for effective handling of the associated data.

But the RAMdisk becomes more useful when the computer can address memory independent of the main computer. For example, the Radio Shack Model 4 was the first 64K machine to accomodate an extra internal 64K bank of memory which could be used for a RAMdisk independent of the main memory, leaving almost all of the conventional 64K in the first bank available for the applications program. Unfortunately, Radio Shack made no provisions for CP/M applications use of the additional 64K. Aftermarket vendors however, provided software which configured the entire extra 64K to function as a RAMdisk. As shown in Figure 2A, the RAMdisk uses the entire second bank of memory, all 64K, for the RAMdisk, while the main computer retains almost its full 64K of RAM (less a smidgen for the RAMdisk software). This results in the system configuration shown in Figure 2B, 64K of memory computer memory plus two full-size floppies

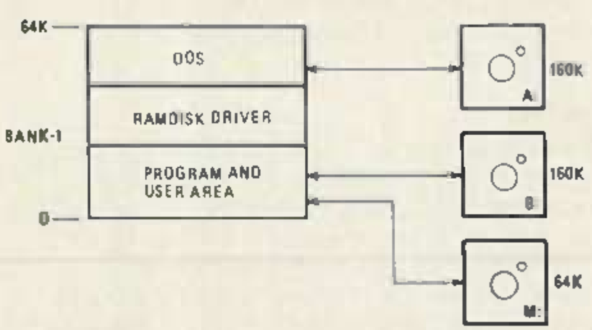


FIG. 2B—IF THE ENTIRE 64K OF MEMORY in the second bank is used for a RAMdisk the functional computer has three disk drives, but a full 64K of memory (from the first bank of 64K).

and a 64K RAMdisk; which is far more advantageous for conventional applications programs than the configuration shown in Figure 1B where part of the original 64K of memory is partitioned for a RAMdisk.

An even more advanced RAMdisk system for 8-bit machines uses a completely independent memory external to the original computer. As shown in Figure 3A, a RAMdisk program within main memory manages all of the external memory as a RAMdisk. Since the external memory is really under software rather than inherent computer or operating system control it can be almost any affordable size. 320K is not uncommon. Once a RAMdisk is greater than approximately 160K it can represent one or more floppy disks, and depending on the particular software that creates the RAMdisk(s) everything on the physical disk including the directory can be written or copied to the RAMdisk. If the external RAM is sufficiently large it can be software partitioned to emulate several disk drives. Figure 3B shows how 320K of external memory can represent two independent 160K RAMdisks.

Once we can create a RAMdisk at least equal in size to a conventional floppy, the speed by which an applications program works can be increased by several orders of magnitude.

But if the disk overlay files are copied to RAMdisk the program operation is almost instantaneous because the program no longer has to wait for disk access. Both the reads and writes to "virtual memory" are made to and from RAM. The value of RAMdisk is even more apparant if WordStar is used with a spelling checker. A spelling checker's dictionary—its list of words—is generally so large it must be maintained on its own disk. If the document being spell checked is being stored on a separate data disk (which is usually the way it's done) two disk drives are needed only for the spelling check, and it's often necessary that the dictionary disk be swapped with the word processing software disk in order to randomly access the spelling checker. This is slow, it's frustrating. However, if the spelling checker

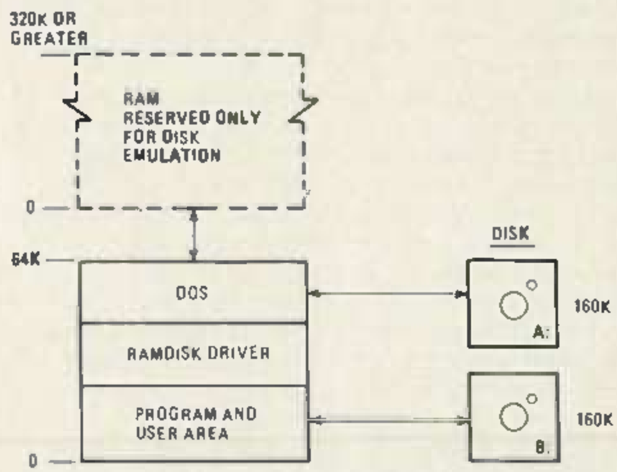


FIG. 3A—IF EXTERNAL EXPANSION RAMdisk memory can be used almost any practical memory can be used for RAMdisks, such as 320K. These special RAMdisk expansion memories are intended specifically for use as RAMdisks, not for user (program) memory.

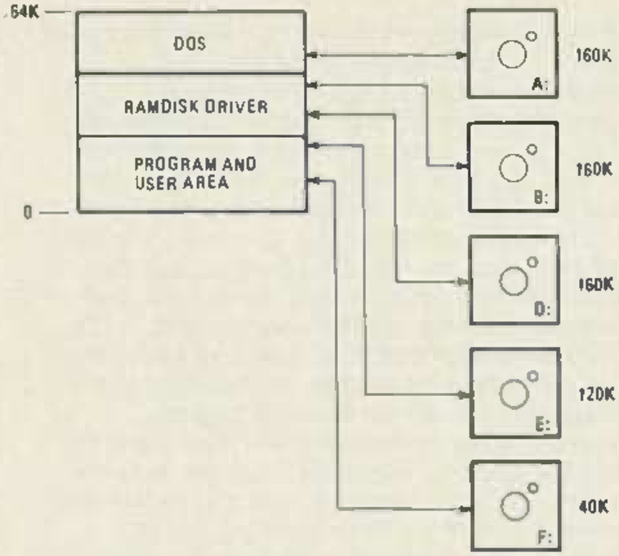


FIG. 3B—EXPANSION RAMDISK MEMORY can be partitioned almost any way the user wants it. For example, 320K might be configured to provide three additional drives so the computer sees a total of five.

software is copied into a RAMdisk the program can easily shift back and forth between WordStar and the RAMdisk spelling checker almost instantaneously.

Full size RAMdisks

Disk emulation in IBM-compatible computers can be handled in several different ways, depending on the amount of installed RAM. If the computer has 256K of RAM disk emulation it's the same as for 64K computers in that part of the RAM is programmed to function as a RAMdisk. But since RAMdisks provide maximum convenience when the emulation is at least equal in size to the floppy with the computer, it makes no sense to create small RAMdisks when the computer has the capacity to emulate full-size disks, for in this way a complete floppy can be easily copied to the RAMdisk. This is easily done in an IBM-compatible computer because of the relatively large amount RAM that can be installed and addressed. (Either the 510K or 640K. To keep things simple we will use 640K.)

One of the features that simplifies RAMdisk in an IBM-compatible is that, as shown in Figure 4A, an applications program can only run with contiguous RAM. If there is a break in the RAM addressing, such as the "missing" 64K in Figure 4B, the applications program can use only the RAM up to the first break. While the RAM above the break cannot be used for the applications program it can be used for utilities, and more importantly, for one or more RAMdisks. The break itself need not be physical: Software can be used to create an artificial break—actually a ceiling beyond which the computer does not see RAM, so the applications software will automatically utilize only the RAM below the break or the ceiling. Figure 4C.

The RAM above the break can be used for a RAMdisk up to the size of the computer's conventional floppy (either 320K or 360K), or the RAM above the break can

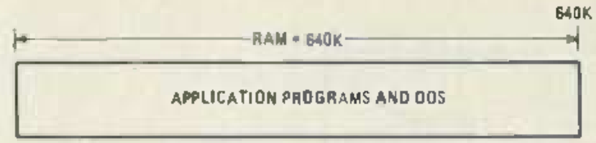


FIG. 4A—IN AN IBM-COMPATIBLE COMPUTER the applications program always attempts to utilize all memory to the highest possible address.

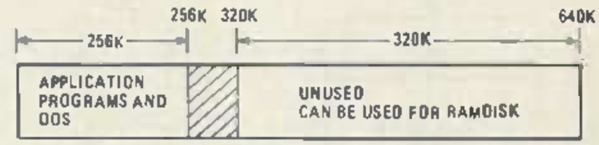


FIG. 4B—IF THERE IS A "BREAK" in the memory—say the memory from 256K to 320K is missing—the application program will run only in the contiguous memory starting from zero. The memory above the break can be used for RAMdisks or anything else other than the applications program.

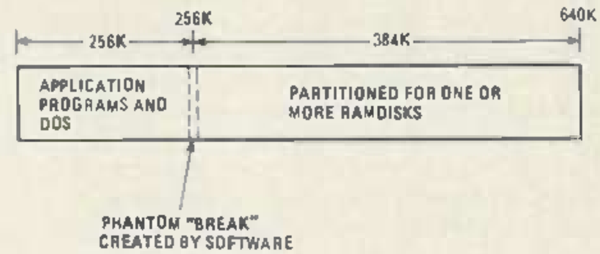


FIG. 4C—RAMDISK SOFTWARE CREATES a "phantom break" and configures the memory above the break for one or more RAMdisks. How and in what size the RAMdisks are created are a function of the RAMdisk software.

be partitioned into a full-size RAMdisk and a smaller RAMdisk, or several smaller RAMdisks. The precise disk emulation depends on what the user needs and the software that creates the RAMdisk(s). Others permit any amount of reserved RAM to be used for several RAMdisks of random size.

An IBM-compatible computer doesn't have to be "fully loaded" with memory to create a RAMdisk. If the computer is equipped with only 256K of RAM most of the disk emulation software will permit one or more RAMdisks to be created as long as a minimum of 128K remains for the applications program (including DOS and the RAMdisk software). Often, if the user attempts to create a RAMdisk that will leave less than 128K for the applications software the program will automatically create the largest RAMdisk coincident with 128K of applications RAM.

