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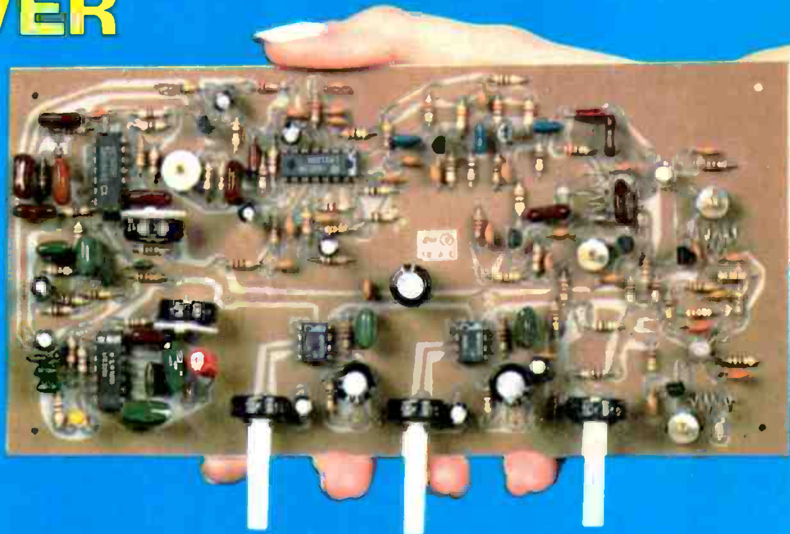

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August 1987

Radio-Electronics

Vol. 58 No. 8

BUILD THIS

PAGE 61

TECHNOLOGY

PAGE 48

CIRCUITS AND COMPONENTS

DEPARTMENTS

AND MORE

ON THE COVER

The FM band abounds with hidden signals. Called SCA broadcasts or transmissions, some carry background music for stores, offices, and restaurants; some carry data for personal and commercial computer users; and some offer special interest programming for the handicapped and other groups. This month, we tell where those hidden signals are, and what makes them possible. Then we'll show you a receiver that will let you tune into the hidden world of FM radio. The story begins on page 39.

COMING NEXT MONTH

THE SEPTEMBER ISSUE IS ON SALE AUGUST 4

BUILD THE VIDEO PALETTE
Add special color effects to a video signal.

BUILD AN UNINTERRUPTABLE POWER SUPPLY
This 40-watt back-up supply kicks in at the first sign of trouble.

CELLULAR TELEPHONE TECHNOLOGY
Learn about the technology that's revolutionized mobile telephones.

R-E ROBOT
Part 10 deals with robot applications.

SCR/TRIAC COOKBOOK
Practical SCR/Triac circuits for your next project.

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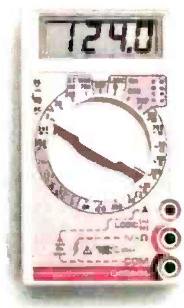

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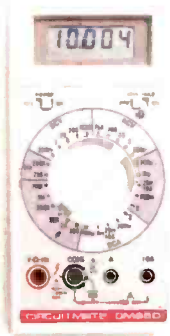

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CIRCLE 98 ON FREE INFORMATION CARD

WHAT'S NEWS

New instrument measures tape surface magnetism

A new device that could lead to improved operation of many devices using magnetic tape has been developed by scientists at the Argonne National Laboratory. The instrument, called a polarized-neutron reflectometer, uses neutrons to measure magnetic fields over microscopic depths at the surface of materials.

"The instrument has already been used to measure the response of new recording materials to magnetic fields," says Gian Fletcher of Argonne. "Better information in this area could lead to improved magnetic recording technologies."

"The trick," Fletcher said, "was to make the probe as sensitive as possible to magnetic fields at the surface. This was accomplished by sending the neutrons nearly parallel to the surface, so they graze it." The instrument can measure magnetic fields within .0002-inch of the surface of the material. It can detect a magnetic field change over a distance as small as a billionth of an inch.

GIAN P. FLETCHER, ARGONNE NATIONAL LABORATORY scientist, with the polarized-neutron reflectometer that could lead to improvements in magnetic recording.

New infrared systems test gallium-arsenide wafers

The National Bureau of Standards reports two testing systems using polarized infrared light. They are expected to be especially useful in production control of gallium-arsenide (gAaS) wafers.

GaAs applications are growing rapidly, but production of the near-perfect crystals needed for best performance is not as advanced as with the older silicon technology. Detecting flaws in GaAs crystals should be easier with the new systems. One can scan an entire wafer; the other uses a 75- to 600-× microscope to view smaller portions. Both permit digital image storing and the use of false-color graphics to represent variations in characteristics that could point to potential problems.

FCC abandons Consumer Radio Service

The FCC reports that it "has declined to amend its rule to establish a Consumer Radio Service within the 462- and 467-MHz frequency segments now assigned to the *G*eneral *M*obile *R*adio *S*ervice (GMRS)." That marks the end of an FCC-sponsored plan to replace the GMRS with a service that many felt would be of far-less value.

Replies to a request for comments "failed to find any specific needs" for such a service, according to the FCC. Moreover, concern was expressed about the fate of present uses of the GMRS, including safety services provided by volunteer public service teams such as REACT (*R*adio *E*mergency *A*ssociated *C*ommunications *T*eams).

Consequently, the Commission concluded "that there was no reason to dislocate current GMRS users" and dropped the Consumer Radio Service concept. **R-E**

VIDEO NEWS

DAVID LACHENBRUCH,
CONTRIBUTING EDITOR

• **TV Sets Large and Small.** TV sets with giant cathode-ray tubes are now included in many manufactures' lines; at the other end of the spectrum are the first active-matrix LCD color sets. Active-matrix LCD's produce a picture that is vastly superior in terms of resolution and color to the passive-matrix type used in the LCD sets introduced to date.

Panasonic originally showed a sample of its 3-inch "Pocket Watch" LCD TV set almost a year ago, then shelved it because of manufacturing problems. Now it has been introduced in a somewhat different form—including stereo-FM/AM radio (with headphones). Because of the inherent expense of producing the active-matrix LCD's, as well as the high value of the Japanese Yen in relation to the Dollar, Panasonic has put a list price of $550 on that little TV set. In addition, Toshiba plans to offer a 4-inch active-matrix LCD TV this fall, and has said it is "aiming" at a price of around $400.

On the large screen front, several manufacturers are introducing sets with screens larger than 26 or 27 inches, but smaller than the 35-inch size produced initially by Mitsubishi, and later adopted by Sanyo, Sharp, Fisher, and Sears.

Panasonic, in its new line, is featuring a 31-inch set, as is North American Philips, which manufactures sets under the Magnavox, Philco, and Sylvania brands, Now Toshiba, the originator of the FST (*F*lat, *S*quare *T*ube), has introduced its *FST Magnum*, a tube that measures 30 inches, diagonally, and whose face is virtually flat. The rest of the industry is choosing up sides among the various sizes. Whichever they choose, the new types are luxuries indeed, with prices ranging from $2,000 and up.

• **Super Camcorder.** The first combination camera-recorder capable of making home movies with higher resolution than broadcast TV or videodisc has been announced by Hitachi. Hitachi says it has developed an MOS camera pickup that can produce 450 lines of horizontal resolution, which it plans to mass-produce starting this summer. Until Hitachi's development became known, it was believed that camera pickups matching the resolution capability of the new Super-VHS system (**Radio-Electronics,** May, 1987) would be unavailable at a consumer price. Hitachi now says it will deliver a high-resolution Super-VHS camcorder this fall. RCA, whose VCR's and cameras are made by Hitachi, is expected to come out with a similar version.

• **Menu-Driven TV Sets.** Television manufacturers are borrowing from computers in providing what they see as the very latest in tuning convenience—the on-screen menu. That feature is carried to the furthest extreme in the new RCA and Magnavox lines, in which virtually every TV function may be tuned with on-screen indicators and legends. In RCA's *Dimensia* audio-video line even the FM- and AM-radio tuning is done on the TV screen. A typical TV tuning system gives on-screen indication of such functions as mono, stereo, SAP (for *S*econd *A*udio *P*rogram), bass, treble, balance, input, brightness, picture, color, tint, sharpness, cable or broadcast tuning, on-off time setting, channel blockout (for parental control), and so forth. The Magnavox *Total Remote Control* system even has a novel "channel captioning" system. The user can identify each channel by its call letters or broadcast- or cable-network (HBO, CNN, etc.) affiliation, and any time that channel is displayed, the identification also is flashed on the screen.

Double-Tuner TV sets. Another innovation in the new models is the two-tuner TV set. The first digital TV models, you'll recall, had the picture-in-picture feature that superimposes a second picture in a corner of the screen, but required a second picture source, such as a VCR, to use the feature. New color-TV sets from Sony and Hitachi get around that by incorporating two tuners. That allows the viewer to watch any two channels simultaneously, switch them around, halt one to a still picture, and so forth. Interestingly, the new double-tuner picture-in-picture storage system is digital, but other processing circuits are analog. And therein lies another trend in the new models: Use digital technology where necessary to provide a special feature; otherwise stay with tried-and-true analog circuitry. **R-E**

ASK R-E

WRITE TO:

ASK R-E
Radio-Electronics
500-B Bi-County Blvd.
Farmingdale, NY 11735

SUNRISE TO SUNSET SIMULATOR

I need a sunrise/sunset simulator, which is a device that will turn on a lamp slowly to simulate the sun rising and then, after a preset time, slowly dim the light to simulate sunset. Do you have anything in your files?—D.E.R., Notre Dame, IN.

Figure 1 shows a circuit that will fill the bill. The circuit was presented by Jamieson Rowe and Kieth Woodward in the article "An Automatic Lamp Dimmer, Using the Triac AC Switch" in the magazine *Electronics Australia*, December, 1966, pages 65–75. Because the circuit was designed for 240-volt operation, some circuit values—those marked with an asterisk—will have to be adjusted for operation on 117-volt powerlines.

Current through a lamp or a heater load connected to socket SO1 is controlled by varying the conduction period (angle) through each half-cycle of line voltage applied to the Triac (TR1), which is connected in series with the load across the AC powerline. The conduction period is varied and controlled by the unijunction transistor (Q3) circuit: a relaxation oscillator that is coupled to Triac TR1's gate through pulse transformer T1. The oscillator's basic frequency depends on R7/C4.

The bridge rectifier develops approximately 165 volts *peak*, which is regulated to approximately 13.5 volts by silicon rectifiers D5 and D6 which are in series with 12-volt Zener diode D8.

Also connected across the 13.5-volt source is Q3's RC timing network, R3/C2. For proper circuit operation, R3 must be adjusted so the voltage across C2 just rises to the conduction point of Q3 at the end of each half-cycle of the line voltage. Under that condition, Q3 delivers a current pulse through T1 to TR1's gate as the instantaneous line voltage drops close to zero. Since the line voltage is near zero, no appreciable current flows through the load (connected to S01) when the Triac conducts.

The adjustable dimming control R2, is a 10K wirewound potentiometer. The voltage tapped off R2 feeds an RC timing network consisting of R3 and RATE control R4 in series with C3, a 100-μF, 16-volt electrolytic capacitor. The voltage across C3 is applied to the base of a Darlington amplifier (Q1 and Q2) that uses 2N3565 or similar NPN silicon transistors. The Darlington's emitter output is connected to timing capacitor C4 and to the emitter of Q3.

As C3 charges, its voltage is applied as a "bootstrap" voltage to C4. Since the Triac is normally off, or nearly so, we simply cause it to turn on earlier and earlier in each half-cycle of the supply voltage when we want to increase current through the load that is connected to socket SO1. On the other hand,

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A robot shall make learning fun for man and thereby improve the quality of life for mankind.

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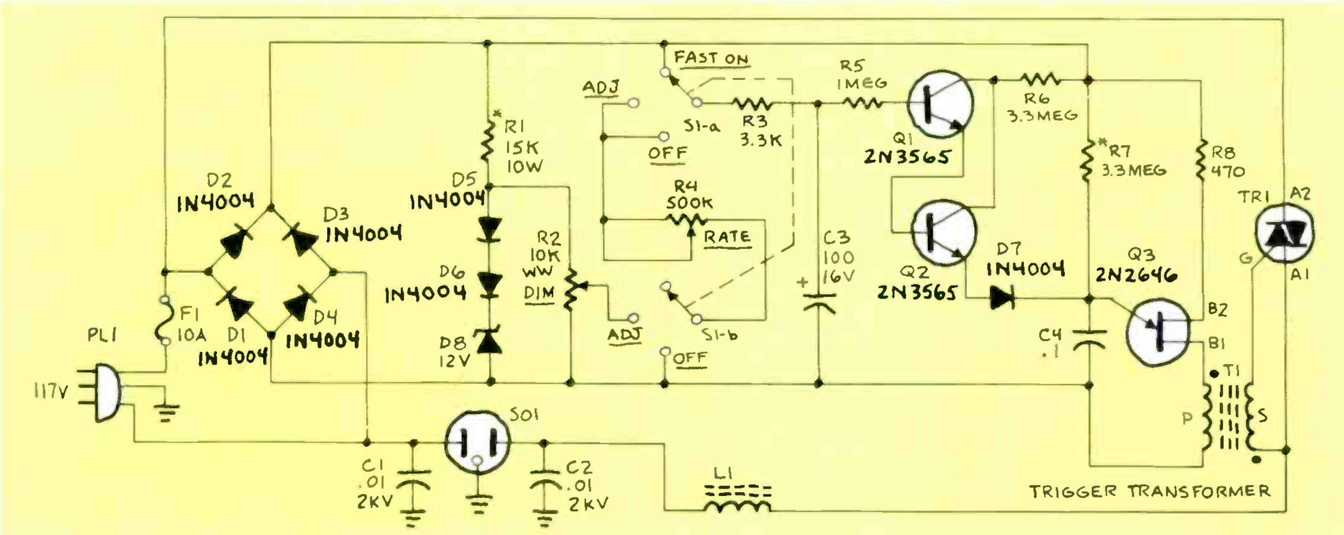


FIG. 1

to reduce current through the load we DIM control R2 to reduce the voltage across C3. That lowers the "bootstrap" voltage available for C4 so Q3 and TR1 begin conducting later and later in each half-cycle of the line voltage.

When RATE control R4 is 500K, the maximum fade-up and fade-down time is about 1 minute. Changing R4 to 5 megohms increases the control range to about 15 minutes.

Pulse transformer T1 is wound on a 1-inch length of ⅜-inch diameter ferrite rod. Each winding consists of 100 closewound turns of No. 36–40 enameled wire.

Inductor L1 is a hash suppresser made of 50 closewound turns of No. 18 enameled wire on a 2-½-inch piece of the same type of rod as used for the core of T1. Insulate the coil with plastic tape.

Resistor R7 may have to be adjusted slightly for correct circuit operation. **R-E**

LETTERS

LEADER DMM/STORAGE OSCILLOSCOPE

I was pleased to see Leader's model *LCD-100* DMM/Storage Oscilloscope (see Fig. 1) featured in a **Radio-Electronics** "Equipment Report" (June, 1987). While the review was informative, the pricing information was incorrect. The actual price is $850.00, and the unit is currently available.

MARC REINER
Leader Instruments Corp.
380 Oser Ave.
Hauppauge, NY 11788

ON SOLDERING

I enjoyed the article, "Soldering: Old Techniques and New Technology," by Vaughan D. Martin, in the May 1987 issue of **Radio-Electronics.** There should be more articles such as that, which give good data to the inexperienced. How else will they be able to learn?

I would like to add two points: One is that we never use any soldering iron that isn't temperature-controlled for electronics soldering. The old "wood-burning" tools are history, but I didn't see any mention of temperature-controlled irons; they really aren't that expensive and are essential to good soldering.

The second point is on technique: The iron must always have an excess of solder in order for the heat to transfer quickly. Get on and get off the joint; otherwise, the heat will travel away from the joint and heat other areas. Understanding heat flow, of course, is what soldering, brazing, and welding are all about. A good rule of thumb would be to apply solder to the tip and joint simultaneously—making contact between the tip and the solder is very important.

Keep up the good work.

GERALD F. DULIN
Torrance, CA

ON PATENT APPLICATIONS

I would like to thank David Pressman for his remarks concerning my article on patents, which appeared in the January, 1987 issue of **Radio-Electronics.** His corrections to details contained within the text illustrate the need for continuous monitoring of patent requirements, and the wisdom of paying an attorney or an agent to at least review the application.

I agree that the task of applying for a patent is not simple, and that

the expression "relatively simple task" (the editor's words, incidentally) could mislead the reader. However, I think that the intent was to introduce the concept that applying for a patent is a finite task comprised of established procedures, standard form, and a structured method of describing the invention.

As to Mr. Arnold's letter concerning the water alarm: Back in 1975, I invented a wetness alarm that used the SCR circuit, and packaged the alarm in a plastic sandwich box. The alarm worked quite well, even after sitting under a hot-water heater for more than a year. In consideration of patenting the idea, I searched the archives of the Patent and Trademark Office and found numerous patents having to do with sensing water and actuating switches.

In addition, I collected advertising for a number of commercial enterprises marketing both water alarms and wetness-detection systems for industrial use. Although I did not come across a water alarm that used the SCR circuit, I concluded that a patent for a water alarm would not be profitable. I used the circuit as an example in the patenting article because it satisfied the need for a simple, easy-to-describe circuit, and yet one that exhibited a unique quality.
DAVE SWEENEY

TESTING SEMICONDUCTORS

I was just reading "Testing Semiconductors" in the April 1987 issue of **Radio-Electronics.** I enjoy reading your articles, because they refresh my memory on how various components work.

In the article, you printed an error that is very common in the field. In Fig. 1, you are measuring the reverse current of a diode using a microammeter (the text says milliameter). The reverse current through the diode should be extremely small as compared to the current used by the voltmeter (M2). With some voltmeters, that current is much higher than with others. It is a good practice, when measuring the properties of any device, to eliminate any external interference that you can. In the present case, simply placing the voltmeter before the current meter would quickly eliminate the problem.

I find that many measurements in the field are inaccurate, due to the technicians involved not knowing how the test equipment affects the circuit that it's being connected to. I once witnessed a technician connecting a meter with a 600-ohm impedance to the input of a transmitter. That was done to measure the audio signal going into the transmitter. However, the meter was connected in parallel to the input, producing a 300-ohm impedance; therefore, the signal level was off by enough to indicate a problem with the transmitter, when, in fact, there was no problem—just an inaccurate measurement.
RICHARD P. MORLEY
APO, NY

PC CLONE

Thanks, **Radio-Electronics**: You finally printed an article, "IBM-
continued on page 22

EQUIPMENT REPORTS

Regency Informant Scanning Receiver

An innovation in scanner technology

CIRCLE 37 ON FREE INFORMATION CARD

SCANNERS HAVE NEVER BEEN POPULAR with John Q. Public. Potential scanner buffs are often intimidated by the task of programming a scanner's memory with frequencies of interest, or by the need to buy crystals for each frequency to be monitored. But the scanner industry could be in for a big change and huge expansion if it follows the example set by the *Informant INF-1*, a new scanner from Regency Electronics (707 Records Street, Indianapolis, IN 46226).

The *Informant* promises to make just about everyone a scanner enthusiast because it's so easy to use—even first-time listeners will be hooked. The *Informant* is so different from other scanners because it's *pre-programmed* with all frequencies used by state and local police in each of the fifty states. Simply turn the scanner on, switch it to your state, and you're sure to hear lots of action.

The *Informant* is so easy to use that it's almost possible to overlook its second impressive feature: high-speed scanning. Thanks to what Regency calls *TurboScan* technology, the *Informant* offers a scanning rate of 40 channels per second. That's *fast*—most scanners on the market today offer a top scanning speed about one quarter of that.

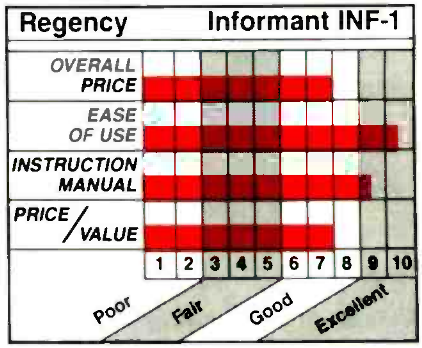
Using the Informant

How easy is it to use the *Informant*? With only two knobs and three toggle switches on the front panel, you know it can't be too difficult. One of the knobs, of course, is the VOLUME control, which also serves as the power switch. The other is the SQUELCH control.

The HOLD switch is used to lock the scanner on a single frequency of interest. Pressing it once puts the scanner in the HOLD mode; pressing it a second time causes scanning to resume. The HIWAY/CITY switch is used to select either state-police frequencies (HIWAY) or local city- and county-police frequencies (CITY). The third switch is the WX SCAN/STATE selector. When WX SCAN is selected, the *Informant* will scan the frequencies used by the National Weather Service to broadcast weather bulletins. The other position is used to select the state whose frequencies you want the *Informant* to scan.

Rounding out the front panel is a two-digit, vacuum-fluorescent display that indicates the state and the type of signal (state, local, or weather) being monitored, and the scanner's mode.

The *Informant* covers state, city, and county police frequencies from 36–47 MHz (VHF Low),



150–163 MHz (VHF High), and 450–462 MHz (UHF). It's packaged in a case that will be at home in just about any car (about 1½ × 5 × 6½ inches) and it comes equipped with a mobile mounting bracket. Also included are a DC power cord for permanent installation in a vehicle, and a cigarette-lighter plug for temporary installation.

The *Informant*'s simplicity is sure to be a great attraction to people who are unfamiliar with scanners, and to those who want an easy-to-use scanner for mobile use. But simplicity has its disadvantages, too. Regency chose not to include a DELAY switch on the *INF-1*, probably to keep it looking as clean and simple as possible. Without a delay switch, the user has no control over how long the scanner will wait on a single frequency for the response to a transmission. The *Informant* waits less than a second, and in many cases that's just not long enough.

The only other thing missing is a frequency display. In a sense, it's really not needed, but it would be nice to have some way to identify a given channel.

Even though a LOCKOUT switch is not included, it is possible (by using two of the toggle switches in combination) to force the scanner to skip an unwanted channel.

The *Informant INF-1* sells for $369.95. We can't compare that price to any other scanner on the market because the *Informant* is unique. When its main features—*TurboScan* technology and simple operation—are incorporated in products built for the scanner hobbyist, things will never be the same. Regency is working on doing that now; by the time you read this, they will have introduced new scanners with features you've never even dreamed of. **R-E**

NEW LIT

ELECTRONICS PRODUCTS CATALOG, includes such items as a color light controller, color LED VU meter, electronic echo and reverberation amplifier, stereo simulator, multi-purpose melody generator, digital clock with two timers, battery fluorescent light, infrared remote-control unit, speaker protection, superior electronic roulette, power supply for microcomputer, and many others. 24 pages. Available on request from **Mark V Electronics, Inc.,** 248 E. Main St., Suite 100, Alhambra, CA 91801.

CIRCLE 38 ON FREE INFORMATION CARD

CONSUMERS'S GUIDE TO PRIMARY BATTERIES, is pocket-size (3½ × 7 inch), six-page guide to the most-commonly used consumer batteries; also some unusual types that are also available in the average supermarket—such as cylindrical, rectangular, and button/coin sizes. The booklet discusses each type and how each should be used to assure the most efficiency and safety. It is available upon request from **National Electrical Manufacturers Association,** 2101 L Street N.W., Washington, DC 20037.

CIRCLE 39 ON FREE INFORMATION CARD

INTRODUCTION TO PACKET RADIO, is an 18-page, letter-sized booklet that explains packet's procedures, operations, and applications in easily-understood terms. It is written in a conversational style, and the contents are organized by the common questions that most potential users ask about packet radio, such as: What is packet radio? Where is it used? What equipment do I need? How do I operate it?—and more. The booklet also includes FCC licensing information. It is available upon request from **Kantronics,** 1202 E. 23rd St., Lawrence, KS 66046. **R-E**

CIRCLE 40 ON FREE INFORMATION CARD

LETTERS

continued from page 14

Compatible Clone Computer," (February 1987 **Computer Digest**) that I can use and relate to. That one article, to me, is worth the three years or so that I have been carrying a subscription. I want to have a computer soon, and I think the article was my ticket to getting one.

That is not to say that I have found the electronics articles useless. I subscribe to your magazine because I want to learn more and understand what's going on. I'm a mechanical-engineering student. My only connection to electronics was a sorry two years that I spent learning printed-circuit artwork preparation from the ground up. You know—the "make a mistake and we'll tell you what you did wrong" approach. I made a lot of mistakes.

Anyone who's taped a PC artwork, made the manufacturing drawing for the boardhouse, and drawn the component layout wants to get a more concrete feeling for electronics. Well, the next step is to stuff boards, get to know actual components, learn how to solder, etc. And *then* get into the theory as a final step.

Radio-Electronics is giving me a library on those things, the "how to," and the advertisers for the parts and the tools.

Again, thanks! And I also think that putting the magazine in a mailing wrapper is great—no more mangled covers.

CURTIS E. VAILLETTE
Madison, WI

ADDITIONAL INFORMATION

In response to the question about operating 117-volt, 60-Hz equipment on 220-volt, 50 Hz power lines that appeared in "Ask R-E" in **Radio-Electronics,** May 1987, here's some additional information. I was stationed overseas for four years; and as the staff Electronics Officer, I did a lot of modifications of that type.

Most manufacturers have kits that you can buy that compensate for the slower rotation speed of 60-Hz motors when operated on 50-Hz power. A different-size drive wheel is usually available for most turntables and tape recorders. A different-size pulley is usually available for motors that drive washers and dryers.

Clock and timer modifications are available for 50 Hz, but are hardly worth the trouble. Buy a clock in the country where it' to be used. The timers on your washer, dryer, oven, etc. will run a little slower, but they can be set to compensate for that.

The resistive load of oven, stove, iron, toaster, room-heater, and clothes-dryer heating elements will work well on either 60 or 50 Hz. Of course, the voltage must be correct. In a clothes dryer, you can modify the circuit to include a transformer on the drive motor and timer circuit. That will greatly reduce the size of the transformer that is needed.

Forget about operating a TV set built for US video systems and 60 Hz: Rent or buy one in the country that you're in; modifications are too complicated to get into.

Do not buy transformers in the U.S. to take overseas with you. There are always people being transferred back to the States or elsewhere, and who want to get rid of the transformers that they have. You can save a bundle. Even if you buy new ones, buy those wound to operate on 50 Hz; they have more iron in them and will operate cooler for a given load.

Some people have one large transformer for the whole house; others have them for individual appliances. Whichever way you go, watch the load. Add up all the possible loads that you will have and get a transformer that's big enough to handle the job.

If you buy equipment overseas, be sure that the adapters are available to operate it when you get back to the U.S.

Whatever you do for yourself or for somebody else, if you modify the equipment or change the wiring, be sure to document what you have done and what it was like before you started. That will be a great help at some later date, for whomever tries to change it back once again.

I've read your publications since I was age 12, and that was 60 years ago; I've been a subscriber for at least 30 years.

ROY A. NORMAN
Lcdr. USN Ret.
Brunswick, GA

HEADLAMP WARNING

On page 67 of the April 1987 issue of **Radio-Electronics** a circuit is shown that warns of the headlamps of a car being left on. If the voltage from the fuse panel used to power the piezobuzzer and LED is taken after the dimmer control for the panel lights, it is possible that there may not be enough voltage to drive those components.

When I built my own version of a warning circuit a few years ago, I used power from the parking lamps, which are not dimmed. Though it is unlikely that the car's fuse block will come after the dimmer control, if that is the case, my solution is bound to work well.

KEVIN STEBLETON
Royal Oak, MI

R-E

NEW PRODUCTS

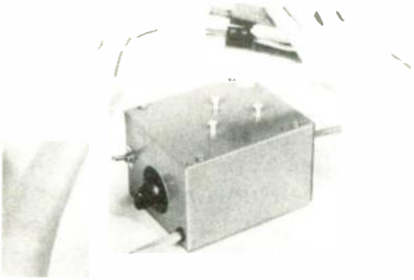
STATIC CONTROL, *Screen Prep* consists of two individual, disposable cloth pads sealed in twin foil packets. The first packet contains a premoistened pad saturated with a combination solvent/anti-static agent that quickly removes dust, dirt, and fingerprint oils. The second packet contains a dry, lint-free pad to wipe the surface clear.

CIRCLE 30 ON FREE INFORMATION CARD

Screen Prep also provides a convenient method for cleaning smudges and stains that result from equipment handling during service calls. It effectively removes CRT screen contaminants that inhibit and destroy vision. Packaged in boxes of 24 dual-packs, *Screen Prep* is priced at $7.50 per box.—**Chemtronics,** 681 Old Willets Path, Hauppauge, NY 11788.

THERMAL WIRE STRIPPER, the model *G*, features a continuously variable heat control that allows the unit to strip virtually any size or type of plastic-insulated wire. Designed for production-line operation, the device can be used either as a bench-operated tool or it can be held in the hand for use in inaccessible locations.

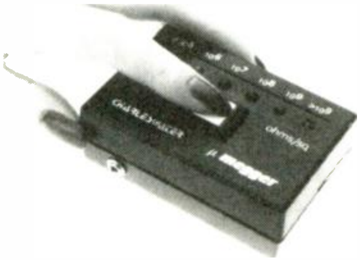
The stripper uses two parallel-heating elements to sever plastic insulation, and provides a pincers action to remove the insulation with a slight pull. No sharp cutting edges are used, so there is complete freedom from cut or nicked wires. The light-weight handle is heat-insulated with cork.



CIRCLE 31 ON FREE INFORMATION CARD

The model *G* strips any size down to the finest stranded #36 AWG wire without adjustment. It is also suited for coaxial cable and will strip Teflon as well materials with a lower melting point, such as vinyl, nylon, dacron, rayon, polyethylene, etc. It is priced at $139.50.—**Western Electronic Products Co.,** 107 Los Molinos, San Clemente, CA 92672.

POCKET MEGOHM METER, the *Micro-Megger* is a hand-held, battery-powered megohm meter for



CIRCLE 32 ON FREE INFORMATION CARD

testing static dissipative and conductive materials. Featuring a series of LED's that indicate surface resistivity, the unit performs over 1000 surface measurements on a single charge.

The *Micro-Megger* measures surface electrical resistance in accordance with ASTM D-257; it uses a rechargeable NiCad battery and presents no electrical shock hazard. It is priced at $249.00.—**Charleswater Products, Inc.,** 93 Border St., West Newton, MA 02165.

ODOMETER DATA COMPUTER, records and stores mileage, date, and time information for up to 60 trips before printing is required; it also keeps a year-to-year mileage total for the current and previous year, and calculates the percentage of auto use for business. It includes a detachable printer.

CIRCLE 33 ON FREE INFORMATION CARD

A simple hookup and command to the printer produces a printed record that can be submitted to the Internal Revenue Service. Each trip's printout includes a purpose section where business activities can be personalized.

The compact computer, which is illuminated for use at night, can be placed anywhere in the vehicle, although the manufacturer recommends that such units be kept off dash due to temperature extremes. The printer, which is powered off the computer, can be stored in the glove box, trunk, briefcase, or the office when not in use. In addition, several people can share a printer.

The *Odometer Data Computer* is priced at $399.00.—**Mileage Validator, Inc.,** P.O. Box 830650, Richardson, TX 75083. **R-E**

COMMUNICATIONS CORNER

Diversity microphone transmission

WE HAVE DEVOTED SEVERAL COLUMNS in the past to the subject of diversity reception as it pertains to high-frequency shortwave signals (to 30 MHz); those signals are particularly sensitive to variations in polarization. Although we call the effects of polarization "selective fading," in fact the signal might not vary in strength at all; only its polarity varies. However, the typical receiver sees a change in polarization as being a change in signal strength.

In the usual form of diversity reception, a special receiver switches between horizontal and vertical antennas, always selecting the antenna input that provides the maximum signal strength. Naturally, a broad range of signal level is accepted as "satisfactory" to prevent the antennas from switching back and forth continuously.

But signal polarization isn't the only reception problem that requires diversity reception, nor does diversity reception necessarily require vertical and horizontal receiving antennas. In particular, FM wireless microphones can be seriously affected by signal-phasing problems caused by multipath reception. Although the problem can usually be resolved through diversity reception, the two antennas involved are both vertically polarized.