Copy first

RAMdisks are volatile. Unless you are using a special kind of memory expansion adapter employing a backup battery that keeps the memory alive when the computer's normal power supply is turned off, both the RAMdisk and its data disappear when the computer is turned off. If you will need the data or a word processed document that's stored in RAMdisk for use at nother time, it must be copied to a physical disk before the computer is turned off.

YOU CAN BUILD THIS MODEM FOR YOUR COMMODORE 64

PART I

Sure you can build your own modem... And save a lot in the process!

JIM STEPHENS

■Modems are expensive but not all that complicated. In fact, they can be quite simple once the function of the main components is understood. Basic modems have two main sections, a modulator and a demodulator. Once these have been built, the rest is easy. Here's how to build your own originate-only modem and save a bundle.

What makes it possible, are two new integrated circuits sold by Radio Shack and other suppliers. The catalog description said that the XR2211 IC was an "FSK decoder used for RTTY and modems." Next to it was another IC, the XR2206 FSK Generator, which had the same caption. The result was better then expected, it worked, and it worked reliably. The circuit could do what it took several dozen IC's in other circuits to do and it did it at less than half the cost of some of the more popular modems for the Commododre 64.

A modem is a circuit that converts serial digital data coming from the computer into tones that can be sent over a single audio channel such as the telephone line. This conversion, called modulation, sends one tone for a digital one and a different tone for a digital zero. The other section of a modem converts tones from the telephone line to either a digital one or zero depending on the tone's frequency. This function is called demodulation.

Since the telephone is built to handle voice communication, the plus and minus voltages which are generated by the computer cannot be handled by the telephone circuits. If a circuit could recognize a certain voltage and convert that voltage to either high or low tone, digital generated tones could be sent over the telephone line and could be reliably picked up at the other end.

That is exactly what the modem does.

To speed things up a bit, modems actually operate using four tones of different frequency. Two tones are used by the sending terminal and two separate tones of another frequency range are used by the receiving terminal. This way, it is possible for both units to talk at the same time and not interfere with each other's data.

The telecommunications terminal that calls up another terminal is called the originating terminal. Its tones are set at 1070 Hz and 1270 Hz for a digital zero or a one. The receiving terminal is the answering unit and its tones are higher with a one represented by 2225 Hz and a zero represented by 2025 Hz. When the two tones are changed from one frequency to the next, they are not stopped and started, but shifted up or down in frequency. This is called "frequency shift keying" or FSK. A demodulator circuit recognizes this shift and changes the digital output at its output pin accordingly. The modulator circuit senses a digital one or zero on its keying input pin from the computer and shifts its output frequency either up or down depending on the level of voltage at this input.

Although it is possible to have both the originating and answering capability in one modem, the need for more-complicated circuits outweigh the benefit. After all, most of us would only use our computer to call up another terminal such as Compuserve. We rarely use it to answer unless we are running our own bulletin board. The simple unit shown here is an originate-only modem, but it could easily be converted to answering capability by changing the values of the components as shown in Table I and setting the output tones of the modulator to the higher set of frequencies. It might even work if a separate set of components were on the board and switched into by a set of switches. This would make the modem capable of both origination and answering.

The most expensive part of telecommunicating can be the modem software that generates and converts the digital data once the modem has accomplished its task. The unit shown here works with most of the available software for Commodore modems. It was used with Smart Terminal 64, Victerm, and with Term 64. Many good terminal programs have been published recently in several of the Commodore publications.

The modem circuit

There are four ICs that make up this modem circuit, but the two major ones are the 2211 FSK demodulator and the 2206 FSK modulator.

As shown in Figure 1, the 2211 demodulator receives the 2225 Hz tone from the earpiece. The level of the received tone is amplified by IC3 which is an LM386 low power audio amp. The descrete components that connect to the 2211 actually set the response frequency of the demodulator. Table I shows the values of the components that set the frequencies at which the demodulator responds. Since we want the demodulator to react to the incoming 2025 Hz and 2225 Hz tones, we have chosen the values for the five components listed under the higher frequency range. Note that the capacitors here should be good quality mylar types to improve the stability of the circuit. Pins 11 and 12 of the 2211 are the oscillator control of the demodulator and this oscillator is peaked by a 5K variable resistor, R7. This is a standard linear taper pot. The tones are transmitted from the earpiece by a small inexpensive speaker.

When a tone in the proper frequency range is detected by the 2211, the demodulator's data output pin goes either high or low depending on the frequency. A tone of 2225 Hz will cause it to go high while a tone of 2025 Hz will cause it to go low.

Adjustment of R7 causes the oscillator to lock onto this frequency range and these adjustments will be discussed in detail later.

The heart of the modulator section is the 2206 FSK generator. Figure 1 shows that it appears as simple as the demodulator but its adjustment is much more complicated than the 2211. It generates a tone of either 1070 Hz or 1270 Hz at pin 2 when either a digital zero or a digital one is detected at its keying pin number 9. The 2206 is capable of producing most any frequency so exact adjustment is necessary in order to produce the correct frequency output.

Pins 7 and 8 of the 2206 connect to the timing resistors that produce the two output frequencies. The value of these resistors is set to produce the two separate tones. Two variable resistors (R13 and R14) have been chosen so that the exact frequency of the tones can be set by hand. R11 is the volume control that determines the intensity of the tone being sent to

PARTS LIST

Resistors
All resistors ⅛-watt
R1, 4—1,000,000 ohms
R2, 10, 12—5100 ohms
R3—510,000 ohms
R5—200,000 ohms (see table 1)
R6—18,000 ohms (see table 1)
R7—5000 ohms Variable
R8, 13, 14, 16—10,000 ohms Variable
R9—10 ohms
R11—25,000 ohms Variable
R15—200 ohms

Capacitors
C1, 4, 7, 10—.1µF ceramic
C2, 8, 11, 14—10 uF electrolytic
C3, 15—5 µF electrolytic
C5—.005 µF ceramic
C6—.05 µF ceramic
C7—.1 µF ceramic
C9, 12—1 µF electrolytic
C13—100 µF electrolytic
C16—.022 µF mylar (see table 1)
C17—.0047 µF mylar (see table 1)

Semiconductors
IC1—XR2211 FSK Decoder
IC2—XR2206 FSK Generator
IC3, 4—LM386 Low Power Audio Amp
IC5—4049 CMOS Hex Inverter
Q1—2N2222 NPN Transistor

Miscellaneous
SW1—SPST Switch
SPKR—8 ohm .5 watt Speaker
Connecto-Edge Connector (Cinch #50 24A-30)
Perfboard
(1) 14 pin WW Socket
(3) 16 pin WW Socket
NOTE: - A ten-minute cassette tape containing five minutes of continuous telecommunications data and examples of both originating and answering tones may be ordered by sending $4.00 to Syntronics, 2324 Dennywood Dr., Nashville, TN 37214.

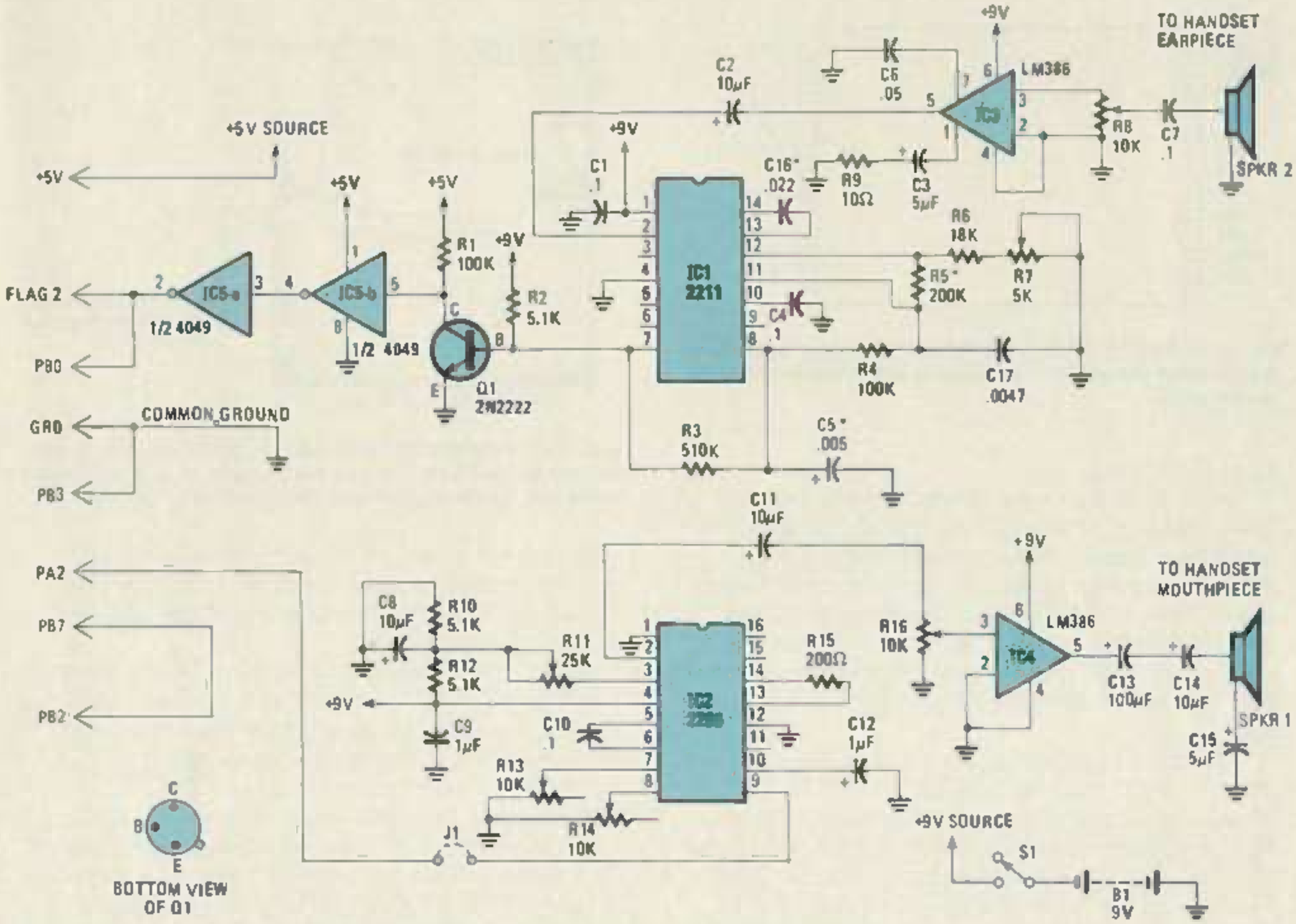


FIG. 1—SCHEMATIC DIAGRAM OF THE MODEM. Heart of the system is two IC's, IC1 and IC2 which are an FSK Decoder and an FSK Generator. Balance of circuit is straightforward and supports these devices. *See Table 1 for values.