For those of you unfamiliar with the wireless microphone, it is actually a system consisting of a transmitter and a receiver. The transmitter might be combined with the microphone into a microphone-shaped device, or the transmitter might be independent of the mike so it can be worn on a belt or concealed under the user's

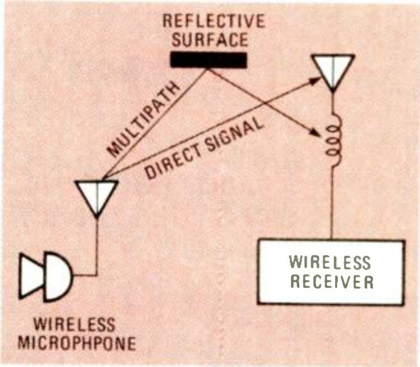


FIG. 1

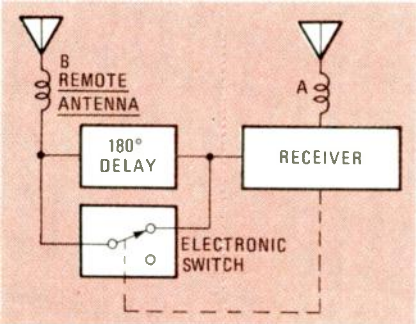


FIG. 2

clothes. Wireless mikes are used by those who prefer to roam unencumbered by the umbilical cord of a conventional microphone. Also, wireless sensors, which are usually wireless-microphone based, are now built into electric instruments such as guitars so that performers can also dispense with the umbilical cord between instrument and amplifier.

In principle, the wireless mikes are much like the inexpensive FM microphone kits you can buy from electronics hobby stores for a few dollars; those, of course, broadcast a signal that can be received by a conventional FM radio. Professional wireless microphones, however, usually pack much more power, have a wider frequency response for high fidelity, and operate on VHF frequencies specifically assigned for stage, radio, and TV communications.

Because they operate on VHF frequencies, they are prone to multipath reflections from by steel

continued on page 31

SATELLITE TV

BOB COOPER, JR.,
SATELLLITE TV EDITOR

Is HDTV the key to an international standard?

IN OUR LAST COLUMN WE DISCUSSED A plan to gradually phase out the 525-line NTSC national television standard. Its replacement would be a new wideband, *High Definition TV* (HDTV) system having more than 1,000 scanning lines. What makes the wideband plan feasible is the concept of satellite distribution of television programming, which, perhaps, will ultimately replace terrestrial VHF and UHF transmitters.

The most logical way to produce high-definition video is to double the picture bandwidth. If a 6-MHz bandwidth is required for 525-line NTSC video, a 12-MHz bandwidth will certainly accommodate 1,125-line video. But it's impossible to allow all existing television stations to increase their bandwidth within the existing VHF and UHF television spectrum because the spectrum is essentially filled to capacity already. Also, the FCC has been chipping away at both the top end (channels 70-82) and the bottom end (channels 14-20) of the UHF band for more than a decade, siphoning off UHF channels for two-way radio and other uses.

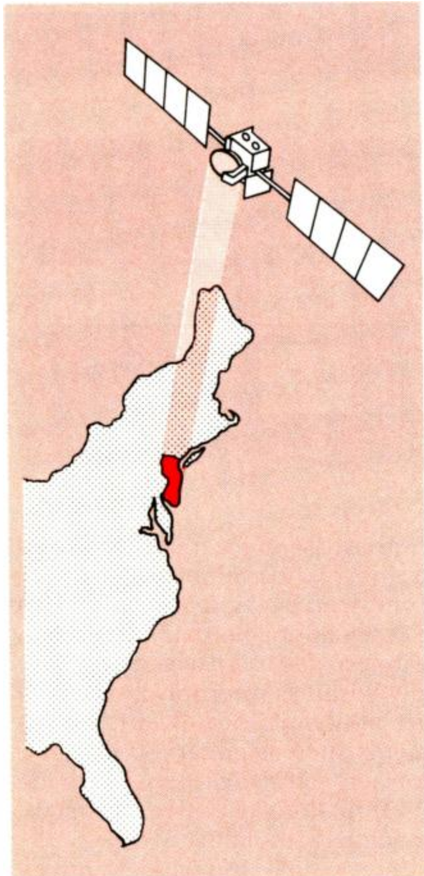


FIG. 1

Out of spectrum

Spectrum space is, in fact, almost non-existent until the microwave region near 12 GHz. There, perhaps with careful planning, is the means whereby we can fit in the wide bandwidths required for HDTV. CBS would like to see ter-

INTERESTED IN SCRAMBLING?

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

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

restrial delivery of HDTV signals, meaning that the signals originate from a microwave transmitting antenna mounted on a tall tower or a tall building. Virtually nobody else likes that concept because transmission ranges would be short (typically, only direct line of sight—under 25 miles). Most favor a satellite-to-home approach, using the DBS-assigned 500-MHz bandwidth between 12.2 and 12.7 GHz. A few engineers are looking at the next higher satellite band, Ka, in the 20-GHz region, because precise beam shaping would allow footprint-patterned satellite transmitting antennas to cover irregular shapes (such as the state of New Jersey) with great accuracy.

It's assumed that the U.S. will make the decision to implement HDTV before 1990 because that's the year that the Japanese expect to launch a fully operational three-channel HDTV satellite (in the 12 GHz-band). Already, new satellite receivers, television monitors, and videotape decks have been designed to support their HDTV program. When the Japanese inaugurate the HDTV service they plan to have all of the consumer receiving equipment on store shelves ready for delivery.

The revolution at the receiving end, while spectacular, is hardly the full effort. To produce HDTV broadcasts, entirely new studio and transmission equipment and programming had to be created, because in addition to the enhanced resolution, the aspect ratio (width to height) was changed as well: from 4 × 3 to 5 × 3. (Sony began delivering 5 × 3 HDTV cameras and professional tape decks late in 1986, and new production studios using that equipment are already operating in several US cities.)

Back-door standards

Although HDTV addresses itself to a better-quality picture, in actual fact it is interlocked with the concept of a global TV standard, and for many communications people the idea of a global TV standard is more important than whether the TV screen can show greater picture detail. But the idea of a high-resolution picture has more sizzle and snap than technical standards—about which the average user couldn't care two hoots—so we will most probably

continued on page 74

DESIGNER'S NOTEBOOK

Logic-family translation

ROBERT GROSSBLATT,
CIRCUITS EDITOR

EVERYBODY HAS HIS FAVORITE LOGIC family. Some like the familiarity of TTL and have never given CMOS a chance since the bad days of the CMOS "A" series devices. On the other hand, some like CMOS and think that anyone hung up on TTL is from the stone age. DTL and RTL users are primarily history.

The truth of the matter is that both TTL and CMOS are going to be around for a while because each has advantages and disadvantages. If you look at enough schematics, you'll see that many circuit designers routinely mix both logic families in the same electronics package.

There are several considerations to keep in mind if you want to do the same thing in your own designs. Mixing logic families requires that you pay attention to the voltage at which they change state. TTL parts have much stricter requirements than CMOS. A TTL low state has a maximum voltage of about 0.8, and a TTL high state has a minimum voltage of 2.4. CMOS, on the other hand, is much more flexible. A low is usually defined as less than half the supply voltage, and a high is more than half the supply voltage.

If you're working with a five-volt-only circuit, mixing TTL and CMOS is simple. As you can see in Fig. 1-*a*, driving a single TTL input with a CMOS output requires nothing more than connecting the two parts together. Going from TTL to CMOS, however, requires a bit more thought. Assuming a five-volt supply, the TTL high output can be as low as 2.4 volts. That's slightly below the point at which the CMOS input will change state, so there's no guarantee that the circuit will work correctly. The solution is to add a pull-up resistor of about 4.7K, as shown in Fig. 1-*b*. The exact value of the resistor depends on the type of TTL you're using (74, 74S, 74LS, etc.), but a value of 4.7K at least will get you in the ballpark.

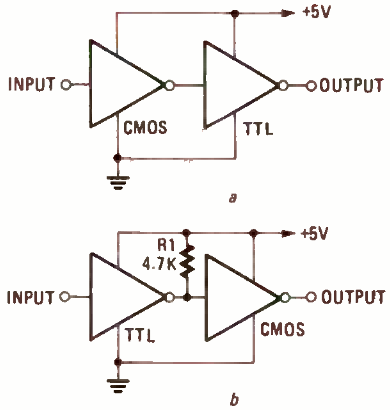


FIG.1

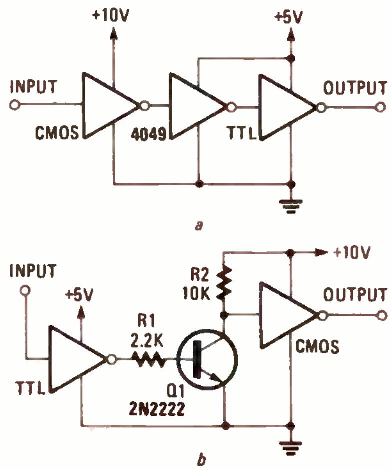


FIG. 2

Different supply voltages

Things get even more tricky if the CMOS and TTL halves of your circuit are powered by different voltages. Two readily available CMOS buffers (the 4049 and the 4050) can translate the higher-voltage CMOS output into something the TTL input can use. A sample circuit is shown in Fig. 2-*a*. To make the translation without inverting the signal, use a 4050.

Going from TTL at 5 volts to CMOS at, say, 10 volts, requires some voltage translation. We can't always do it the way we did in Fig. 1-*b* because the TTL output must be isolated from the higher CMOS voltage.

There are many schemes to get the job done, but an easy one is shown in Fig. 2-*b*. A small-signal NPN transistor is used as a buffering switch between the TTL and the CMOS parts, but keep in mind that the transistor will invert the signal from the TTL output. You can re-invert the signal by using another transistor or a spare CMOS gate.

Fanout

Before we leave the subject of logic-family translation, we must talk about fanout. If you're a regular CMOS user, you're probably used to ignoring fanout limits altogether. The reason is that the input impedance of a typical CMOS part is so high that you can drive as many inputs as you want with a single output. The same is true when driving CMOS with TTL: A typical TTL output has more than enough current-capacity to drive any number of CMOS inputs.

Going the other way, however, is a bit of a problem.

The reason is that most CMOS outputs simply can't deliver much current into a low-impedance TTL input. The number of TTL inputs you can drive with a CMOS output depends on the specific TTL part you're using. As a general rule you can drive more LS inputs than regular or S inputs, but it's usually better to be safe than sorry. So don't drive more than two inputs, regardless of type. As a matter of fact, it's better not to drive more than one, and make it a 7404 or 74S04. You'll have no trouble whatsoever driving the single input and then following the standard rules for TTL-to-TTL fanout.

If you anticipate designing many mixed-family logic circuits, work out each problem on a breadboard and standardize the design. By doing so, any time you're faced with the same problem, you'll have a debugged module you can drop in your circuit and solve the problem. And that will let you go on to more important things. **R-E**

COMMUNICATIONS CORNER

continued from page 27

beams, stage hardware, and anything else that can reflect radio signals. As shown in Fig. 1, any reflected signals arrive at a wireless-microphone system's receiving antenna after a directly received one; hence, they are usually out of phase with the directly received signal. That phase difference can plunge the received signal level right into the noise level. As a result, at one moment the audience may hear the performer, but at the next only the lips are seen moving. That's because, when the signal strength is too low, the microphone's receiver squelches to prevent the listener's ears from possibly being assaulted by the sound of random noise.

Curing multiphase distortion

Multipath distortion plagued wireless-microphone communications until the introduction of a diversity antenna/receiver system that Shure (222 Hartrey Ave., Evanston, IL 60202), a manufacturer of high-performance microphone equipment, calls *Diversiphase*.

The wonder of *Diversiphase* is that it wasn't invented earlier. Figure 2 shows how it works. The signal is received by vertical antennas A and B, which feed the receiver in parallel. To ensure that both antennas aren't affected by the same multipath signals, at least one antenna must be remotely located. Usually, 25-foot spacing between the antennas is best; the minimum spacing is 6 feet.

However, note that antenna A feeds the receiver directly, whereas antenna B feeds the receiver through a 180° delay line that is bypassed by an electronic switch. The delay line is a half-wavelength (at the operating frequency) coaxial section.

The signals from the two antennas always add together, so that when they are in-phase, the total signal delivered to the receiver is 3

continued on page 78

AUDIO UPDATE

The audio answerman

LARRY KLEIN,
AUDIO EDITOR

IT OCCURRED TO ME RECENTLY THAT I've been answering consumers' hi-fi questions in various publications for about 30 years! Of course, as times have changed and electronics has advanced, the nature of those questions has also evolved. In 1964, for example, I cautioned a reader that a metal 6L6 tube was not an adequate replacement for a 6L6GC because the glass GC tube was designed to withstand the higher voltages to be encountered in the new audio amplifiers.

Over the years I've handled problems of stereo and then quadraphonic conversion, advised on the pros and cons of switching to transistor equipment, and so forth. Today those questions and their answers are no longer pertinent, but new queries have arisen to take their place, so I've assembled a group of today's recurrent Q's and A's in hope that they will be of some aid and comfort both to the novice and to the technically beleaguered audiophile.

On-off switching

Q. Should audio equipment be left on permanently? Some audiophiles and manufacturers claim that there is less wear on the equipment if it is left on, and that it also sounds better.

A. Several manufacturers of preamps and accessories advise that their equipment be switched on permanently. In fact, some equipment is designed so that its circuits are powered at reduced voltage even when switched off, as long as the AC line cord is plugged in. The purpose in both cases is simply to prevent audio thumps and other noises as the circuits charge at the moment of turn-on. When dealing with vacuum tubes there's an additional reason not to have the equipment fully off. Tube filaments (like electric light bulbs) tend to suffer stress from turn-on surges. If a tube is always on (with reduced filament voltage), thermal shock is reduced, and the tube's filament life is extended.

Aside from noise and longevity, some manufacturers claim that there is a sonic advantage in having their equipment constantly on. That may be, but my feeling is that any design that needs to be permanently powered to avoid a long warm-up drift needs to be gotten back to the drawing board as quickly as possible! In any case, most manufacturers would advise you to turn off your audio equipment when you don't plan to use it again for several hours.

Separate speakers

Q. I have been told that you should use one type of speaker for classical records and another for rock. Do you agree with that idea?

A. Absolutely not! Every speaker system should deliver an accurate acoustic analog of the electrical signal provided to it by the amplifier. Those pushing the concept of different speakers for different music are saying, in effect, that certain types of music sound best with speakers whose frequency-response curves, dispersion, distortion levels, etc. deviate from the ideal.

It seems to me that if each musical instrument in a band or orchestra has been recorded with a specific loudness level relative to the other instruments in that band or orchestra, you want your speakers to reproduce those levels accurately, no matter what kind of music is involved. For example, if the recording has been engineered so that the brass has an extra "nasal" quality, the bass extra "sock," and the string extra "bite," a speaker with a flat response will deliver those qualities—neither more nor less. In other words, you want a speaker system that is neutral, rather than having a specific built-in tonal quality. When a speaker system injects its own tonal qualities—such as an upper-midrange boost—into the music, some program material may sound "better"—but on most program material the contribution will be inappropriate and will only be heard as coloration.

I *can* see a situation in which a speaker that does a fine job of reproducing string quartets is not suitable for rock, but only because it lacks the acoustic-output capability to achieve the desired sound-pressure levels. Achieving an adequate loudness level for rock or contemporary electronic music can drive your amplifier, your speakers, or both into distortion. The distortion may be due to (1) inadequate amplifier power, low speaker efficiency, or both, or (2) inadequate power-handling capacity on the part of the speakers. In such a case, other speakers with greater efficiency and power-handling capacity would, of course, do a better job. However, all other performance criteria in respect to frequency range and smoothness, distortion, dispersion, etc., continue to be valid.

For that reason, a speaker that can deliver the high volume levels desirable for rock reproduction, if it is in truth a high-fidelity reproducer, should do just as good a job reproducing the more moderate levels of a string quartet.