IC4 which is an LM386 low power audio amp. The audio amp also has a 10K pot that adjusts the level of the final output to the 8 ohm speaker.

Circuit power

Notice that both the 2211 and the 2206 are powered by 9 volts. This voltage is necessary because the 2206 will not operate at less than 8.5 volts. Since direct current at 9 volts is not present on the user port of the Commodore 64, we use a 9 volt transistor battery. A small separate power supply could be built to provide this voltage. The modem only draws around 25 ma so the battery should last some time depending on use.

A transistor battery should never be placed on the user port pins. If this were done, the output port of the 64 could be harmed. The output signal of the 2211 demodulator is connected to the 64 through a 2N2222 NPN transistor which obtains its power from the 5 volts on the user port. The signal is then fed through two stages of IC3 which is a CMOS 4049 inverter. The inverter is powered by the computer's 5 volts. This IC shapes the final digital levels before they are presented to the port. Both power supplies have their ground connection in common for proper signal reference.

After extended use, it will be necessary to replace the 9-volt battery since the lower voltage level will cause the modem's output and lock-on frequency to drift off. This will cause mis-reads in the data. If garbage starts showing up for no reason, suspect low battery voltage. Again, this would not be a problem if a small separate 9-volt supply were constructed, though it would increase the complexity and cost of the circuit. The transistor battery did fluctuate when left off for a long period and would sometimes make retuning necessary.

Wiring the modem board

You must keep the components close together and the leads short or risk stray capacitance which upsets the audio circuits. This is especially true of the LM386 amplifiers. You may hear a local disk jockey coming in on the modulator circuit. This interference disappears once the final connections are made. Make sure you use flexible sheilded microphone cable to the speakers. These lines should be no more than ten inches long. They tend to act as antennas and the modem will try to decode the sound of the latest rock group.

IC sockets were used for the integrated circuits and wire-wrap posts for mounting some of the descrete components. One 16 pin IC socket mounted both of the LM386 amplifiers. The sockets were inserted into a 3-inch by 2-inch perf board. Leave the jumper test point (J1) disconnected until the final adjustments have

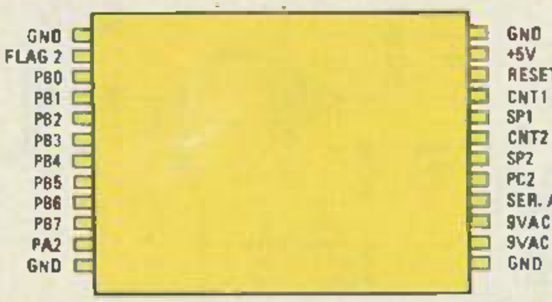


FIG. 2—DIAGRAM OF THE COMMODORE 64 user port. Make sure that the connector is properly oriented before attaching to user port.

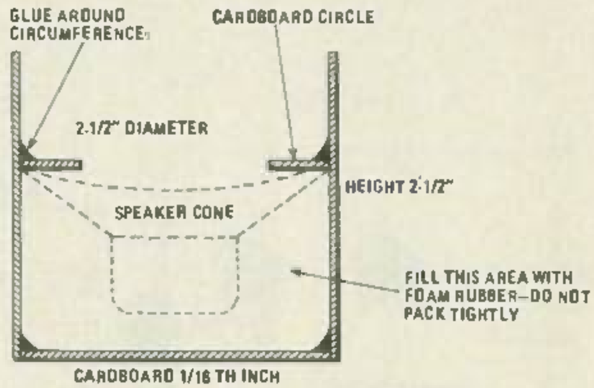


FIG. 3—CONSTRUCTION OF ACOUSTIC COUPLER. Speakers are backed with foam to keep sound in and interfering noise out. Extraneous noises can turn data to garbage.

been completed.

The parts list shows the values for the various components and many of these can be just within the value range shown. Those that are marked with an asterisk and shown by Table I must be the exact values listed. Those components connected to the LM386 amps should also be exact. You may want to diagram or label the variable resistors on the board layout since they can get confusing once final adjustments are started.

Connection to the computer is critical. It is important that the correct user port pins are selected for connection. Connections to the board is through very short lengths of hook-up wire. Some of the pins on the user port such as PBO and FLAG 2 are wired in parallel. This is necessary because of the way some software handles the output and input ports. Figure 2 shows the user port pinout which is viewed as though you were looking at the user port from the back of the computer. The connector to the port must always be inserted with the leads correctly oriented to the port pins. Never insert the connector upside down since this would place the unregulated alternating 9 volts of the port on the data lines. This could harm the port also. Some anti-reversing means such as connector keying might be necessary on the connector to prevent accidental backward insertion. I simply marked one side of the connector as "TOP."

The 9-volt power supply is switched on and off by a SPST toggle switch. The 5-volts for IC5 and Q1 are supplied by the computer and it is activated when the 64 is turned on. With this dual power arrangement, it is easy to forget to turn off the modem when it is not in use. This tends to shorten the battery life somewhat. The low continuous tone of the modulator alerts you that the unit is operating.

The coupler is the housing for the mike and speaker and into which you insert the handset. It does not have to be elaborate. Use two lengths of heavy cardboard wrapped in a circle which fits the handset snugly. This cardboard circle is then taped around the circumference. The speaker and mike are placed into them and glued. Foam rubber is used to seal the back. The sealing is necessary since the tones are continuous and tend to be irritating after a while. In order to prevent damage to the speakers, a stiff cardboard circle was cut and glued over the speakers to keep the handset from touching them. The leads to the couplers should be short and the couplers can be permanently mounted on a board. Again, use flexible sheilded mike cable here. Figure 3 shows how the couplers are constructed. See Figure 4 to examine the author's unit.

TABLE 1

FSK BAND	COMPONENT VALUES
300 Baud frequency 1070–1270Hz	C16–.039μF C5–.005μF C17–.01μF R6–18K R5–100K
300 Baud frequency 2025Hz–2225Hz	C16–.022μF C5–.005 μF C17–.0047μF R6–18K R5–200K

TABLE 1—TABLE OF COMPONENT VALUES for the 2211 decoder. If decoder is built to be an answering device, values in the first part of the table should be used.

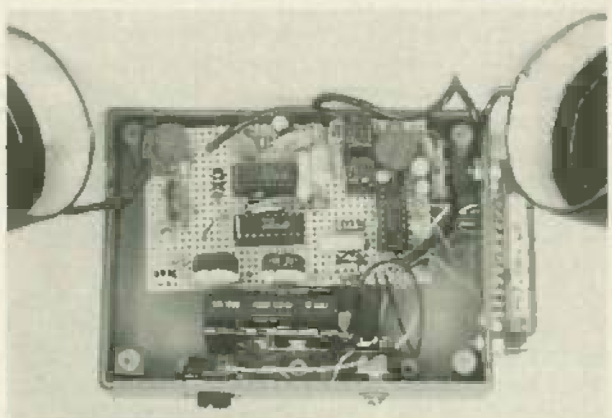


FIG. 4—AUTHOR'S UNIT with cover removed reveals simplicity of wiring. Component placement is not critical and perfboard works well.

That's all the room we have in this issue. However, we'll complete the Modem in the December issue of **Computer Digest**. There's still much information to come!

the sweep jack on the back of the generator. The range of the sweep may be set by rotating RANGE and FREQUENCY controls. Many scopes have a built-in 60-Hz sweep signal that may be used to drive the function generator. Doing so will ensure a steady display on the scope.

The sweep frequency test can be used to diagnose amplifiers that have a buzz or rattle at one frequency. If you have that problem in your amplifier circuit, you'll see a sharp peak at the problem frequency on your scope. However, speakers are more often responsible for that problem than the electronics, and if the problem is in the speaker, you'll see no peaks.

You don't actually need an automatic sweep generator to perform that test; you can do it with a regular signal generator by simply executing a "manual sweep:" just rotate the frequency knob slowly over the entire audio range. At some point the rattle will become apparent, and you'll be able to trace out its source and fix it.

I had a case like that once: One of the seams of a speaker cone had come unglued and caused the speaker to rattle at about 700 Hz, if I remember correctly. At any rate, after I found that loose seam, a small dab of cement solved the problem.