Tape-dub overload

Q. When I dub some of my records onto cassette, sections of the tape (usually at the beginning) suffer from a sort of breakup in the sound every second or so. When I listen to the disks themselves during dubbing or later, they sound fine. What's wrong?

A. The records you are trying to dub are probably warped sufficiently to cause severe vertical deflection of your phono stylus during play. That produces a very strong, very low frequency signal that overloads your tape (or cassette) deck's electronics. The records themselves sound fine when heard through your system probably because the subsonic warp signal is either handled without overload or it is filtered out by components following the tape-output jack in your equipment. You can test my hypothesis by playing the problem disks again and noting whether warps displace the phono stylus toward the cartridge body and whether the warps coincide with the taped overload distortion.

Dubbing Dolby

Q. When copying a Dolby-encoded tape from one deck to another, is it better to decode the tape playing on deck A and re-encode it when recording on deck B, or to record the tape from deck A to deck B without decoding and re-encoding?

A. You'll achieve the best results in duplicating Dolby-processed tapes if you decode the signal during playback and re-encode it while copying. In other words, the Dolby circuits should be switched on in both machines. If you were to copy Dolby-processed audio material with the decoding and encoding circuits switched off, the signal is likely to be recorded by the second machine at a different level than on the original tape. That can confuse the Dolby-decoding circuits during playback of the copied tape because the Dolby reference level has been shifted. The result will be less noise reduction and some high-frequency boost (or loss) in playback of low-level signals.

Power and volume loss

Q. Although I have a CD player, I need a record player for my 10-year collection of LP's. I recently replaced my old phono cartridge with a new high-quality unit, but now the power fed to my speakers is much lower on phono than on tape or tuner. Exactly what is the problem?

A. Variations on that question have appeared in my mail at least twice a month for many years. The problem—and it really isn't a problem—is a loss (or a gain) in volume resulting from a change in equipment: phono cartridge, tape deck, CD player, tuner, preamplifier, power amplifier—in fact, *any* component.

The "problem" arises partially because many audiophiles mistakenly believe that volume control setting correlates directly with amplifier output power. *It does not!* Think of an amplifier's volume control as a handle on a water faucet. If the water pressure (signal voltage) is very high, then a slight twist will deliver a high volume of water (sound); if the pressure is lower, then the faucet has to be opened further to get the *same* volume of water flowing from it. In the case in point, the new phono cartridge obviously delivers less signal to the preamplifier for a given record-groove velocity than the previous model.

To determine whether the output level of a phono cartridge is adequate, play a record at the loudest volume at which you would ever normally listen to it, and then, without touching the volume control, lift the tone arm with its cue control. Listen for noise from the phono-preamp stages. If you don't hear hum, hiss, or RF buzz, phono gain is within the proper range. R-E

You've probably seen advertisements from other electronic schools. Maybe you think they're all the same. They're not!

CIE is the largest independent home study school in the world that specializes exclusively in electronics.

• • •

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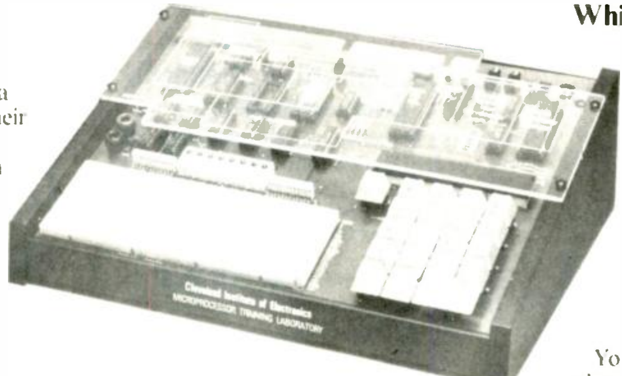

Microprocessor Trainer

State-of-the-art Laboratory Equipment

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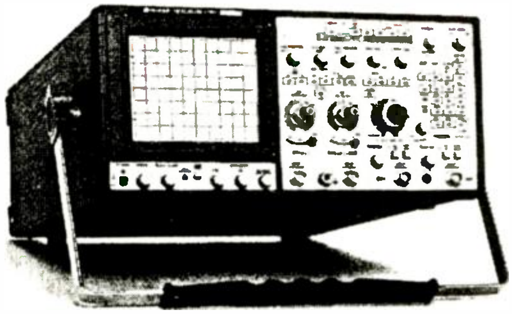

DC TO 150MHz, Quad Channels, Delayed Sweep

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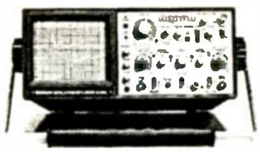
VC-6020



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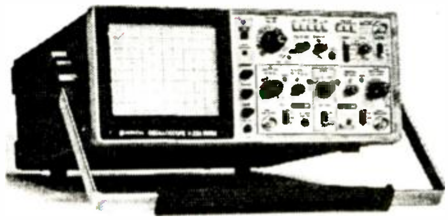
V-223 $695. Save $100!



DC to 20MHz, Dual Channels, Delayed Sweep

- **CRT:** 6" rectangular with 2k V Potential
- **Vertical Deflection:** Ver. Modes: CH1, CH2, ALT, CHOP, ADD (DIFF). Bandwidth: DC to 20MHz(-3dB). Sensitivity: 5mV/div to 5V/div. Max Sensitivity: 1mV/div at X5 Mag. Extends.
- **X-Y Operation** (CH1:X, CH2:Y): 3° or less from DC to 50kHz
- **Weight:** 7kg (15.5 lb)

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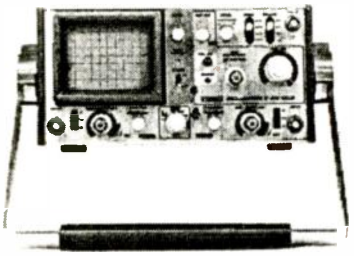
- **X-Y Operation** (CH1:X, CH2:Y): 3° or less from DC to 100kHz
- **Weight:** 5kg (11 lb)



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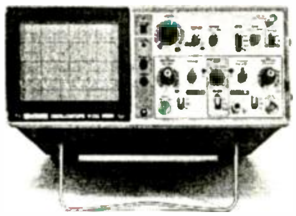
V-212 $465. Save $150!



DC to 20MHz, Dual Channels

- **CRT:** 6" rectangular with 2k V
- **Vertical Deflection:** Ver. Modes: CH1, CH2, ALT, CHOP, ADD (DIFF). Bandwidth: DC to 20MHz(-3dB). Sensitivity: 5mV/div to 5V/div. Max Sensitivity: 1mV/div at X5 Mag. Extends.
- **X-Y Operation** (CH1:X, CH2:Y): 3° or less from DC to 50kHz
- **Weight:** 6kg (13.3 lb)

V-222

- **Same as above,** but with CH1 output and DC offset voltage monitor outlet available for external counter or DVM.

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SCA/FM-STEREO RECEIVER

Tune into the "hidden" signals on your FM dial with this SCA receiver.

RUDOLF GRAF and WILLIAM SHEETS

DID YOU KNOW THAT WITH A STANDARD FM-broadcast receiver you can only hear part of the signals available on that band? The rest, called SCA (*S*ubsidiary *C*ommunications *A*uthorization) transmissions, are hidden away on subcarriers and are intended to be received only by certain segments of the public.

SCA originated with the founding of the 88–108-MHz band in the 1940's. It was intended as an income producer to help FM stations financially until the band became economically viable. It has been used for various purposes, such as background music without commercials for restaurants and offices, for medical news, for second-language programming, and for radio reading and news services for the visually handicapped.

In this article we are going to explore the world of SCA. We'll discuss, what it is, what makes it possible, and what types of programs and services make use of it. We'll also show you how to build an FM stereo/SCA receiver that will let you tune in to all of the signals on the FM band.

But before we get too far along, it would be helpful to have an understanding of FM-radio basics. Let's take care of that step first.

FM-radio basics

An FM (*F*requency *M*odulation) signal is simply any RF (*R*adio *F*requency) signal whose instantaneous frequency is determined by the modulation. The deviation of an FM signal is the component of change in carrier frequency that is determined by the amplitude (primarily) and frequency of the modulating signal. In the U.S., FM broadcast stations are permitted ±75-kHz deviation, which is defined as 100% modulation. Both a 20-Hz audio signal and a 15-kHz audio signal can produce 75-kHz deviation because it's the combination of the frequency and the amplitude of the modulating signal (program audio) that determines the deviation. If one volt of fixed-frequency audio produced ±75-kHz deviation, then one tenth of a volt would produce ±7.5-kHz deviation. Although deviation and modulation frequency are independent variables, the ratio of deviation to modulation frequency is called the *modulation index*, or β, where

β = deviation/modulation frequency

In a typical FM-broadcast situation, with a 1-kHz audio signal at 50% modulation (37.5-kHz deviation), β = 37.5 (37.5 kHz/1 kHz).

It's noisy

Because the ear is most sensitive to high-frequency noise, and because the FCC wanted FM to have the best possible signal-to-noise ratio, FM broadcasting incorporates a system of preemphasis/deemphasis equalization, whose parameters are based on the fact that the high-frequency energy of the sounds that are commonly part of programming decreases at an almost fixed rate per octave above 1000 Hz. (That was before the era of electronic instruments.) That allows the high frequencies to be preemphasized before transmission, and mirror-image deemphasized at the receiver. The end product is a "flat audio response"; however noise generated anywhere between the preemphasis and the deemphasis (such as atmospheric noise) is attenuated. Because the equalization reflects nature's own frequency characteristics, it is therefore possible to preemphasize say, a concert orchestra that is reading 100% modulation on a VU

WARNING!

SCA is not a broadcast service, and SCA transmissions are not intended for reception by the general public. As a result, SCA transmissions may be governed by Section 605 of the FCC Rules, which forbid unauthorized individuals from receiving such communications and using them for their own or other's profit, or divulging their contents, intent, or meaning to any other unauthorized individual.

Many for-profit services make use of SCA, and reception of those in most cases is permitted by paying subscribers, and under certain circumstances, only. Some not-for-profit services do make use of SCA also, however, such as those providing assistance to the blind. It may be possible to receive those without obtaining prior permission or paying a subscription fee, as long as the terms of Section 605 are observed. We advise you to contact the approriate programmers in your area for more information and to obtain any necessary authorizations.

fidelity service; its audio-response band- ratings, and revenue. Stations in those system (an RCA CA3189E can be sub-

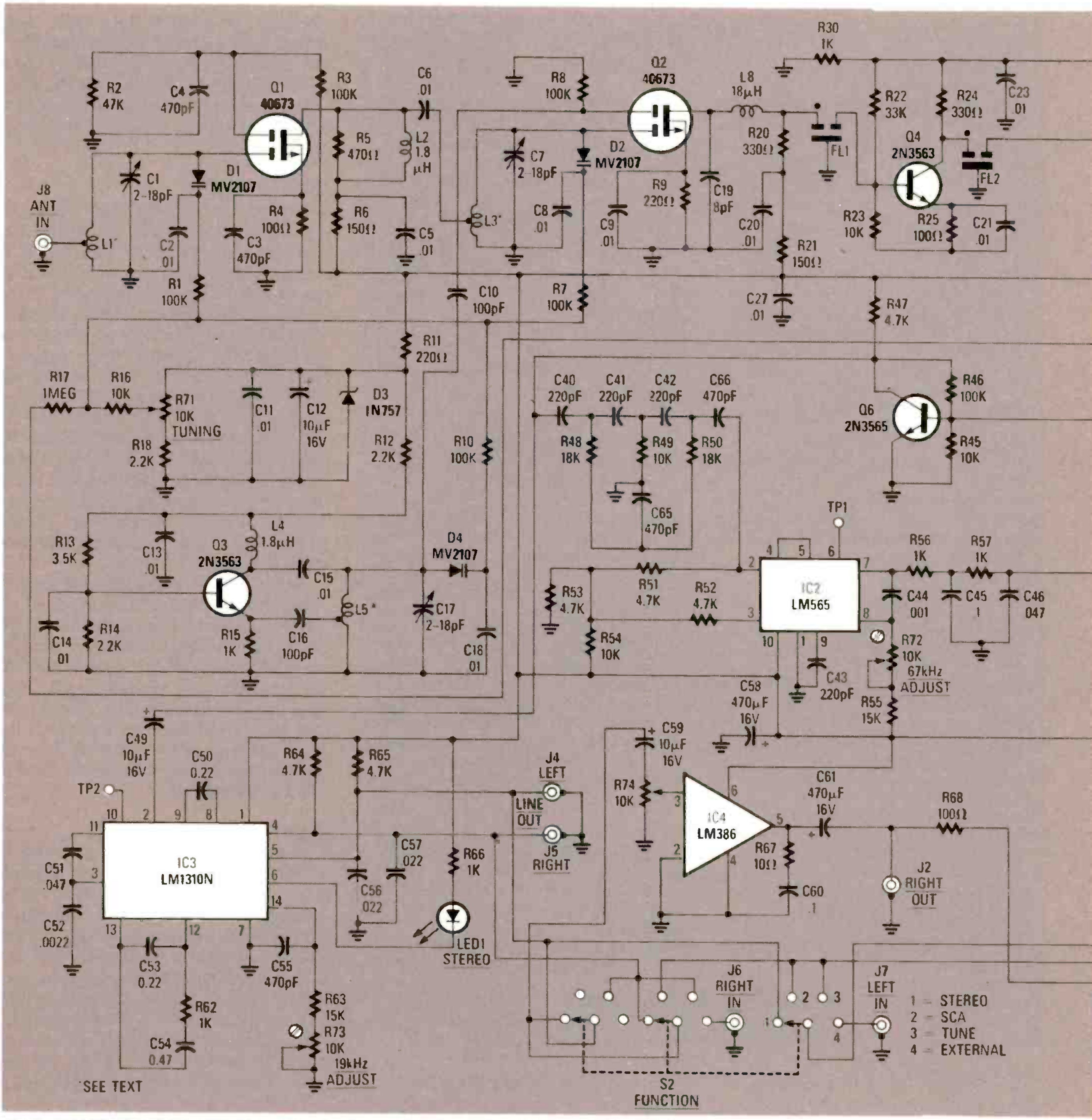


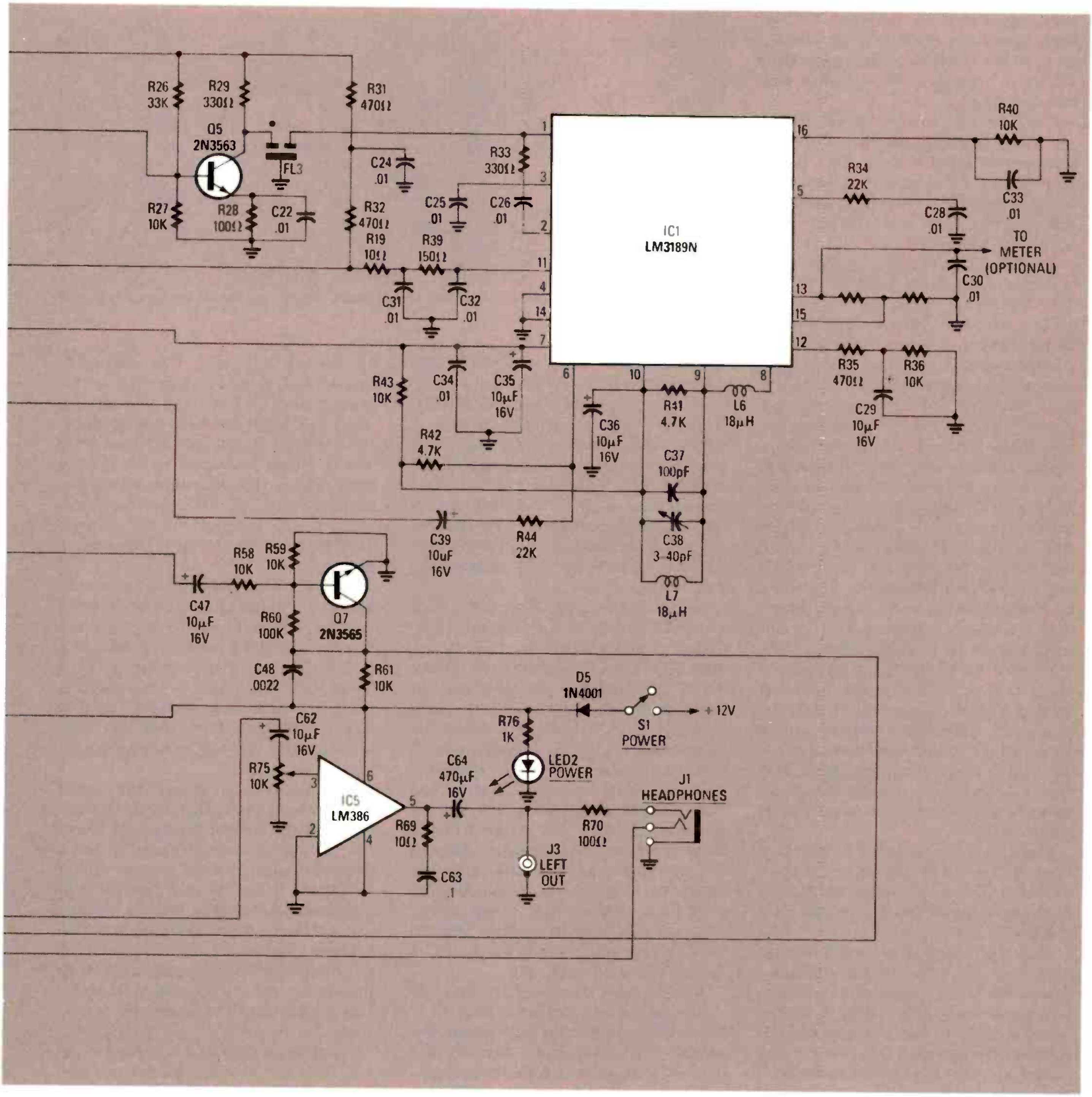
FIG. 2—THREE OF THE INDUCTORS shown in this schematic diagram must be wound by hand. Even so, they are simple to make; complete details will be given in the next installment of the article.

stituted) IC, IC1, performs limiting and quadrature detection of the FM signal, and recovers the original audio baseband. That IC offers high gain, good limiting, and low-distortion detection. It also provides an AFC voltage to correct drift in the local oscillator and to aid in tuning a selected station. Due to the very high gain, layout is *very* critical and we strongly recommend using the PC layout that will be presented next time. Otherwise you may leave yourself open to RF-instability problems.

The audio output of the LM3189N is fed to an 2N3565 audio amplifier, which delivers an output level of about 3-volts p-p. That baseband audio is used to feed the phase-locked-loop SCA detector (an LM565) and the FM-stereo detector (an LM1310N).

A high pass and twin-T R-C filter designed to reject frequencies below 50 kHz passes the SCA carrier to the LM565. The output of the IC is the VCO control voltage, which follows instantaneous frequency variations of the 67- or 92-kHz subcarrier. That output (about 50 to 100 millivolts p-p) is the SCA audio. It is passed through a low-pass de-emphasis R-C network to remove high-frequency noise. An SCA audio amp (a 2N3565) amplifies the signal to about 500-mV p-p, which is sufficient to fully drive the audio power amplifiers.

The LM1310N is designed to accept the baseband audio and reproduce the original L and R audio channels. Baseband audio of about 2–3-volts p-p is fed to the LM1310N and L and R audio signals ap-



pear at the outputs. Shunt connected capacitors provide de-emphasis. An LED can be connected to the decoder to indicate stereo reception.

A 3P4T (three pole, 4 throw) switch selects among FM (stereo in the case of stereo broadcasts), SCA, tune, and auxiliary positions for input to the dual power amps. In the tune position, FM main channel audio is input to one of the amps while SCA audio is input to the other. That makes tuning in an SCA subcarrier easier; more details will be provided when we talk about using the receiver. In the auxiliary position the unit becomes a power amp and will accept an external input via its LINE IN jacks.

The dual power amps are identical and are built around a pair of LM386N's. Power output is ½ watt (500 mW) per channel. That is sufficient to drive a pair of small speakers, but we recommend using stereo headphones for best results. If desired, the LM386N amps can be omitted and the outputs fed to the line inputs or tuner inputs of an audio system. About 500 mV into a 10k load is available at the LINE OUT jacks.

More detail

Looking at the circuit in more detail, FM signals from the antenna are applied between the tap on L1, which is the antenna coil, and ground. The antenna coil is tuned by C1 and varactor D1 to the signal frequency. The varactor has a variable back bias of 1.5 to 8 volts across it. That will sweep its capacitance from 15 to 30 pF. When that capacitance is added to the stray capacitance on the board and the input capacitance of Q1, it yields a tuning range of 87–109 MHz; that is more than sufficient to cover the complete FM broadcast band.

Capacitor C2 provides an RF ground and allows DC bias from the tuning-voltage line to be supplied through R1. It also cleans up any noise present on the tuning voltage line. No DC current flows in R1, and therefore there is no voltage drop across that component.

The tap on L1 is placed so that Q1 sees a high input impedance. Transistor Q1 is a 40673 MOSFET device with a noise figure of 4 dB or less (typically 2–3 dB at FM frequencies); that ensures high sensitivity and there is no base-emitter junction to cause unwanted rectification of strong signals. Resistor R4 and capacitor C3 provide biasing and RF grounding for Q1's source terminal. The G2 terminal is biased at about +4 volts by R2 and R3, and C4 bypasses that terminal to ground. The gain of the stage may be controlled by reducing that bias to −2 volts (cut-off) for AGC purposes. However, AGC was not necessary in the receiver, and was not used. The drain is biased through R6 and L2 to about +11-volts DC. Drain current (which is exactly equal to the source current) is about six to eight milliamperes.

Resistor R5 limits the stage gain to about 6 times. That is the optimum amount of gain to ensure circuit stability; it is quite adequate to override mixer noise, yet not so high as to unnecessarily overload the mixer on strong signals. Further, it allows about a 3-dB margin for mistracking and errors in alignment of the tuned circuits.

Capacitor C6 couples the RF signal to L3, which serves to tune the mixer input. Capacitor C5 is an RF bypass and resistor R6 decouples the RF stage from the +12-volt line.

The mixer-input tuned circuit is tuned by C7 and D2, with stray circuit capacitances once again playing a role. Ideally, total capacitance in the circuit is exactly equal to that in the antenna circuit. However, the operating Q is a little higher (about 30). The overall RF bandwidth is about 2 to 3 MHz, which provides quite adequate image rejection—about −30 dB or better.

The mixer is driven by a signal of about 3-4 volts p-p on G2 of Q2. Since the transconductance of the 40673 is a function of the G2 voltage with respect to the source, the local oscillator (more on that in a moment) signal in effect modulates the transconductance of Q2. That results in the 40673 acting as a mixer. Resistor R8 returns G2 to DC ground. Resistor R9 and capacitor C9 provide about a 0.6-volt bias, which places both gates at about −0.6 volt, with respect to the source terminal. The power gain of the mixer (the ratio of the IF signal at 10.7 MHz to the

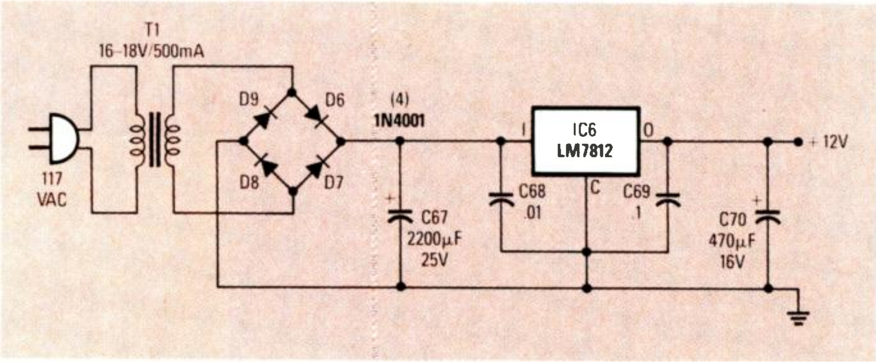


FIG. 3—THE CIRCUIT REQUIRES a regulated 12-volt power supply. The one shown here fills the bill nicely.

RF input signal) is about 12 to 15 dB, depending on local oscillator drive level.

The local oscillator uses a 2N3563 transistor, Q3, whose operating point is 4 volts at 1.5 milliamperes. That operating point is established by the network comprised of R12, R13, R14, and R15. Note that the local oscillator is actually a voltage controlled oscillator set up to be in the common-base mode at RF frequencies. At such frequencies, C14 grounds the base of Q3.

Inductor L4 is an RF choke that is used to feed DC voltage to the collector of Q3. Capacitor C15 couples the tank circuit made up of L5, C17, and D4 to the collector of Q3. That tank circuit is used to determine the oscillator frequency, which should be 10.7 MHz above or below the signal frequency. In this receiver, the local oscillator operates 10.7 MHz above the incoming signal. Therefore, it must tune from about 98 to 120 MHz. The spacing should be 10.7 MHz over the entire tuning range of 87-109 MHz. Resistors R16 and R17 are used to couple the AFC correction voltage to the tuning line, eliminating the need for a separate AFC tuning diode. The value of R16 can be anything from 1K to 100K, depending on how much AFC is desired. We used a 10K unit.

As previously mentioned, L5 and C19 match the mixer to ceramic filter FL1. Those components also help prevent unwanted VHF components from leaking into the IF stages, which could cause spurious responses. A ceramic filter is a piezoelectric device that is the equivalent of an IF transformer. It acts as a double-tuned transformer with a 1-dB bandwidth of 250 kHz, centered at 10.7 MHz. The device's insertion loss is about 6 dB, and its termination impedance is specified as 330 ohms.

The first IF amplifier is built around Q4. That transistor is biased by R22, R23, and R25 to about 2 milliamperes when the collector voltage is 4. Ceramic filter FL2 couples Q4 to Q5, which is biased identically to Q4, using R26, R27, and R28. Capacitors C21 and C22 bypass the emitters of Q4 and Q5 respectively. The IF stages are decoupled from the power-supply line by R32, R31, C24, and C23. Resistor R30 is used to determine the operating points of Q4 and Q5. It results in a +4.5-volt supply to those stages, forming a voltage divider with R31 and R32. The IF signal is coupled to the limiter/detector stage (IC1 and peripheral components) by FL3. The three ceramic filters shape the IF bandpass of the receiver. They are fixed tuned and no alignment is required.

The gain of Q4 and Q5 is about 26 to 30 dB. That gives a total gain so far, from the antenna, of about 55 to 60 dB, ensuring that the front-end noise will cause limiting in IC1. The maximum output of Q5 is about 0.25 volt, which is the saturation point, no matter how strong a signal is received; IC1 can easily handle that without distortion. No AGC was found necessary in this receiver.

Most the functions of an FM IF system are provided by IC1. That device includes a three-stage limiter, signal-level detectors, a quadrature detector, and an audio amplifier with optional muting circuit (squelch). It has its own internal regulators for DC voltages, and can drive an external tuning meter. While we specified using a National LM3819N, an RCA CA3189E is pin-for-pin compatible with that device and can be used in its place. Use whichever IC is easiest for you to find.

Input signal from FL3 is applied to pin 1 of IC1. R33 is a bias resistor and also terminates FL1. Capacitors C25 and C26 are RF bypass capacitors. The 12-volt supply line is connected to pin 11 of IC1 by R19, C31, R39, and C32; those components provide RF decoupling as well. While they are not used in the receiver, the IC's squelch (mute) circuits must be terminated; R34, C28, C29, R35, and R36 serve that function.

An optional tuning meter can be installed in the receiver. We chose not to do so, but if you do, install it at the junction of C30 and R37 as indicated in Fig. 1. Otherwise, the junction makes a good test point for aligning of the front-end's tuned circuits.

continued on page 81

ROSS ORTMAN

Versatile Digital Timer

You don't need a fancy microprocessor-based timer to turn a device off and on several times a day. This easy-to-build and inexpensive timer will do it with no hassle!

TIMERS CONTROL EVERYTHING FROM SEcurity systems to computer systems to coffee makers—the list goes on and on. Timers vary in sophistication from simple mechanical devices to microprocessor-based controllers. But there is a middle ground. A low-cost module allows you to build a high-performance unit that operates like a VCR timer, is inexpensive, and is very easy to build. The timer allows three on/off set points per day, and it can control any device that draws as much as 6 amps of current. If the timer's output capacity is insufficient, you can easily add an output switching device with greater capacity. The timer can be built for about $60 using all new parts.

How it works

The timer's schematic is shown in Fig. 1. The heart of the timer is the PCIM 2303 LCD timer/clock module, made by PCI (Printed Circuits International, 1145 Sonora Court, Sunnyvale, CA 94086). The 2303 module contains the timer IC, clock crystal, an LCD display, and all support components. It requires only 1.5 volts and draws a maximum of 10 µA. That low power requirement allows the module to be powered by a single AA battery, which makes it great for use in portable equipment.

The module has a single output that is high during the on period and low during the off period. Because the output is powered by the module, it cannot deliver any appreciable current. Therefore the control voltage is fed to a transistor switch composed of Q1, Q2, R3, and R4. The switch circuit in turn controls IC1, an MOC3010 optocoupler, which isolates the power-control section from the rest of the circuit.

The power-control section is composed of Triac TR1, current-limiting resistor R5, and an MOV (*M*etal *O*xide *V*aristor). The latter protects the triac and the optocoupler from power-line spikes and transients caused by highly inductive loads.

The power supply is composed of T1, D1, and C1; it provides nine-volts DC that powers the switch circuitry. It can also be used to trickle-charge a Ni-Cd battery. Although a regular lead-acid or alkaline battery will last for quite some time, a 1.5-volt rechargeable battery will give best results. The 1-mA trickle charge supplied by optional components D2 and R1 should increase battery life indefinitely. If those components are not installed, never apply power to the unit without a battery in place, or damage to the PCIM 2303 module may result.

The specified Triac is rated at 6 amps. If that is inadequate for your application, a larger one can be used. Regardless of which Triac is used, it will generate heat, so provide an adequate heatsink and adequate ventilation to avoid overheating. Fuse F1 protects not only the transformer and circuitry, but also the Triac. If a device tries to draw more current than the Triac can handle, the fuse will blow, thus saving the Triac from damage. If you use a Triac with a larger current rating, be sure to install a fuse of the proper size.

Other types of power-control circuits are possible; several examples are shown in Fig. 2. An SCR-based circuit is shown in Fig. 2-*a*, and a relay-based circuit in Fig. 2-*b*. If you use a different circuit, be sure to isolate the timer module from the voltage being switched. And whether you use a relay, a Triac, an SCR, or some other device, be sure it can handle the maximum current the device you want to control will draw.

Construction

The timer circuit is simple enough to be wired using point-to-point techniques; but for a cleaner layout, PC boards can be used. You can purchase pre-etched and drilled boards from the source mentioned in the Parts List; alternatively, foil patterns for etching your own board are shown in PC Service. As shown in Fig. 3, the display board contains the timer module and S1–S4. The main board, shown in Fig. 4, contains the power supply, the battery, the switching circuit and the output circuit. If you use a different output-switching circuit you can alter the design of that board to fit your application.