A leaky tube or transistor can also cause clipping and distortion. Many times the best way to diagnose that problem is by substituting new components. That is easy with tubes, but not with transistors, unless the manufacturer was kind enough to use sockets. Many transistor testers can measure leakage; mine reads leakage in the microamp range. Once I found a power transistor with a 10-μA leakage—but that was enough to cause distortion! R-E

SERVICE QUESTIONS

RESISTOR BURNING UP

On a Sony KV1910D chassis, I've replaced the horizontal oscillator IC, the horizontal and vertical output amplifiers, and the regulator, all of which were bad. Resistor R556, which sits on the collector of Q511, is burning up. In addition, I have no high voltage, and the voltage readings around the regulator are all wrong.—L.W. Baltimore, MD

You appear to have two problems here, one of which should be taken care of before you do anything else. The resistor in the Q511 circuit (which incidentally is the starter transistor) is cooking because the transistor is being overworked. The 18-volt scan-derived supply is supposed to switch the transistor off immediately after turn-on. Apparently that 18-volt supply is not reaching the transistor, thereby causing it to stay on.

Now simply start with the basics: Hook up an external 18-volt power supply to get the sweep circuit working. (In the Sept., 1983 issue of **Radio-Electronics** an article "Servicing Horizontal Sweep Circuits" covers the procedure in some detail.) Once you get the high voltage, the regulator problem may fall into place, or at least will be easier to handle.

AGC PROBLEMS

A Panasonic model CT-316 that I've been working on has AGC trouble. I have changed the AGC control as well as IC101, the first IF. I've tested all the components in the AGC circuit, and have sprayed around with coolant. I wonder if IC102, the second IF, could be giving me this problem.—L.G., South Portland, ME

Definitely!—I've seen several of instances in which that was so. And incidentally, I've also seen cases where the IC101 was the culprit, and many cases when the AGC control itself was "spotty," so you did cover all the right steps.

ARCING AT CRT

I have a Philco E20-107 chassis that's arcing between pins 9 and 11 of the CRT. After I changed the spark gap located on the tripler, R970 (tied onto pin 11) began to smoke. Those spark gaps have me confused. Can you help me?—T.D., Corbin, KY

I think you have a bad tripler. An internal short is placing part or most of the high voltage at the focus terminal. That voltage (looking for the path of least resistance) will jump across the spark gap, the CRT pins or, in your case, through R970.

ROBOTICS

continued from page 90

ceive functions. In addition, the same tuned circuit is used for both transmitting and receiving, so you don't have to worry about frequency mis-matching due to component drift.

Transmission is initiated by applying a logic "1" to pin 8 of the LM1812. The receiver will be disabled, and pin 14 will be low. To receive, pin 8 is simply grounded. Pin 14 will go high after the circuit receives an echo of the signal.

The time between initiating transmission and pin 14's going high is then equal to the time required to travel from the transmitter to the object and back. So to obtain the distance to the object, that time would be halved and plugged into the formula $D = V/T$ ($V = 13{,}080$). The circuit shown in Fig. 3-a has a range from 4 inches to about 6 feet. By adding the 555 circuit shown in Fig. 3-*b*, the low end of the range may be decreased to 3 inches, and the high end increased to 20 feet. Potentiometer R2 should again be adjusted to a frequency of 40 kHz.

That circuit is so simple and so inexpensive that you could build several for one robot.

Polaroid's ultrasonics

Polaroid Corporation has been using ultrasonic ranging in cameras such as the *SX-70* for some time now. Distance information obtained through ultrasonics is used to focus the camera's main lens automatically. The transducer used has a larger diameter and is slimmer than the type usually found in electronics surplus stores. Several years ago Polaroid packaged the electronics from their cameras along with a good tutorial manual, as well as an interesting experimenter's board. The package is called the "Polaroid Ultrasonic Ranging System Designer's Kit," and is available for $165 from the Polaroid Ultrasonics Components Group (Polaroid Corp., 119 Windsor Street, Cambridge, MA 02139). It comes with a special interface that displays distance information on an LED readout. **R-E**

AUDIO COMPANDING

continued from page 70

what happens when a burst of 15-kHz pulses is sent through a compander circuit. The upper trace shows the input signal; the middle trace shows the signal after it has been processed by the compressor; and the bottom trace shows how it has been restored to its original form after being processed by the expander.

Automatic level control

The NE570/1 may be used for ALC (Automatic Level Control). In that configuration, the Δ-G cell is placed in the feedback loop of the op-amp, and the rectifier

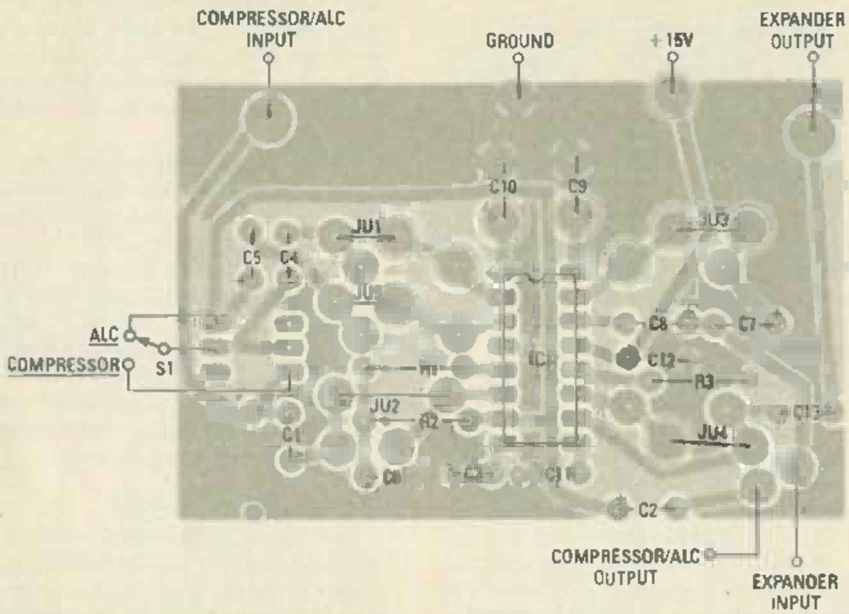
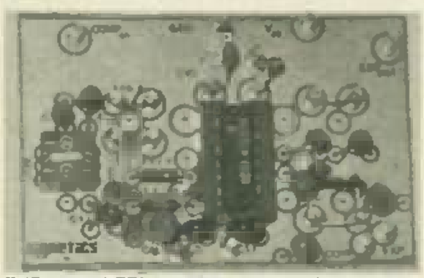


FIG. 12—COMPONENT-PLACEMENT DIAGRAM for the experimental compander circuit that is shown in Fig. 10.



THE COMPLETED COMPANDER let's you make recordings with wide dynamic range and less noise.

is connected to the input. A sample circuit is shown in Fig. 9.

The circuit functions as follows. As the amplitude of the input signal increases above the crossover point, the gain of the Δ-G cell decreases proportionally, and that keeps the output level constant. As the amplitude of the input decreases below the crossover point, the gain of the Δ-G cell increases proportionally, which again keeps the output amplitude constant. The gain equation is:

$$A_v = \frac{R1\ R2\ I_B}{2\ R3\ V_{IN(avg)}}$$

For very low input levels, ALC may not be desirable because the high gain would accentuate transmission noise. Resistor R_X has been added to limit the gain. The modified gain equation is:

$$A_v = \frac{\left(\frac{R1 + R_x}{1.8}\right) R2 I_B}{2R3}$$

The value of R_X may be calculated as follows:

$$R_X = (A_v \times 26{,}000) - 10{,}000$$

All remarks made above regarding DC biasing, maximum signal levels, AC coupling, and attack/decay time constants may be applied to the ALC circuit.

The oscilloscope photograph in Fig. 10 shows the response of the ALC circuit.

Experimental compander circuit

Shown in Fig. 11 is the schematic for a circuit you may use to experiment with companders. The circuit uses a NE570 or NE571 (or SA571), and provides one channel of compression and one channel of expansion. In addition, the compression channel may also be configured to function as an ALC circuit merely by flipping a switch. Full-size printed-circuit artwork is shown in the "PC Service" section of this magazine, and the component-layout diagram for that board is shown in Fig. 12.

Space has been reserved on the PC board for RC pre- and de-emphasis networks. If you have no need for them, simply install jumpers JU1 through JU4; JU5 should be installed in any case. R-E

DIGITAL IC'S

continued from page 76

the present value is loaded into the counter, the circuit will increment one step for each negative-going transition of clock line CLOCK1.

Down counters

The counter circuits presented thus far are up-counters: that is, they increment one step for each active transition of the clock line. A down-counter, on the other hand, decrements for each active transition of the clock line.

Figure 7 shows an example of a base-16 down-counter. Note the difference between that circuit and the base-16 up-

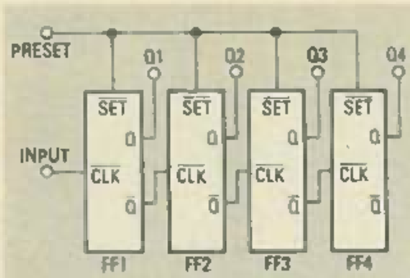


FIG. 7—IN A DOWN COUNTER, the count decrements. Thus, the count after 0000 is 1111.

counter of Fig. 2. In the *up* version, the flip-flops are connected in cascade by connecting the Q output of the driving stage to the clock input of the following stage. In the *down* counter version, the clock input of the following stage is driven from the $\overline{\text{Q}}$ output of the driving stage.