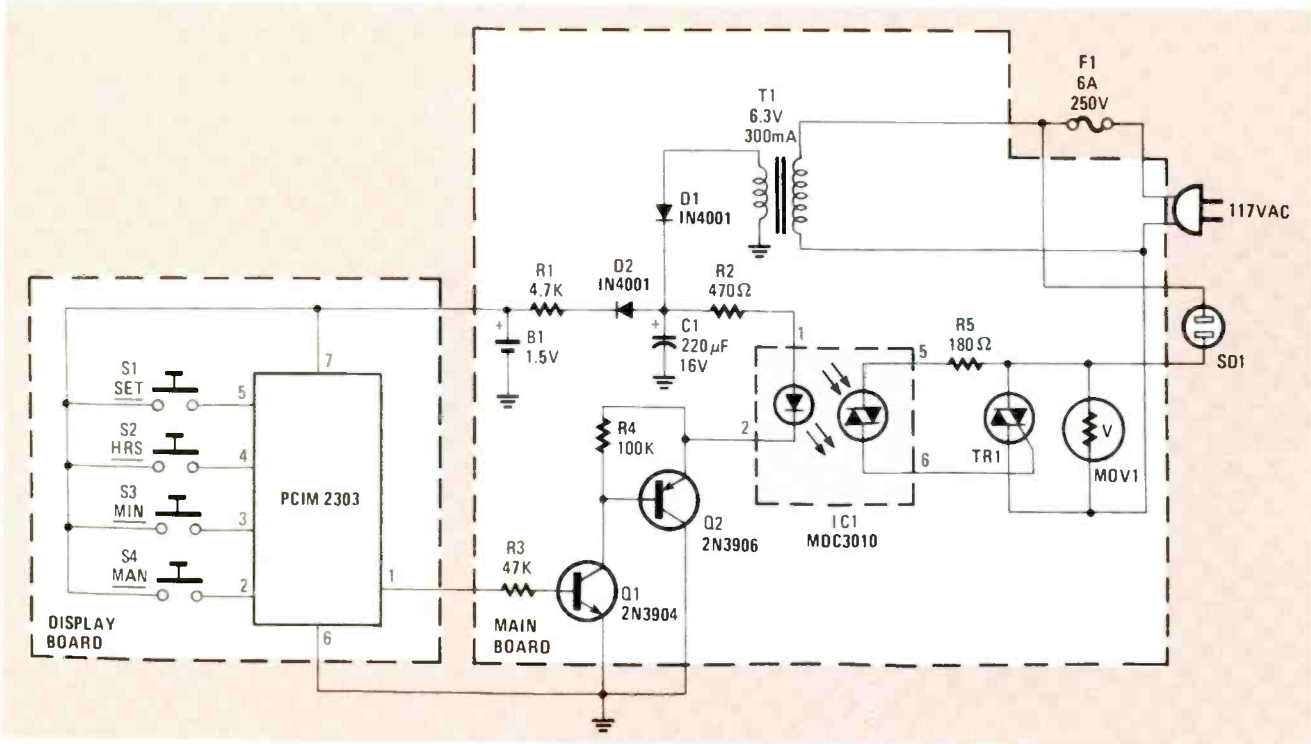


FIG. 1—SCHEMATIC DIAGRAM OF THE TIMER. The PCIM 2303 timer module contains all timing circuits and an LCD display.

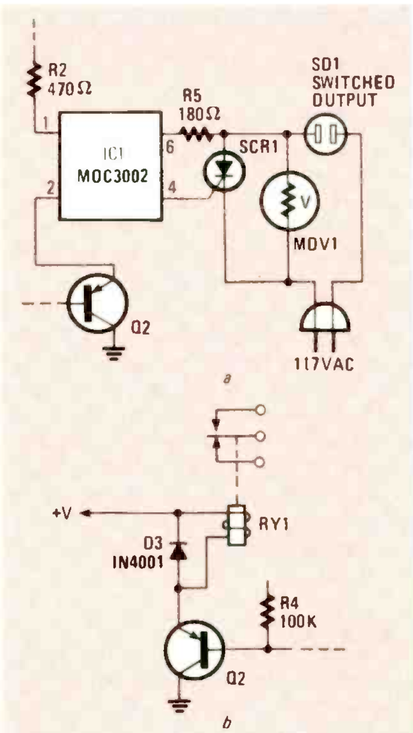


FIG. 2—AN SCR (*a*) OR RELAY OUTPUT (*b*) driver can be substituted for the triac output circuit in Fig. 1.

Stuff the boards in the usual manner, starting with the low-profile components, and working up to the larger ones. The timer module contains CMOS circuitry, so handle it with care. Be sure to observe the polarities of capacitor C1 and the semiconductors. Install the transformer last, making sure that it is installed correctly.

An excellent case for the timer is mentioned in the Parts List. If you use the specified case, note the limited clearance between the bottom of the PC board and the case. Be sure to insert a piece of fishpaper (or some other insulator), between the board and the bottom of the case to avoid shorts—and possible shocks.

Note, in Fig. 4 and Fig. 5, the small strip of PC board material glued to the top of the main board behind the display board. That strip reduces stress on the module and prevents the display board from bending when the pushbuttons are pressed. The remainder of construction is straightfoward. In our prototype the module (and the attached PC board with switches) is glued from behind to an opening in the front panel.

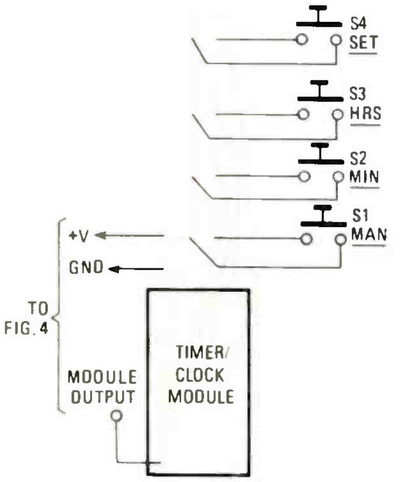


FIG. 3—THE TIMING MODULE and four switches mount on the display board, which connects to the main board via three wires.

Testing

After mounting all components, inspect your work carefully for open solder joints, solder bridges, etc. Correct any mistakes.

Then insert a battery into the holder, being sure to observe polarity. Now press the SET and MAN buttons simultaneously to reset the module. If the module doesn't display anything, re-check your wiring.

After you get the module to reset, plug the line cord into an AC outlet, and plug a table lamp (or other electrical device) into SO1 and press the MAN button. The light should turn on. If it doesn't, check the module's output pin. It should have about 1.1 volts on it. If it does, make sure that Q1 and Q2 are turning on and enabling the LED in IC1. If the LED is turning on, you should measure about 1.4 volts across it. If the LED does turn on, the problem lies with the AC portion of the circuit. **Be very careful when troubleshooting the AC section, because it has 117-volts AC across it.** Check for wiring errors; otherwise, the triac may be bad.

After you get the circuit working, assemble the case. The timer is now ready to go to work for you in whatever application you see fit.

Operation

Programming the timer is very similar to programming a VCR timer. At initial power-up, the device must be reset. That's

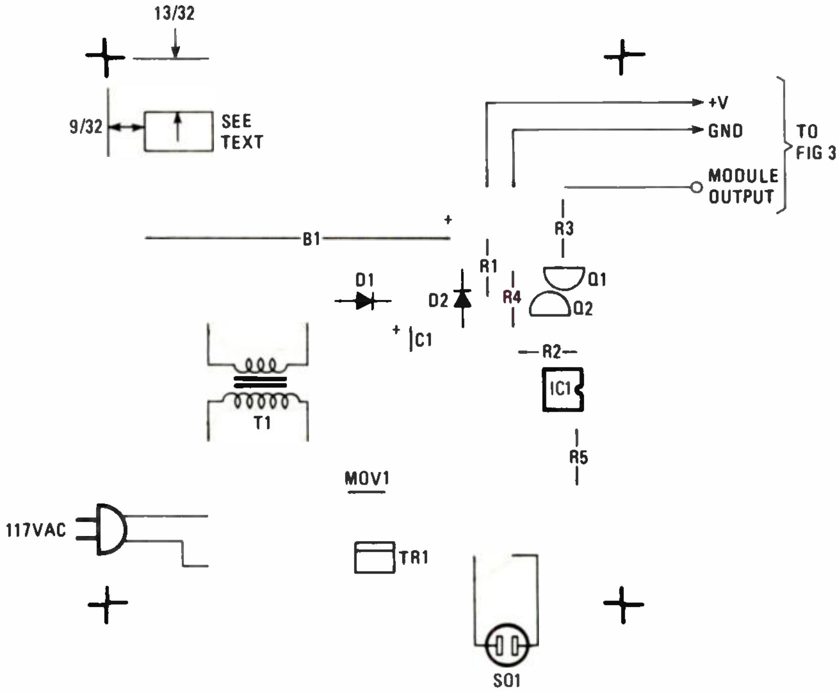


FIG. 4—STUFF THE MAIN BOARD as shown here. Three wires connect to corresponding points on the display board, as shown in Fig. 3.

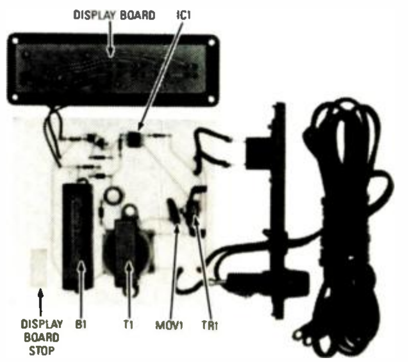


FIG. 5—THE COMPLETE TIMER CIRCUIT appears as shown here. Trim the PC board so that it fits into the case properly, and insert a sheet of insulating paper between the board and the bottom of the case.

accomplished by pressing the SET and MAN buttons simultaneously. Then the correct time must be entered. Press SET once to enter the set mode; a flashing *T* will be displayed. Now set hours and minutes by pressing the HRS and MIN buttons as appropriate. The displayed hours (or minutes) will advance once for each press of the button; if you keep the button pressed, the display will advance continuously at a rate of about two digits per second.

By pressing the SET button again, the first on time can be set in the same way that time is set. Then press the SET button again to set the first off time. By continuing to press the SET button, the second and third on and off times can be programmed into the unit. After the third off time is set, pressing the SET button once more returns the unit to displaying the current time, which is indicated by a flashing colon. The programmed timer will now turn the device you connected on and off at the preset times.

The MAN button allows you to override the present state of the timer manually. If the output is off when the MAN button is pressed, the output will turn on. Conversely, if the output is on, pressing the MAN button will turn the output off. After pressing the MAN button, the state of the output remains constant until the MAN button is pressed again, or until a preset time forces the output of the timer into a different state.

The MAN button controls another important function. It can be used to override the pre-set times. For example, to override the first on time, advance the set mode until the first on time is reached and press the MAN button. An *X* will appear in the display; it indicates that the first on time has been overridden. The timer will then ignore the locked-out set point until it is "unlocked" by repeating the lock-out sequence.

Applications

The timer is versatile, so its applications are virtually limitless. As a stereo timer, the unit outperforms most commercially available systems. The timer could be programmed to turn your stereo on in the morning, turn it off just after you leave for work or school, turn it on just as you are getting home, and turn it off after you have gone to bed.

The unit could also be used to control house lighting for convenience or security. When used as a security device, a house can be made to look "lived in" by turning the lights on in the morning for a preset time and turning them on and off several times during the evening. If several timers were used to control different lights throughout a house, the effect would be even greater.

Other items can be controlled. For example, you could turn your coffee pot on in the morning 10 minutes before you get up. Then you could always have your morning coffee first thing. You could also control your heating system with the timer, heating your house only while you're home and awake, and turning it off during the day while you're gone and at night while you're asleep. The money saved doing that will add up quickly.

During the winter, in cold climates, the timer could be used to turn your car's engine-block heater on in time to warm the block up enough for safe usage.

Of course, the PCIM 2303 can be used in many other applications. It's a versatile device and it can be used in countless applications. Whether you're replacing an existing timer or designing a timer system for a custom application, the PCIM 2303 clock/timer module is the ideal starting point for many designs. **R-E**

PARTS LIST

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

R1—4700 ohms
R2—470 ohms
R3—47,000 ohms
R4—100,000 ohms
R5—180 ohms

Capacitors

C1—220 µF, 16 volts, electrolytic

Semiconductors

IC1—MOC3010 Optocoupler (Radio Shack 276-134 or equivalent)
D1, D2—1N4001 rectifier diode
Q1—2N3904 NPN Transistor
Q2—2N3906 PNP Transistor
TR1—6-amp 400-volt Triac (Radio Shack 276-1000 or equivalent)

Other components

B1—1.5 volts, rechargeable AA battery
F1—6-amp, 250-volt fuse
MOV1—117-volt metal oxide varistor (Radio Shack 276-568 or equivalent)
S1-S4—SPST, momentary, normally open
SO1—chassis-mount AC receptacle
T1—6.3-volt 300-mA transformer (Radio-Shack 273-1384, or equivalent)
Miscellaneous: PCIM 2303 timer/clock module, chassis-mount fuse holder, battery holder, line cord, case (Radio Shack 270-286).

Note: the following are available from Dakota Digital, R. R. 1, Box 83, Canistota, SD 57012: display PC board, \$3.50; main PC Board, \$9.95; PCIM-2303 module, \$23.95; module and four pushbutton switches, \$26.50. All orders add \$1.50 for shipping and handling. South Dakota residents add appropriate sales tax

The most important change in TV technology since it was invented is just over the horizon.

JOSEF BERNARD

CREATED BY NEON LAMPS AND VIEWED through a spinning spiral of holes in a Nipkow disc, the very first TV images were so crude that they barely allowed the viewer to distinguish light from shadow. Today we are much more fortunate—on-screen resolution of several hundred lines, both horizontally and vertically, permits us to read street signs, subtitles, and movie credits on color CRT's or LCD's.

Even so, we're always aware that we're looking at a television picture, that is, a picture displayed on a screen. And when we can not discern the finer details in an image, no matter how hard we strain, the shortcomings of the current system become evident. That is true whether the system in question is the NTSC system used in this country, or the slightly higher-resolution PAL and SECAM systems that have been adopted by most of the rest of the world.

But help is on the way. Dramatic improvements are on the horizon in the form of *High-Definition TV* (HDTV) systems that will add realism and detail to the images we view for entertainment and information.

HDTV technology exists today; it is used, for example, in Hollywood for special-effects work in TV. By as early as 1990, Japanese broadcaster NHK plans to have an HDTV system in place and operational. And work here, in Europe, and elsewhere is progressing so fast that systems may be in place worldwide shortly thereafter. In this article we'll examine the Japanese HDTV system and others, see how they evolved, and learn about what obstacles remain before they can become adopted for widespread use.

HDTV criteria

One of the goals of HDTV is to create a sense of realism for the viewer that's at least as good as that provided by motion-picture film. How? Tests have shown that, to overcome the "picture-in-a-box" effect of TV viewing, the image must subtend a viewing angle of at least 30°. To obtain such an angle, one could simply sit closer to the screen. However, at a distance of less than 7 times the image height, scan lines become noticeable and give the image a grainy appearance.

Figure 1 compares the geometries provided by viewing both conventional TV and HDTV screens from the distance at which scan lines are rendered invisible. In a conventional system, the viewing angle is only about 10°, but an HDTV system provides the desired 30° viewing angle.

As shown in the figure, if the number of scan lines is increased to 1000 or more, the minimum viewing distance is reduced to about 3 times the image height. At that distance a 30° viewing angle can be achieved. Further, due to the limited resolution of the human eye, the lines will blend together and give the impression of a smooth image.

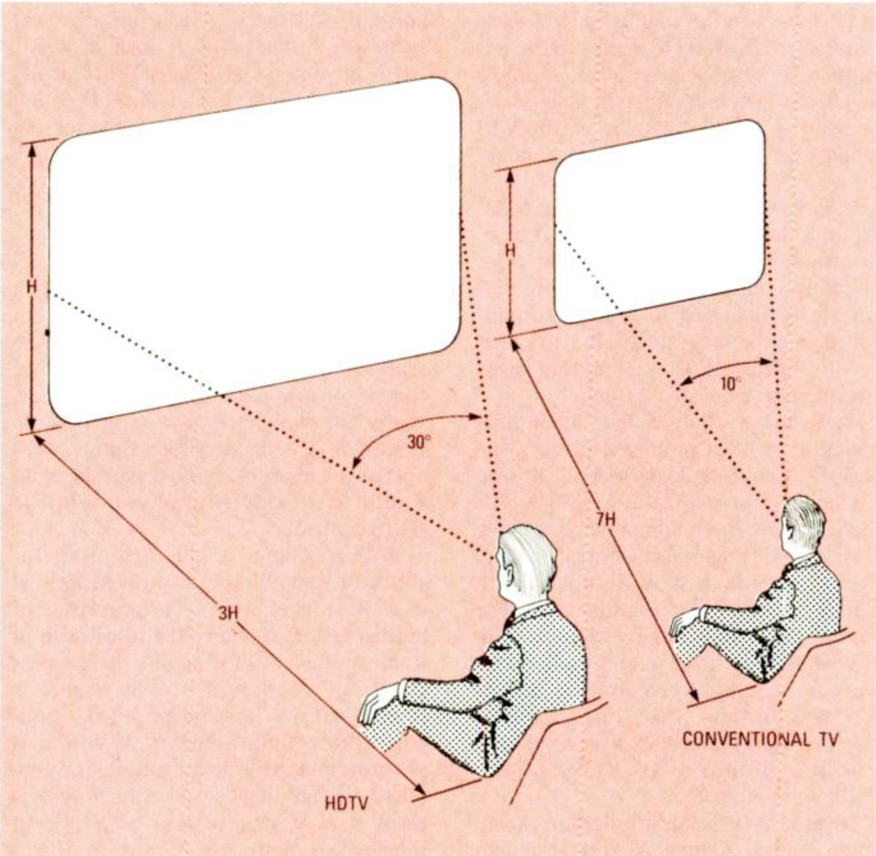


FIG. 1—THE GEOMETRY OF TV VIEWING. With an HDTV image, a viewer can sit closer to the screen to attain a greater viewing angle, thereby improving the sense of realism. Because the signal has approximately twice as many scan lines as a conventional system, those lines are not visible at distances as close as three times the image height.

Another factor adding to the impression of realism offered by HDTV is a change in aspect ratio, the ratio of an image's width to its height. Conventional TV has a 4:3 aspect ratio, which means that the picture is four units wide and three units high. That aspect ratio was adopted originally to conform to what was used at the time for motion-picture photography. These days, most films are shot using the Panavision process, which uses a 1.85:1 (5.55:3) aspect ratio. It is expected that HDTV will use an aspect ratio between the two, with 1.77:1 (16:9) being endorsed by many. See Fig. 2.

The NHK system

As we mentioned earlier, the HDTV system closest to being a practical reality is the one proposed by Japan's NHK. That system uses a signal with 1125 scan lines and a 2:1 interlaced scan rate of 60 fields (30 frames) per second. NHK's HDTV system has already been demonstrated both in Japan and in the U.S.

One problem with all HDTV systems is that they potentially require enormous amounts of bandwidth. For instance, in the system proposed by NHK, a high-definition TV picture contains about five times more luminance (brightness) information that does a conventional one, thus requiring a bandwidth at least five times greater than that specified for the NTSC system used by U.S. broadcasters today. That translates to a bandwidth requirement of 30 MHz, compared to the 6 MHz NTSC standard.

To squeeze all of the information required for a HDTV picture into a more manageable bandwidth, NHK developed a system called MUSE (*MU*ltiple Sub-Nyquist *S*ampling *E*ncoding). MUSE converts a wideband analog studio signal to digital form, compressing it to slightly more than 8 MHz for transmission. At the receiver, the signal is re-expanded to its original form for display. The MUSE specifications call for:

- Processing of luminance and chrominance information by TCI (*T*ime *C*ompressed *I*ntegration).
- Time-compressed line-sequential processing of chrominance information generating R − Y (red minus luminance) and B − Y (blue minus luminance) color-difference signals.
- Time compression of the chrominance signal by a factor of four.
- Bandwidth reduction of the TCI signal through subsampling.
- A PCM digital audio signal to be multiplexed with the video signal.

MUSE is known as a "motion-compensated subsampling" system. The terms *subsampling* and *sub-Nyquist* refer to the fact that when the video information is processed, fewer samples are extracted from it than would be the case if it were to be processed using conventional methods, where sampling occurs at twice the highest frequency (i. e., the *Nyquist frequency*) involved; the lower sampling rate is the reason why that method is called sub-Nyquist.

The principal trick used by the MUSE system is that it sub-samples the video signal over a four-field sequence prior to transmission; the sampling pattern used is shown in Fig. 3. That technique allows for the 4:1 reduction in required bandwidth.

Reconstruction of the MUSE signal requires an HDTV receiver equipped with a memory capable of storing the four fields. For still (non-moving) parts of an image, the picture can be reconstructed using samples from all four fields since there will be no movement from field to field.

But where there is movement, attempt-

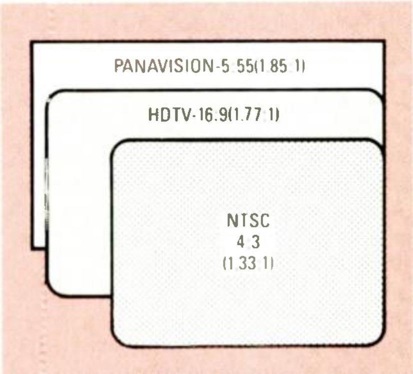


FIG. 2—ASPECT RATIOS. Here, the aspect ratios of conventional-TV, HDTV, and Panavision motion-picture viewing screens are compared.

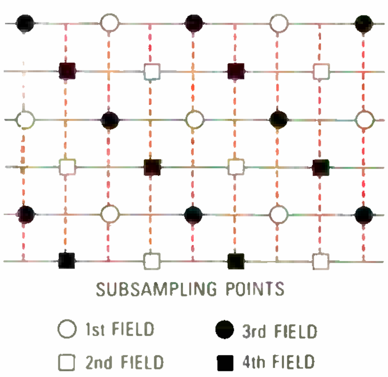


FIG. 3—THE SAMPLING PATTERN used by NHK's MUSE system. Picture information is transmitted over four fields rather than the two of conventional TV.

ing reconstruction using two or more fields will yield a picture with unacceptable blurring. That's because the picture content will be changing from field to field. Therefore, only the information from one field can be used to form the image and a 1:4 loss of resolution occurs.

However, a MUSE receiver also incorporates a motion detector. That stage enables the receiver to integrate the stationary and moving parts of a scene into a single image. (That's where the "motion-compensated" part of the MUSE system comes in.) The result is that stationary parts have maximum resolution while moving parts appear slightly blurred. Such blurring is not considered serious, however, since our perception of sharpness is not reduced by blur in a moving image. We simply accept it as an attribute of the motion.

A special case in the MUSE system occurs when the camera is panned or tilted, causing the entire image to change. When the encoding circuitry detects that type of picture content, a vector representing the motion of a scene is calculated and the information is sent during the vertical-blanking interval. At the receiver, the information is applied to the field memories, causing the position of the sampled picture elements to be shifted as appropriate to the motion. The bottom line is that the moving pictures are processed as if they were stationary ones, with conspicuous blur in uniformly moving regions of the image held to a minimum, subject to the accuracy of the motion vectors. Note however that non-uniform moving regions will unavoidably suffer a loss of resolution. In most instances, however, such loss will be acceptable as a consequence of motion.

Other systems

Although NHK's MUSE system is the one closest to implementation, work on HDTV is also continuing in Europe and the U.S. In this section we will look at some of the more promising systems.

Most of these systems are based on the following standard: 1125 lines, 60 frames per second, 2:1 interlace, 16:9 aspect ratio. The number of lines was chosen as a compromise between the PAL/SECAM and the NTSC camps. It is more than 1000 lines, but not exactly equal to twice either 625 or 525 lines. Also, although 50 frames per second is used in Europe and elsewhere, the NTSC standard of 60 frames per second was accepted because it substantially reduces flicker and allows a higher sampling rate. Interlaced scanning, as opposed to a progressive scanning scheme, is used because of the reduced bandwidth it requires.

Note that those specifications have not been formally accepted as a worldwide standard, however. It was hoped that a standard would be adopted at the International Radio Consultative Committee's 1986 Plenary Assembly. Instead, a decision was postponed until 1990, at the earliest. That postponement has added some confusion to the HDTV world, so there is no guarantee as to what shape, if any, a worldwide specification will take. It is expected, however, that the 1125/60/2:1 standard will become a *de facto* standard in most 60-Hz HDTV studios.

Several of the systems are of the MAC (*M*ultiplexed *A*nalog *C*omponents) type. In a MAC signal, the luminance, color difference, and multiple digital sound signals are compressed in time and multiplexed onto the same signal. In particular, most European HDTV systems are based on some type of MAC system.

For instance, Philips, the Dutch electronics giant, has proposed a European HDTV system called HD-MAC. The system is based on the 625-line, 50-Hz PAL standard. The input signal is 1250 lines, 50 Hz, with 2:1 interlace. Vertical filtering is used to make a wide-bandwidth 625/50/2:1 signal for transmission. The bandwidth is reduced by transmitting only alternating horizontal samples; four fields are required to receive a complete HD-MAC picture. That, once again of course, means that the receiver must have a frame memory to display the 1250/50/2:1 picture.

Other MAC systems are similar, except for the numbers involved. For instance, B-MAC is a MAC system that's compatible with the 1125/60/2:1 proposed worldwide standard.

And things have not been quiet in this country, either. Bell Laboratories has proposed a two-channel transmission system in which one channel contains an NTSC signal that is derived from an HDTV signal of 1050 lines. The second channel contains the high-frequency luminance and color-difference information. According to Bell Labs, a normal NTSC receiver would receive the NTSC channel with only a slight degradation of picture quality. An HDTV receiver would receive both channels and combine them using a frame store. The result is then scan-converted to reproduce the original 1050-line picture.

CBS has proposed another two-channel system. One channel would contain a MAC-like time-multiplexed component signal in a 525-line/60-Hz format. The second channel would contain another time-multiplexed component signal. When the two signals are combined, an HDTV image results. The system does not require a receiver with frame store and would use *D*irect-*B*roadcast *S*atellite (DBS) delivery.

William Glenn of the New York Institute of Technology has proposed a system that makes use of the properties of human vision to reduce the bandwidth of a transmitted HDTV signal. In his proposal, an "improved" NTSC signal is transmitted over a standard NTSC channel. (Those improvements could entail pre-combing to eliminate interference between the luminance and color information, use of progressive rather than interleaved scan, etc. Some improvements may require modified NTSC receiving equipment.) That signal, which already will offer somewhat better resolution than standard NTSC, is accompanied by a 3-MHz wide auxiliary signal that contains high-frequency, low temporal-rate information, as well as information

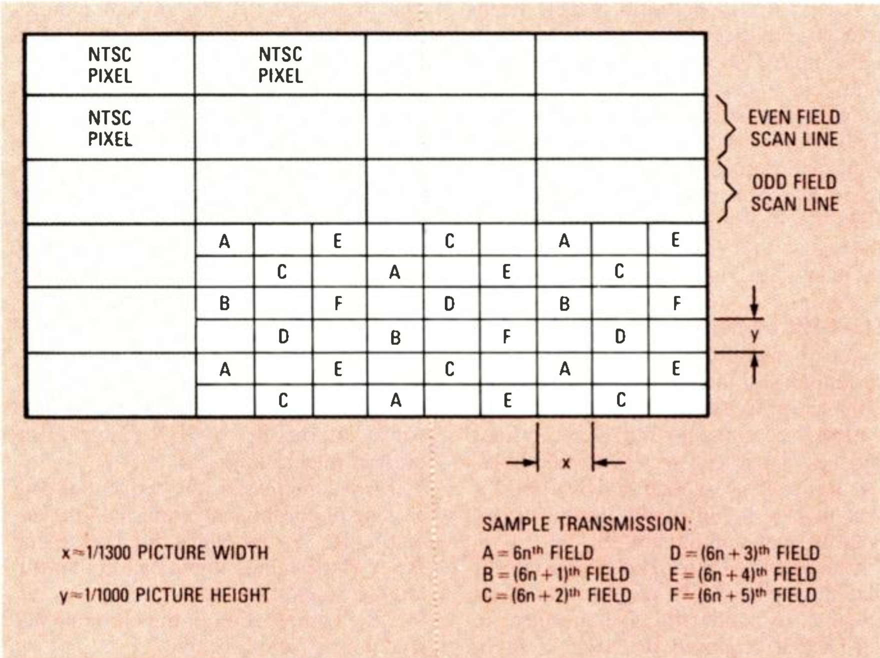


FIG. 4—IN THE DEL RAY HDTV SYSTEM, each NTSC pixel is broken up into six samples for transmission. Picture information is relayed in a sequence of six fields.

required to produce a wide aspect-ratio picture. The two signals would be combined in a frame store to produce an HDTV image.

The Del Ray Group of Marina Del Ray, CA, has proposed a system that uses a single NTSC channel to transmit a 525/60/2:1 HDTV signal. They propose a system in which a single NTSC luminance sample (pixel) is broken up into 6 samples. One sample is transmitted each field until after 6 fields the complete NTSC pixel is sent. The sampling pattern is shown in Fig. 4. At the receiver, a frame store is used to recreate the complete picture. According to the Del Ray Group, such a signal could be displayed on a non-HDTV NTSC receiver with little degradation when compared with a normal NTSC signal.

A wider aspect ratio is achieved in this system by reducing the number of active video lines transmitted by 69. The Del Ray Group contends that due to overscan losses in a typical receiver, the removed lines would not be missed. Further, those 69 lines could then be used to transmit digital sound.

Distribution

After an HDTV specification has been established and agreed upon, the problem remains of how to distribute material produced in that medium to the public waiting for it. So specifications, distribution, and compatibility are HDTV's toughest remaining problems. Let's look at the distribution problem in more detail first; later on we'll delve deeper into compatibility.

As with today's video programming, there are two alternatives: broadcast and pre-recorded material. In the realm of broadcasting, one possibility is, of course, DBS. Satellites could provide a distribution route completely independent of those used for conventional broadcasting, and the compatibility issue could, in a sense, be skirted. It has been suggested that the most economical and practical system for distributing HDTV is by DBS in the 22- and 40-GHz bands. (For more on HDTV and DBS, see Satellite TV elsewhere in this issue, as well as in the July issue of **Radio-Electronics.**)

Until recently, most observers had ruled out terrestrial broadcasting as a possible distribution medium. However in a test conducted this past January in the Washington, DC area by the NAB (*Na*tional *A*ssociation of *B*roadcasters) and the MST (Association of *M*aximum *S*ervice *T*elecasters), two adjacent UHF channel slots were used to transmit a MUSE HDTV signal. At the same time, a 13-GHz terrestrial-microwave relay signal was used as a backup, and to demonstrate the feasibility of using that band in areas where sufficient UHF spectrum was unavailable. On the UHF band the broadcast was made using vestigial sideband AM; on 13 GHz, FM was used. In general, the results were satisfactory, although some problems were encountered with the PCM digital audio, which was designed for satellite rather than terrestrial distribution, when the signal was attenuated. That problem will have to be solved to make terrestrial distribution of a MUSE signal practical.

FIG. 5—AN HDTV videotape recorder from Sony was used this past spring to present one designer's spring line in New York.

The other way in which HDTV programming could be provided is in pre-recorded form—on videotape and videodiscs. While the wide bandwidths of HDTV are beyond the capabilities of conventional broadcast and consumer equipment, Sony and other manufacturers have developed systems capable of storing HDTV images. See Fig. 5.

Compatibility

High-definition television is certainly practical. Indeed, it already exists. The problem that concerns many, though, is how to get program material produced in that medium to the greatest number of viewers.

In the past, virtually all improvements in broadcasting in the U.S. have been achieved within the framework of the system established in the 1940's by the NTSC; other TV systems have also maintained compatibility with existing equipment as they were improved. Although newer receiving equipment has been required to take full advantage of improvements such as color and stereophonic broadcasts, program material incorporating those improvements has generally been able to be received and enjoyed using equipment already in use.

The ideal, of course, is to develop a system in which a current receiver could accept an HDTV transmission and display it in HDTV form. In all likelihood, that is an unattainable dream. More likely would be a system in which an NTSC receiver would be able to receive an HDTV signal and display it with the same or slightly worse quality as it displays an NTSC signal. Another possibility would be a system in which an NTSC receiver could be modified, perhaps through an outboard adapter, to receive HDTV signals. Of course, the cost of such a modification must be relatively low to be practical. If it is too high, most consumers would opt to forgo modification and simply replace their equipment when they decide to upgrade. A final possibility would be that an NTSC receiver simply could not be used to receive and display HDTV signals in any form. In other words, it would be a completely incompatible system.

Of course, compatibility is a desirable goal, but you can not overlook the cost at which it is achieved. At this point in HDTV research, it appears that the higher the compatibility with existing systems, the poorer the high-definition performance. Images will be strikingly better than those provided by a non-HDTV system, but they will not provide maximum possible performance.

On the other hand, the highest performance HDTV system will likely be achieved only if the compatibility problem is completely ignored. In that event, a separate programming distribution system likely will develop that will supply programming to viewers that possess the appropriate equipment.