A BCD version can be made using the BCD counter circuit of Fig. 4 modified in the same way; that is, all clock inputs are driven by the $\overline{\text{Q}}$ (instead of the Q) output of the preceding stage. Also, the NAND output resets only the two middle flip-flops.

Up/down counters

An up/down counter is designed to operate as either an up-counter or a down-counter, depending upon the state of the signal (high or low) applied to a special MODE input. Figure 8 shows the circuit for a two-stage up/down counter.

To see how that circuit operates, recall

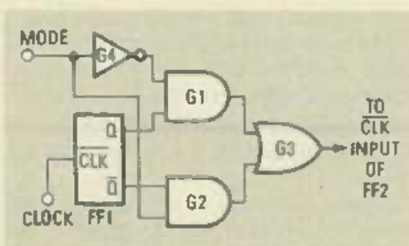


FIG. 8—AN UP/DOWN COUNTER. The direction of the count is determined by the state of the MODE input.

the differences between up and down counters: in the down-counter, the clock is driven from the $\overline{\text{Q}}$ output, while in an up-counter the clock is driven from the Q output of the preceding stage. In Fig. 8, the state of the signal at the MODE input determines which output drives FF2.

Gates G1 and G2 are AND gates whose outputs will be high only when both inputs are high. One input for G1 and G2 is taken from Q and $\overline{\text{Q}}$, repectively. The MODE input is used to provide the second input. For G1, that input is first inverted and then fed to the gate; for G2, that input is fed directly to the gate.

When the MODE input is high, a low is fed to G1 and a high is fed to G2. In that situation, the output of G1 is always held low, while the output of G2 is high when $\overline{\text{Q}}$ is high, and low when $\overline{\text{Q}}$ is low. The outputs of the two gates are then OR'ed together and fed to the clock input of the next stage. In the situation just described, the counter is a down-counter because the clock input of the next stage (FF2) follows the $\overline{\text{Q}}$ output of FF1.

When the MODE input is low, the opposite occurs. The input to G1 is high and the input to G2 is low, and the clock input of FF2 follows the Q output of FF1.

Of course, there are many other types of counter circuits, including those with division ratios other than 2, 10, or 16. Also, while all of the counters that we've presented thus far are decodable, some are not. Such circuits can not be used to present numerical data, but are useful for prescaling and other applications.

Clocking considerations

Thus far, we've proceeded as if the timing of the clock pulses was not critical. If you stick with clocking frequencies of under 1 MHz and pulse widths of over 1 µs, that is indeed the case. Otherwise, there are certain timing parameters that you should be aware of. Those parameters are specified by the manufacturer, and differ for each device. They can be found on the IC's data sheet. Let's briefly go over some of those parameters and what they mean.

The *setup time* refers to the minimum time that an input must be stable before clocking occurs. The *hold time* refers to the minimum time that the input must be stable after clocking occurs. *Minimum reset time* refers to the narrowest width pulse that can be used to reset the device. *Minimum clock-high time* refers to the narrowest pulse width that can be used for clocking. *Maximum clock frequency* is the fastest clock speed that should be used. Propagation delay is the length of time between clocking and a change in the output state.

Monostable multivibrators, also called *one-shots*, are circuits that output just one pulse for every trigger pulse received. Next time, we'll turn our attention to those interesting circuits. R-E

SATELLITE TV

continued from page 12

available on a number of satellite channels. Thus, while the ESPN numbers are surprisingly high—considerably higher than with cable TV viewers—once again no hard conclusions should be drawn from the study's figures.

TVRO owner use-patterns change with time: although 6.6% of those surveyed said news was their most-viewed type of program, that number rises to 11.1% for owners of systems three or more years old. Interest in sports programming also declines as length of ownership increases, and viewing of religious channels nearly triples with long-time viewers.

The future

Defining who TVRO users are, why they buy, and how they use their TVRO systems is a very important task for the home-TVRO industry. That point was driven home when retail sales of home systems fell off sharply this past spring, and several long-established equipment suppliers in the receiver and antenna field found themselves requesting court protection from creditors.

The consensus is that the first 1,000,000 TVRO systems bought (a mark reached this past May) may have been "easy sales" because buyers were eager to purchase after their first exposure to TVRO. However, fears that the market may have become saturated are not supported by the study. What the study does show is that "shotgun" sales techniques, which lack coordinated market planning and direction, may not work as well in the future as they have in the past.

The TVRO distribution chain is going through a difficult year of adjustment. Radio Shack is expected to formally announce their own line of TVRO hardware in their September catalog—and that line will be featured on the front cover. Other large distribution outlets also plan entry into the marketplace during late 1985 and early 1986, so TVRO selling patterns are going to continue changing rapidly. **R-E**

NEW IDEAS

continued from page 8

use a 74LS14 and eliminate R2. That resistor is what gives the circuit its "snap-action," and is unnecessary with a 74LS14, as that IC has the proper circuitry built right in.

How you wire the cassette interface is not critical, but you should use a socket for IC1, and connect all unused inputs (pins 5, 9, 11, and 13) to ground. That applies whether you're using a 74LS04 or a 74LS14 for IC1. Make sure you choose plugs that match your recorder's input, output, and remote jacks. If you'll be using our circuit with a VIC, you can eliminate the relay, as VIC's don't control cassette motors. Switch S1 can be virtually any SPST or SPDT type.

After you've got the circuit wired up, check everything over! Reversing pins A1 and B2 on the computer connector could be disastrous! When you're sure everything is OK, plug PL1, PL2, and PL3 into your recorder, turn on the power, and save a *short* file to tape. Don't forget to close S1 when the prompt appears on the screen. (And always open the switch when you're done saving or loading.)

Next try loading your file back into memory. If you can't load your file, first make sure it was recorded. Rewind the tape, pull plug PL2, and listen. You should hear a high-pitched whirring sound. If that's OK, try connecting an LED through a 330-ohm resistor to pin D4 on the computer connector. With everything hooked up you should see the LED flicker on and off rather rapidly. If it doesn't, there's probably a wiring error. Trace out your connections, and if they still seem OK, IC1 may be at fault.

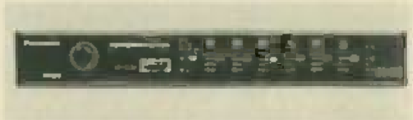
Disk owners may find our circuit handy as a means of backing up valuable data disks. Just load your files from disk in the usual manner, and save to tape similarly. By the way, very low-cost cassettes *don't* make good storage media for computer data. Those cassettes frequently suffer from "dropouts." If that happens in the wrong place, a whole tape could be rendered useless—so don't scrimp on tapes! —*Micheal R. Lockwood*

NEW PRODUCTS
continued from page 42

price of 39.95.—AP Products, Incoporated, 9325 Progress Parkway, PO Box 540, Mentor, OH 44060.

GRAPHIC EQUALIZER, model *CY-SG60,* is a 7-band graphic equalizer/booster amplifier, and measures 1 inch in height. Combined with most Panasonic compact chassis car-audio units, it fits snugly into the dashboards of many cars that are manufactured in the U.S.A.

Dual inputs allow the model *CY-SG60* to be connected to car-audio units with pre-amp output, or to units with speaker output only. A total maximum output power of 50 watts, and THD of less than 1% at 12 watts per channel helps ensure clear sound at high volume levels. A tone defeat/attenuator switch reduces volume by 20 dB to mute sound output without changing volume-control settings. The



CIRCLE 27 ON FREE INFORMATION CARD

unit's controls are illuminated.

With the model *CY-SG60's* remote power switch, the unit can be turned on automatically with the main car audio unit. Efficient heat dispersion is provided by a specially designed heat sink. The suggested retail price is $119.95.—Panasonic, One Panasonic Way, Secaucus, NJ 07094.

VIDEO DISPLAY TERMINAL, the model *ADM 11plus,* incorporates all of the features of the model *ADM 11* with additional function keys and editing capabilities.

The *ADM 11plus* is compatible with the Lear Siegler *ADM 3A, ADM 5,* and *ADM 11, ADDS Viewpoint* and *Regent25, Hazeltine 1400, 1420,* and *1500,* and *DEC VT52* terminals.

CIRCLE 28 ON FREE INFORMATION CARD

This conversation-mode terminal features 16 function keys for 16 programmable and 16 non-programmable functions, and will handle transmissions up to 19,200 baud without handshaking. The terminal also features three edit keys and a break key, which can be programmed to perform an additional seven functions. Editing features include character/line insert, character/line delete, line erase, and page erase.

The model *ADM 11plus* is priced at $695.00.—Lear Siegler, Inc., 901 East Ball Road, Anaheim, CA 92805. R-E

PULSE GENERATOR

continued from page 59

Connect an oscilloscope to either the TTL or the CMOS clock output, set S1 to FREE RUN, and verify that R1 and S3 vary the clock speed as expected. Toggling switch S8 should invert the output. Next connect the scope to one of the pulse outputs. With S2 in the DIRECT position, R6 and S6 should vary the width of the pulses, and S5 their polarity. R1 and S3 vary their repetition rate, of course.

With S2 in the EXT. TRIGGER position, each low-to-high transition on jack J6 should cause a pulse of the selected width and polarity to appear at jacks J2 and J3. Similarly, with S2 in the ONE-SHOT position, each time S7 is depressed a pulse of the selected width and polarity should appear at those jacks.

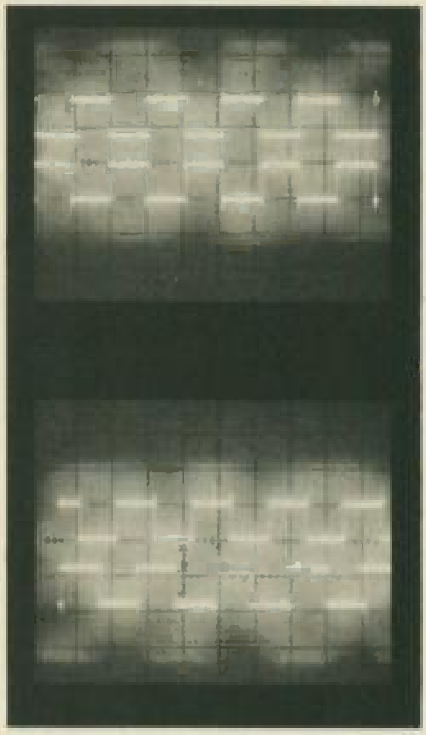


FIG. 3—THE TOP TRACE of each oscilloscope photograph shows the pulse output, while the bottom trace shows the clock output. The pulse output in *a* is direct, while that shown in *b* is delayed by about 7 microseconds.

You'll need a dual-channel scope to test the delay function. Place S2 in the DELAYED position. Connect one channel to a clock output and one channel to a pulse output. If your scope has a separate SYNC input, connect it to the pulse generator's SYNC OUTPUT jack, J1. Now by varying S4 and R8, you should be able to vary the length of time (from 1 µS to 100 µS) that the pulse train lags behind the clock output. Figure 3 shows two oscilloscope photographs, one showing zero delay, and the other showing a delay of about seven µs.

When everything checks out, mount the PC board to the chassis with short standoffs, tighten all hardware, and screw the cabinet together.

Practical applications

Our pulse generator may be used to troubleshoot or test already-existing equipment; it may be used to aid the design of new equipment, and it may also be used for experimental and educational purposes.

For example, the pulse generator could be used to troubleshoot a high-speed clocked-logic system that seemed to be missing pulses and giving erroneous outputs. You could disconnect the system clock from the piece of equipment under test, and then substitute the pulse generator's clock output. Then, by running that device at a slower rate—perhaps one pulse at a time—you would find it easier to trace a signal through the system. That sort of procedure won't always work; NMOS microprocessors, for example, often cannot be run below about 250 kHz. But you can usually slow things down enough to be able to see what's going on better than at the full clock rate.

You can use the pulse generator to experiment with shift registers and counters. Wire up your circuit on a solderless breadboard and single-step through all logic states.

For example, suppose you have a circuit built around a 4018 presettable dividy-by-n counter. That IC has five "jam" inputs and five (complemented) data outputs. The outputs may be recycled, in various combinations, to the IC's DATA input, allowing division of the input clock by any ratio between two and ten. The only hitch is that division by an odd ratio (three, five, seven or nine) requires use of an external AND gate.

Anyway, suppose your design requires outputs that cycle from four to nine and then reset (i.e., start counting from four again). You have wired the circuit up, but there is a bug; the circuit counts from four to eight and then resets. Feeding the pulse generator's output to the 4018's clock input and monitoring the IC's outputs, you discover that you have forgotten to AND the $\bar{Q}_4$ and $\bar{Q}_5$ outputs.

To synchronize pulse output with an external clock, connect the clock to J6 and place S2 in the EXT. TRIGGER position. If you need one output pulse for a predetermined number of clock pulses, simply insert a divider IC between the clock source and J6. The 4059 is a programmable divide-by-N counter which can be used for that purpose. That IC can divide the frequency of the clock fed to it by any ratio between three and 15,999. If your work involves much of that sort of thing, there is room on the PC board to mount several extra IC's. You would then mount appropriate division-ratio selection switches on the front panel. R-E

REMOTE-CONTROLLER

continued from page 66

The example circuit uses the 4029B up/down binary/BCD counter, since that is the most flexible type available. Not only is that counter capable of counting up or down, but it can count in either straight binary or BCD formats. In addition, it is presettable and cascadable. If the alternate counting format is not needed, the similar 4510B or 4516B binary counters can be used.

Whichever of the three counters is used, a single device will give a total of 10 or 16 steps. All three types can be cascaded to a second counter, giving 100 or 256 steps. One continuous command should be used to step the counter up, and a second to step it down. Gating could be added to prevent over- and under-flow by disabling the UP enable when the maximum count is reached, and disabling the DOWN enable when the all-zero state is reached.

That type of decoder could be used in a number of ways, the most flexible of which is to interface its outputs with a resistor string or an IC digital-to-analog converter to obtain an analog voltage output. A series of optocouplers and such a resistor string could be used in standard D/A format to replace a potentiometer on the controlled device.

The data port has been left out of this discussion, since it is meant primarily to carry channel numbers, tuning frequencies, and other numerical data. However, if the controller is converted to single-digit operation, another BCD or hex 1-of-n line decoder could be added via that port, giving 20 or 32 separate enable lines.

There are a number of methods that can be used to interface the CMOS outputs of the various decoders to the controlled device; let's examine some of those next. If the device is digital and uses a matching 5-volt supply, often the outputs can be directly connected. However, if more current is needed, power drivers such as transistors must be added to the CMOS outputs. If different voltages are used in the controlled device, either power driver IC's or optocouplers must be used. Light-duty reed relays can be used without special driver circuitry.

It's now up to you to take the 14457/14458 remote control system and use those output devices (or a system of your own) to interface it to what you want to control, be it a TV, VCR, stereo, cable tuner, CD player, computer, or any other device or circuit that you can think of. Whatever that device or circuit is, it can be controlled by an invisible beam of light or an ultrasonic wave linking the two halves of this system! R-E

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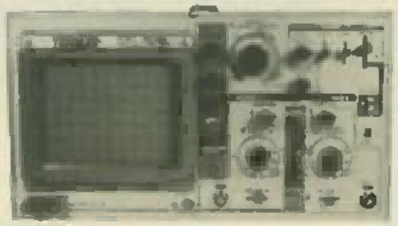

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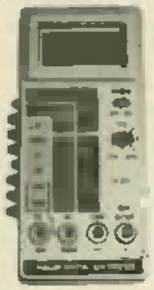

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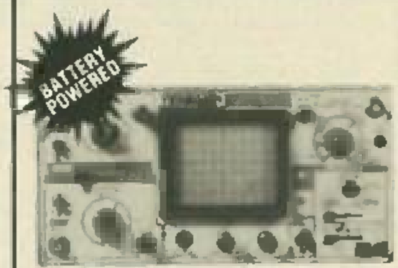

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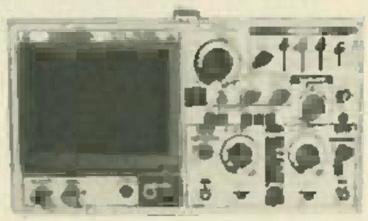

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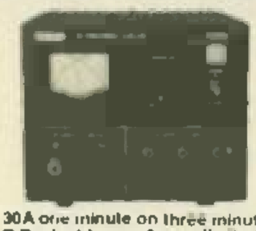

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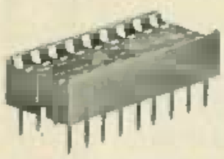

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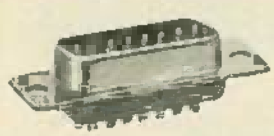

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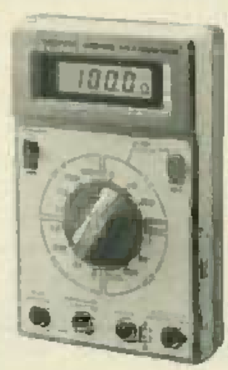

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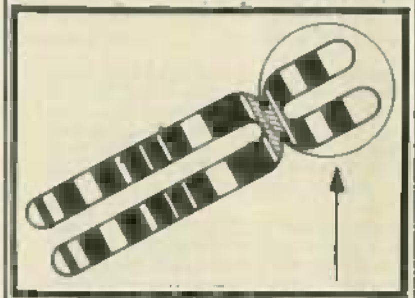

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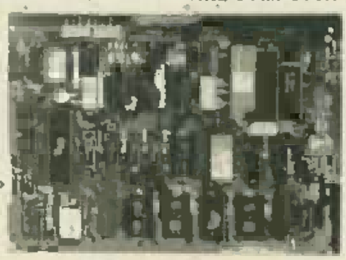

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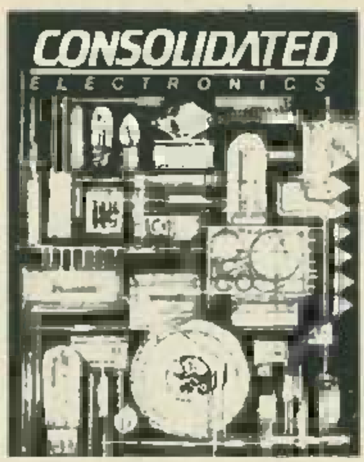

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2114	1024x4	(450ns)	.99
2114L-4	1024x4	(450ns)(LP)	1.09
2114L-2	1024x4	(200ns)(LP)	1.49
2114L-15	1024x4	(150ns)(LP)	1.95
TMS4044-4	4096x1	(450ns)	1.95
TMM2016-150	2048x8	(150ns)	1.69
TMM2016-100	2048x8	(100ns)	2.49
HM6116-4	2048x8	(200ns)(CMOS)	1.79
HM6116-3	2048x8	(150ns)(CMOS)	1.89
HM6116LP-4	2048x8	(200ns)(CMOS)(LP)	1.89
HM6116LP-3	2048x8	(150ns)(CMOS)(LP)	1.99
HM6116LP-2	2048x8	(120ns)(CMOS)(LP)	2.95
HM6264P-15	8192x8	(150ns)(CMOS)	4.75
HM6264LP-15	8192x8	(150ns)(CMOS)(LP)	4.95
HM6264LP-12	8192x8	(120ns)(CMOS)(LP)	5.95

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)	.49
4164-150	65536x1	(150ns)(5V)	.49
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
41256-200	262144x1	(200ns)(5V)	2.95
41256-150	262144x1	(150ns)(5V)	2.95

5V=Single 5 Volt Supply REFRESH=Pin 1 Refresh

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REPLACES 8088 TO SPEED UP IBM PC 10-40%

- HIGH-SPEED ADDRESS CALCULATION IN HARDWARE
- PIN COMPATIBLE WITH 8088
- SUPERSET OF 8086/8088 INSTRUCTION SET
- LOW POWER CMOS

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2708	1024x8	(450ns)	3.95
2716-6	2048x8	(650ns)	2.29
2716	2048x8	(450ns)(5V)	2.49
2716-1	2048x8	(350ns)(5V)	3.95
TMS2532	4096x8	(450ns)(5V)	3.95
2732	4096x8	(450ns)(5V)	2.49
2732A	4096x8	(250ns)(5V)(21V PGM)	2.89
2732A-2	4096x8	(200ns)(5V)(21V PGM)	4.95
27C64	8192x8	(250ns)(5V)(CMOS)	7.95
2764	8192x8	(450ns)(5V)	2.29
2764-250	8192x8	(250ns)(5V)	2.49
2764-200	8192x8	(200ns)(5V)	4.95
TMS2564	8192x8	(450ns)(5V)	6.95
MCM68766	8192x8	(350ns)(5V)(24 PIN)	17.95
27128	16384x8	(250ns)(5V)	3.49
27C256	32768x8	(250ns)(5V)(CMOS)	15.95
27256	32768x8	(250ns)(5V)	5.95

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

SPECTRONICS CORPORATION EPROM ERASERS

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

8000

8035	1.95
8039	2.95
8080	2.95
8085	2.95
8087-2	139.95
8087	109.00
8088	7.95
8088-2	9.95
8155	2.95
8155-2	3.95
8748	9.95
8755	19.95
80286	129.95
80287	185.00

8200

8203	34.95
8205	3.29
8212	1.49
8216	1.49
8224	2.25
8237	4.95
8237-5	8.95
8250	6.95
8251	1.95
8251A	2.49
8253	1.95
8253-5	2.49
8255	1.95
8255-5	2.49
8259	2.49
8259-5	2.95
8272	4.95
8279	2.95
8279-5	3.49
8282	3.95
8284	2.95
8286	3.95
8288	4.95

Z-80

Z80-CPU 2.5 MHz 1.79

4.0 MHZ

Z80A-CPU	1.89
Z80A-CTC	1.95
Z80A-DART	5.95
Z80A-DMA	5.95
Z80A-PIO	1.89
Z80A-SIO/0	5.95
Z80A-SIO/1	6.95
Z80A-SIO/2	5.95

6.0 MHZ

Z80B-CPU	4.95
Z80B-CTC	5.95
Z80B-PIO	8.95
Z80B-DART	14.95
Z80B-SIO/0	12.95
Z80B-SIO/2	12.95
Z8471 ZILOG	19.95

6500

1.0 MHZ

6502	2.79
65C02 (CMOS)	12.95
6507	9.95
6520	1.95
6522	4.95
6526	26.95
6532	6.95
6545	6.95
6551	6.95
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	8.95

6800

1.0 MHZ

6800	1.95
6802	4.95
6803	9.95
6809	5.95
6809E	5.95
6810	1.95
6820	2.95
6821	1.95
6840	6.95
6843	19.95
6844	12.95
6845	4.95
6847	11.95
6850	1.95
6883	22.95

2.0 MHZ

68B00	4.95
68B02	5.95
68B09E	7.95
68B09	7.95
68B21	4.95
68B48	9.95
68B50	3.95
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	15.95
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CRT5037	9.95
TMS9918A	19.95

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1791	9.95
1793	9.95
1795	12.95
1797	12.95
2791	19.95
2793	19.95
2797	29.95
6843	19.95
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IM6403	9.95
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76489	8.95
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AY3-8912	12.95
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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
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18.0	1.95
18.432	1.95
20.0	1.95
22.1184	1.95
24.0	1.95
32.0	1.95

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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

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11C90	13.95
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AY5-2376	11.95
AY5-3600 PRO	11.95

74LS00

74LS00	.16	74LS165	.69
74LS01	.18	74LS166	.95
74LS02	.17	74LS169	.95
74LS03	.18	74LS173	.49
74LS04	.16	74LS174	.39
74LS05	.18	74LS175	.39
74LS08	.18	74LS191	.49
74LS09	.18	74LS192	.69
74LS10	.16	74LS193	.69
74LS11	.22	74LS194	.69
74LS12	.22	74LS195	.69
74LS13	.26	74LS196	.59
74LS14	.39	74LS197	.59
74LS15	.26	74LS221	.59
74LS20	.17	74LS240	.69
74LS21	.22	74LS241	.69
74LS22	.22	74LS242	.69
74LS27	.23	74LS243	.69
74LS28	.26	74LS244	.69
74LS30	.17	74LS245	.79
74LS32	.18	74LS251	.49
74LS33	.28	74LS253	.49
74LS37	.26	74LS256	1.79
74LS38	.26	74LS257	.39
74LS42	.39	74LS258	.49
74LS47	.59	74LS259	1.29
74LS48	.69	74LS260	.49
74LS51	.17	74LS266	.39
74LS73	.29	74LS273	.79
74LS74	.24	74LS279	.39
74LS75	.29	74LS280	1.98
74LS76	.29	74LS283	.59
74LS83	.49	74LS290	.89
74LS85	.49	74LS293	.89
74LS86	.22	74LS298	.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	2.20
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
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74LS163	.39	26LS31	1.99
74LS164	.49	26LS32	1.99

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

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74HC02	.59	74HC151	.89
74HC04	.59	74HC154	2.49
74HC08	.59	74HC157	.89
74HC10	.59	74HC158	.95
74HC14	.79	74HC163	1.15
74HC20	.59	74HC175	.99
74HC27	.59	74HC240	1.89
74HC30	.59	74HC244	1.89
74HC32	.59	74HC245	1.89
74HC51	.59	74HC257	.89
74HC74	.75	74HC259	1.39
74HC85	.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	.89	74HC4020	1.39
74HC138	.99	74HC4049	.89
74HC139	.99	74HC4050	.89

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

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74HCT02	.69	74HCT174	1.09
74HCT04	.69	74HCT193	1.39
74HCT08	.69	74HCT194	1.19
74HCT10	.69	74HCT240	2.19
74HCT11	.69	74HCT241	2.19
74HCT27	.69	74HCT244	2.19
74HCT30	.69	74HCT245	2.19
74HCT32	.79	74HCT257	.99
74HCT74	.85	74HCT259	1.59
74HCT75	.95	74HCT273	2.09
74HCT136	1.19	74HCT367	1.09
74HCT139	1.15	74HCT373	2.49
74HCT154	2.99	74HCT374	2.49
74HCT157	.99	74HCT393	1.59
74HCT158	.99	74HCT4017	2.15
74HCT161	1.29	74HCT4040	1.59
74HCT164	1.39	74HCT4060	1.49

74F00

74F00	.69	74F74	.79	74F251	1.89
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74F04	.79	74F138	1.69	74F257	1.69
74F08	.59	74F139	1.89	74F280	1.79
74F10	.69	74F157	1.69	74F283	3.95
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4017	.49	4522	.79
4018	.89	4526	.79
4020	.59	4527	1.95
4021	.49	4528	.79
4024	.49	4529	2.95
4025	.25	4532	1.95
4027	.39	4538	.95
4028	.65	4541	1.29
4035	.69	4553	5.79
4040	.69	4585	.75
4041	.75	4702	12.95
4042	.59	74C00	.29
4043	.85	74C14	.59
4044	.69	74C74	.65
4045	1.98	74C83	1.95
4046	.69	74C85	1.49
4047	.69	74C95	.99
4049	.29	74C150	5.75
4050	.29	74C151	2.25
4051	.69	74C161	.89
4052	.69	74C163	.99
4053	.69	74C164	1.39
4056	2.19	74C192	1.49
4060	.89	74C193	1.49
4066	.29	74C221	1.75
4069	.19	74C240	1.89
4074	.59	74C244	1.89
4077	.29	74C374	1.99
4081	.22	74C905	10.95
4085	.79	74C911	8.95
4086	.89	74C917	8.95
4093	.49	74C922	4.49
4094	2.49	74C923	4.95
14411	9.95	74C926	7.95
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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	74156	.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	.89
7430	.19	74166	1.00
7432	.29	74175	.89
7438	.29	74177	.75
7442	.49	74178	1.15
7445	.69	74181	2.25
7447	.89	74182	.75
7470	.35	74184	2.00
7473	.34	74191	1.15
7474	.33	74192	.79
7475	.45	74194	.85
7476	.35	74196	.79
7483	.50	74197	.75
7485	.59	74199	1.35
7486	.35	74221	1.35
7481	2.15	74246	1.35
7490	.39	74267	1.25
7492	.50	74248	1.85
7493	.35	74249	1.95
7495	.55	74251	.75
7497	2.75	74265	1.35
74100	2.29	74273	1.95
74121	.29	74278	3.11
74123	.49	74367	.65
74125	.65	74368	.65
74141	.65	9368	3.95
74143	6.95	9602	1.50
74144	2.95	9637	2.95
74145	.60	96502	1.95

74S00

74S00	.29	74S163	1.29
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74S05	.29	74S188	1.95
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74S15	.35	74S196	1.49
74S30	.29	74S197	1.49
74S32	.35	74S226	3.99
74S37	.69	74S240	1.49
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74S140	.55	74S288	1.69
74S151	.79	74S299	2.95
74S153	.79	74S373	1.69
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7815T	.49	7915T	.59

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

TO-92 CASE

78L05	.49	79L05	.69
78L12	.49	79L12	.69

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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

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TL072	1.09	LM747	.69
TL074	1.95	LM748	.59
TL081	.59	MC1330	1.69
TL082	.99	MC1350	1.19
TL084	1.49	MC1372	4.95
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LM309K	1.25	LM1458	.49
LM311	.59	LM1488	.49
LM311H	.89	LM1489	.49
LM317K	3.49	LM1496	.85
LM317T	.95	LM1812	8.25
LM318	1.49	LM1889	1.95
LM319	1.25	ULN2003	.79
LM320 see 7900		XR2206	3.75
LM322	1.65	XR2211	2.95
LM323K	4.79	XR2240	1.95
LM324	.49	MPQ2907	1.95
LM331	3.95	LM2917	1.95
LM334	1.19	CA3046	.89
LM335	1.40	CA3081	.89
LM336	1.75	CA3082	.99
LM337K	3.95	CA3086	.80
LM338K	3.95	CA3089	1.95
LM339	.59	CA3130E	.89
LM340 see 7800		CA3146	1.29
LM350T	4.60	CA3140	1.19
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LF357	.99	MC3487	2.95
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LM383	1.95	LM3911	2.25
LM386	.89	LM3914	2.39
LM393	.45	MC4024	3.49
LM394H	4.60	MC40	3.99
TL494	4.20	RC4136	1.25
TL497	3.25	RC4558	.69
NE555	.29	LM13600	1.49
NE556	.49	75107	1.49
NE558	1.29	75110	1.95
NE564	1.95	75150	1.95
LM565	.95	75154	1.95
LM566	1.49	75188	1.25
LM567	.79	75189	1.25
NE570	2.95	75451	.39
NE590	2.50	75452	.39
NE592	.98	75453	.39
LM710	.75	75477	1.29
LM723	.49	75492	.79

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

DATA ACQ / INTERFACE

ADC0800	15.55	8T26	1.29
ADC0804	3.49	8T28	1.29
ADC0809	4.49	8T95	.89
ADC0816	14.95	8T96	.89
ADC0817	9.95	8T97	.59
ADC0831	8.95	8T98	.89
DAC0800	4.49	DM8131	2.95
DAC0806	1.95	DP8304	2.29
DAC0808	2.95	DS8833	2.25
DAC1020	8.25	DS8835	1.99
DAC1022	5.95	DS8836	.99
MC1408L8	2.95	DS8837	1.65

IC SOCKETS

		1-99	100
8	PIN ST	.13	.11
14	PIN ST	.15	.12
16	PIN ST	.17	.13
18	PIN ST	.20	.18
20	PIN ST	.29	.27
22	PIN ST	.30	.27
24	PIN ST	.30	.27
28	PIN ST	.40	.32
40	PIN ST	.49	.39
64	PIN ST	4.25	CALL

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	1.69	1.49
40	PIN WW	1.99	1.80

WW-WIREWRAP

16	PIN ZIF	4.95	CALL
24	PIN ZIF	5.95	CALL
28	PIN ZIF	6.95	CALL
40	PIN ZIF	9.95	CALL

ZIF-TEXTOOL
(ZERO INSERTION FORCE)

EDGECARD CONNECTORS

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

36 PIN CENTRONICS

MALE

IDCEN36	RIBBON CABLE	6.95
CEN36	SOLDER CUP	4.95
CEN36PC	RT ANGLE PC MOUNT	4.95

FEMALE

IDCEN36/F	RIBBON CABLE	7.95

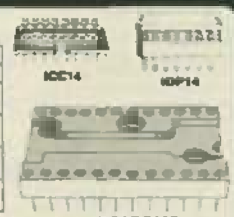
INTERSIL

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	...	.95	.95	...	...	...	1.75	...	2.95

FOR ORDERING INSTRUCTIONS SEE D-SUBMINIATURE BELOW



ICC14 IDP14 AUGAT 24ST

DIODES/OPTO/TRANSISTORS

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

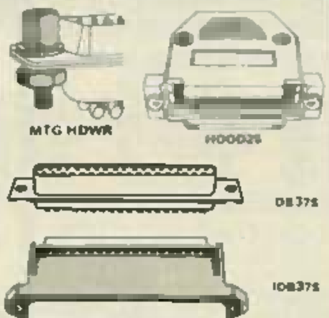
D-SUBMINIATURE

DESCRIPTION		ORDER BY	CONTACTS 9	15	19	25	37	50
SOLDER CUP	MALE	DBxxP	.82	.90	1.25	1.25	1.80	3.48
	FEMALE	DBxxS	.95	1.15	1.50	1.50	2.35	4.32
RIGHT ANGLE PC SOLDER	MALE	DBxxPR	1.20	1.49	...	1.95	2.65	...
	FEMALE	DBxxSR	1.25	1.55	...	2.00	2.75	...
WIRE WRAP	MALE	DBxxPWW	1.69	2.56	...	3.89	5.60	...
	FEMALE	DBxxSWW	2.76	4.27	...	6.84	9.95	...
IDC RIBBON CABLE	MALE	IDBxxP	2.70	2.95	...	3.98	5.70	...
	FEMALE	IDBxxS	2.92	3.20	...	4.33	6.76	...
HOODS	METAL	MHOODxx	1.25	1.25	1.30	1.30	...	...
	GREY	HOODxx	.65	.65	...	.65	.75	.95

ORDERING INSTRUCTIONS: INSERT THE NUMBER OF CONTACTS IN THE POSITION MARKED "xx" OF THE "ORDER BY" PART NUMBER LISTED.

EXAMPLE: A 15 PIN RIGHT ANGLE MALE PC SOLDER WOULD BE DB15PR

MOUNTING HARDWARE $1.00



MTG HDWR HOOD25 DB37S IDB37S

LED DISPLAYS

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

DIFFUSED LEDS

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

SWITCHES

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

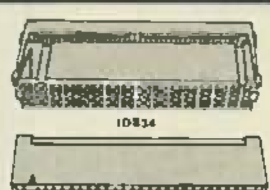
DIP SWITCHES

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

IDC CONNECTORS

DESCRIPTION	ORDER BY	CONTACTS 10	20	26	34	40	50
SOLDER HEADER	IDHxxS	.82	1.29	1.68	2.20	2.58	3.24
RIGHT ANGLE SOLDER HEADER	IDHxxSR	.85	1.35	1.76	2.31	2.72	3.39
WW HEADER	IDHxxW	1.86	2.98	3.84	4.90	5.28	6.63
RIGHT ANGLE WW HEADER	IDHxxWR	2.05	3.28	4.22	4.45	4.88	7.30
RIBBON HEADER SOCKET	IDSxx	.79	.99	1.39	1.59	1.89	2.29
RIBBON HEADER	IDMxx	—	5.50	6.25	7.00	7.50	8.50
RIBBON EDGE CARD	IDExx	1.75	2.25	2.65	2.75	3.80	3.95

FOR ORDERING INSTRUCTIONS SEE D-SUBMINIATURE ABOVE



IDS34 IDE50

RIBBON CABLE

CONTACTS	SINGLE COLOR 1'	10'	COLOR CODED 1'	10'
10	.16	1.60	.30	2.75
16	.28	2.50	.48	4.40
20	.30	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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27C16	(450ns) CMOS EPROM	9.95	MC146818	REAL TIME CLOCK & RAM	7.95
4164N-200	DRAM	9/9.95	27128-25	(250ns) EPROM	5.95
6116P-4	(200ns) SRAM	3.49	41256-150	(150ns) DRAM	6.49
6116LP-4	(200ns) LP SRAM	3.69	68764	(450ns) 25V EPROM	12.95
			68766	(350ns) 25V EPROM	14.95

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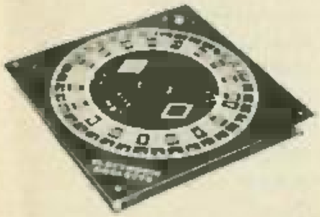

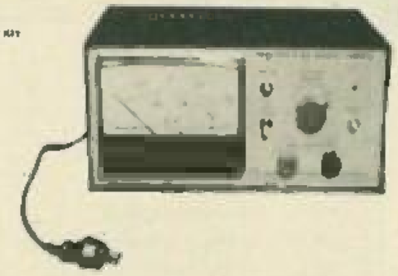

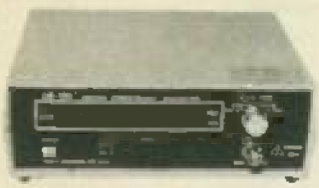

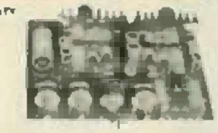

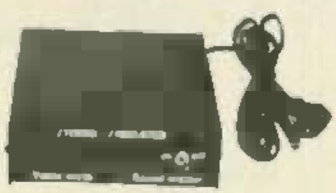

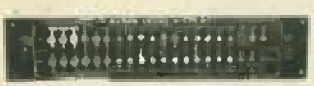

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