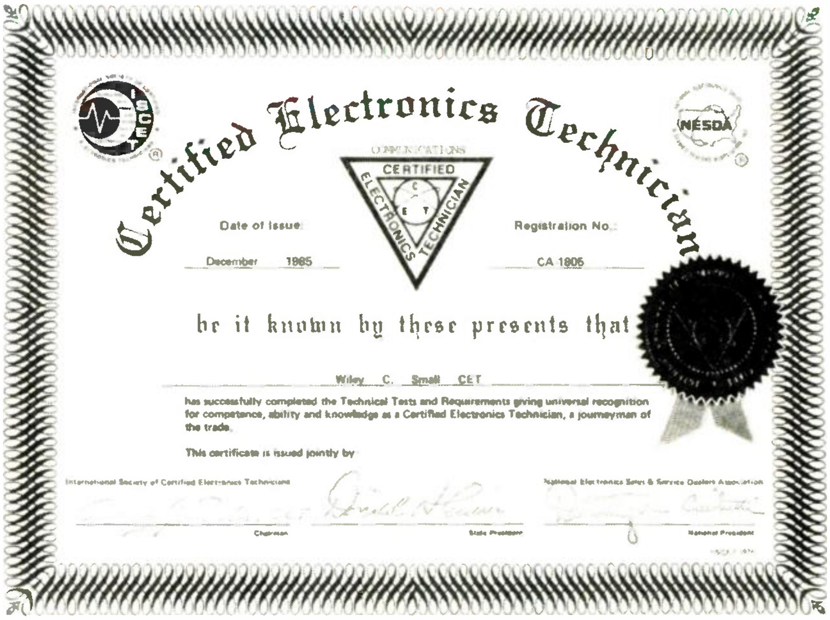
Ignoring compatibility altogether is not without precedent. When FM radio broadcasting was introduced, that mode was incompatible with the existing AM system. That, however, did not stop people from investing in what then was expensive equipment to take full advantage of the benefits (superior audio quality) offered by that medium.

The newer FM system coexisted with the older AM one, and prospered. Today, it is commonplace to find AM and FM tuners in the same piece of equipment—even small portable receivers. And even now the same program material is sometimes broadcast by a station in both AM and FM, so that those with FM equipment can enjoy the all the benefits of the new technology, and those who are still AM-bound will not be left out.

Similarly, television broadcasters could provide high-quality HDTV programming by satellite or some other means to those equipped to receive it, while performing scan- and media-conversion at their own facilities and simultaneously sending NTSC-format signals containing the same material on their conventional VHF and UHF frequencies for viewers with existing NTSC (or PAL or SECAM) receivers.

Whatever final form politics, policies, and technology dictate for HDTV, it appears that there's no holding that technology back. In just a few short years, Japanese viewers will be enjoying its benefits; it's very likely that shortly thereafter we'll be getting the "big picture" in this country, too! **R-E**

ALL ABOUT CERTIFICATION FOR



ELECTRONICS TECHNICIANS

If you really have specialized knowledge and skills—if you know your stuff—you can become a certified electronics technician.

W. CLEM SMALL, CET

EVEN INTO THE EARLY YEARS OF SOLID-state equipment design, the FCC's examination for a *1st Class General Radiotelephone License* which is almost universally known as a "First-Phone," covered most of what there was to know about the electronics of communications. Except for radar, which was an endorsement on the license obtained through a separate examination, the knowledge needed to get a First-Phone was so broad and so thorough that the license was often a prerequisite for general technical employment, even though the license was intended only for technicians whose job involved transmitter adjustments.

The reason why employers placed so much faith in the First-Phone was because it certified a minimum level of knowledge and skill. Even if the job open was repairing home stereo receivers, an employer could be reasonably certain that someone with a First-Phone had an acceptable understanding of both electronics and electric fundamentals.

But suddenly, almost overnight, the general radiotelephone license lost both its value and its need. First, as with all other things, electronics technology became so complex and sophisticated that no one could be expected to be expert, or even merely competent, in more than one or two specialized areas of interest. Because the radio broadcasting services no longer represented a major area of electronics, having a license that certified competence with transmitters and antennas no longer implied competence with the mainstream of electronics equipment.

Second, there was something called "license deregulation." Modern technology had made the stability of radio equipment so reliable that as far as the FCC was concerned, other than for the ship and aircraft services there was really no longer a need for a specially-licensed technician. So the FCC eliminated the requirement that only an FCC-licensed technician could make adjustments and repairs to transmitters: It became the responsibility of the owners and operators of radio-transmitting equipment to ensure proper operation. (Although Congress implied that the FCC could recognize technician "certification" by industry-sponsored private organizations—and that agency has sent out notices about programs available—it officially recognizes no "private" certification of any kind.)

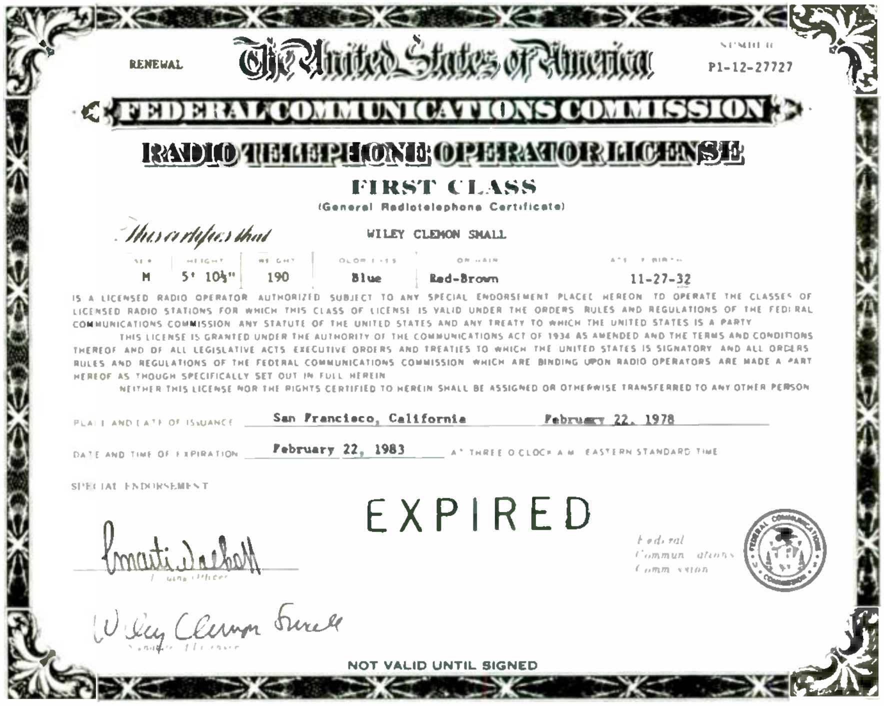
Since an FCC license no longer reflected the major interests of electronics, and since very few positions in the communications industry required an FCC license, how, then, was an employer to evaluate a potential employee's technical knowledge and skill?

For the seasoned technician, past employment records may be all the recommendation that's needed, but for the less experienced person it is usually a different and more complex situation. While it is possible for an employer to ask for transcripts of the applicant's trade-school training, many new technicians who want to work in communications have picked up their knowledge without going to a formal trade school: How are they to establish their knowledge and competence?

Certifications

Often, employers will test job applicants, but if properly done, on-site testing can be a relatively expensive undertaking that often costs more than many small shops can afford to spend. One effective way to ensure the proper testing and evaluation of potential employees is to use the certification procedures of the various professional organizations that have evolved to serve the communications and electronics industry. In fact, within the broadcast and telecommunications industry, most employers who formerly required the FCC First-Phone now require (or accept) certification by a professional or industry-sponsored organization.

The exact procedure used for the certification of technicians depends on the particular organization. For example, one early approach was to consider a technician's past FCC license level and perhaps his employment under that license. Both


RENEWAL

The United States of America

SERIAL NO. P1-12-27727

FEDERAL COMMUNICATIONS COMMISSION

RADIO TELEPHONE OPERATOR LICENSE

FIRST CLASS

(General Radiotelephone Certificate)

This certifies that WILEY CLEMON SMALL

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M	5' 10½"	190	Blue	Red-Brown	11-27-32

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PLACE AND DATE OF ISSUANCE San Francisco, California February 22, 1978

DATE AND TIME OF EXPIRATION February 22, 1983 AT THREE O CLOCK A M EASTERN STANDARD TIME

SPECIAL ENDORSEMENT

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Federal Communications Commission

Wiley Clemon Small

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THIS WAS THE LEGENDARY First-Phone FCC license. No longer in existence, it attested to the holder's general technical competence. It was often a "ticket to success" in communications.


International Society of Certified Electronics Technicians

REGISTERED RADIOTELEPHONE OPERATOR LICENSE

(General Radiotelephone Certificate)

This certifies that the individual named and described below is a licensed radio operator and is authorized to operate licensed radio stations for which this class of license is valid. The authority granted is subject to any endorsement placed on this license. The authority granted is also subject to the orders, rules, and regulations of the International Society of Certified Electronics Technicians and the statutes of the United States.

The license may not be assigned or transferred to any other person. It expires at three o'clock AM Eastern Standard Time on the date shown below.

SAMPLE

Licensee

Sex	Height	Weight	Color Eyes	Color Hair	Date of Birth

Place of Issuance	Expiration Date	License Number

SAMPLE

Signature of Licensee

Not Valid Without ISCET Seal

SEVERAL PRIVATE CERTIFICATES are similar in appearance or format to the old FCC First-Phone license.

the *N*ational *A*ssociation of *B*usiness *A*nd *E*ducational *R*adio (NABER) and the *S*ociety of *B*roadcast *E*ngineers (SBE) have had certification programs that required prior possession of an FCC license as a basic requirement. Upon satisfaction of their requirements, a certificate that resembles the old FCC license is awarded to the applicant. On the other hand, various aspects of existing and emerging radio technologies such as cellular telephone, as well as the telecommunications skills needed since the breakup (deregulation) of AT&T, requires highly specialized knowledge, which is certified through special exams given by the *N*ational *A*ssociation of *R*adio *A*nd *T*elecommunication *E*ngineers (NARTE), which certifies on two levels: technician and engineer. Almost without exception, NARTE certification requires a combination of advanced schooling and extensive experience. For example, their lowest class of engineering certification requires either a two- or four-year engineering degree, or previous high-level technical certification plus two years of engineer level experience. The NARTE's minimum technician certification (Class IV) requires an examination, while the highest (Class I) requires previous certification plus six years verifiable radio or telecommunications experience.

CET

Long before FCC deregulation, electronics professionals recognized the need for certifying electronics technicians in troubleshooting consumer products, in basic logic circuits and industrial controls, and the safety and accuracy of calibration for medical electronic instruments. As early as 1965, the CET test used by the *I*nternational *S*ociety of *C*ertified *E*lectronics *T*echnicians (ISCET) used exams that tested black and white television adjustments, audio speaker enclosures and adjustments, and the use of electronics test equipment. Nearly 20,000 technicians had passed those exams (out of about 70,000) even before the FCC deregulation. Persons passing the appropriate tests may first attain the apprentice electronics-technician certificate, and then one or more advanced journeyman-level certificates.

CERTIFICATION PROGRAMS

Electronic's Technicians Association
604 N. Jackson St.
Greencastle, IN 46135

International Society of Certified Electronics Technicians
2708 West Berry St.
Fort Worth, TX 76109

National Association of Business and Educational Radio
P.O. Box 19164
Washington, DC 20036

National Association of Radio and Telecommunications Engineers
P.O. Box 15029
Salem, OR 97309

National Institute for Certification in Engineering Technologies
1420 King St.
Alexandria, VA 22314

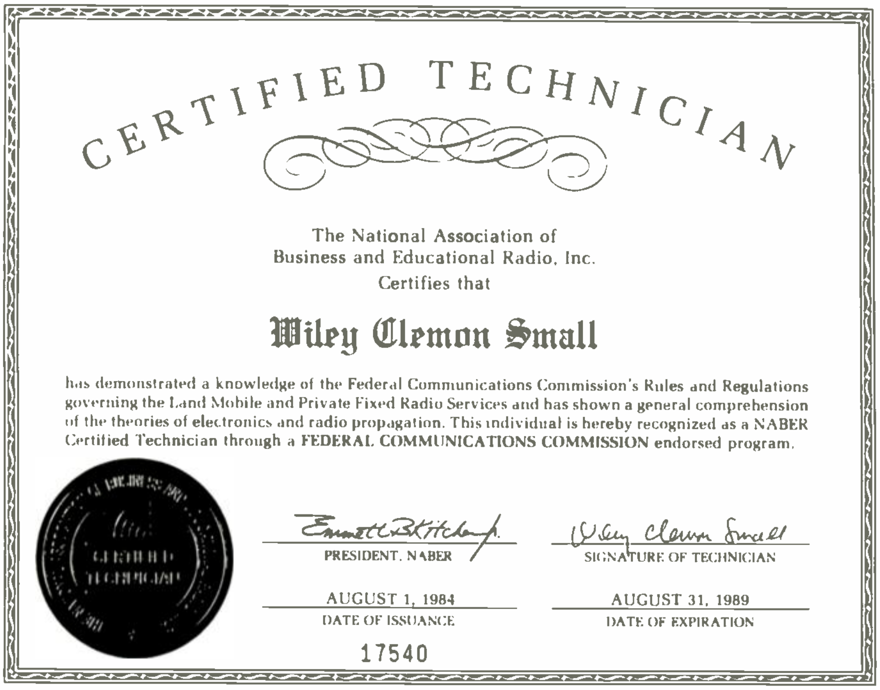
Society of Broadcast Engineers
P.O. Box 50844
Indianapolis, IN 46250

Two organizations that offer a CET or C.E.T. testing program are ISCET and the *Electronic Technician's Association* (ETA). Options that are available from one or the other of these programs include most major areas within electronics technology.

Within the ETA program are the advanced options of *Senior C.E.T* and *Master C.E.T.*, which are available to persons with eight or more years of experience in the profession. Higher passing scores in a chosen option are required for the senior level than for the lower levels. The master option requires passing an examination that covers consumer electronics, commercial electronics, communications, industrial electronics, computers, and biomedical electronics.

ISCET has two levels of certification. *Associate CET's* must pass an exam covering basic electronics, circuits, semiconductors, test instruments, and basic troubleshooting. Technicians with four years experience can take the higher-level *Journeyman* exam at the same time. They must be certified at the Journeyman level to use CET after their names. CET's are issued permanent certificates suitable for framing and a plastic wallet card.

Once certified as a CET or C.E.T., technicians are eligible for membership in the parent organization, ISCET or ETA. Members receive books, magazines, reprints, and regular technical material; may attend conventions and technical training programs; and receive discounts on books, tapes, and software. But the real benefit of certification is a growing awareness within the electronics industry that a certified technician is a person who has demonstrated considerable skill, understanding, and competence in his or her tested areas.



CERTIFIED TECHNICIAN

The National Association of
Business and Educational Radio, Inc.
Certifies that

Wiley Clemon Small

has demonstrated a knowledge of the Federal Communications Commission's Rules and Regulations governing the Land Mobile and Private Fixed Radio Services and has shown a general comprehension of the theories of electronics and radio propagation. This individual is hereby recognized as a NABER Certified Technician through a FEDERAL COMMUNICATIONS COMMISSION endorsed program.

PRESIDENT, NABER — SIGNATURE OF TECHNICIAN

AUGUST 1, 1984 — DATE OF ISSUANCE

AUGUST 31, 1989 — DATE OF EXPIRATION

17540

EVEN WHEN THEY DON'T RESEMBLE the First-Phone license, some private certificates such as this one state or imply endorsement by the FCC, although the FCC does not approve, sanction, or endorse any private program.

International Society of
Certified Electronics Technicians

Associate Certified Electronics Technician

Expiration Date — Registration No

be it known by these presents that

has successfully completed the Technical Tests and Requirements giving universal recognition for competence, ability and knowledge as an Associate Certified Electronics Technician

This certificate is issued jointly by

SCET Chairman — ISCET Executive Director

PRIVATE-SECTOR CERTIFICATION attesting to a minimum level of knowledge and skill is available for various areas of electronics. It often serves as a "ticket to success."

The FCC and CET

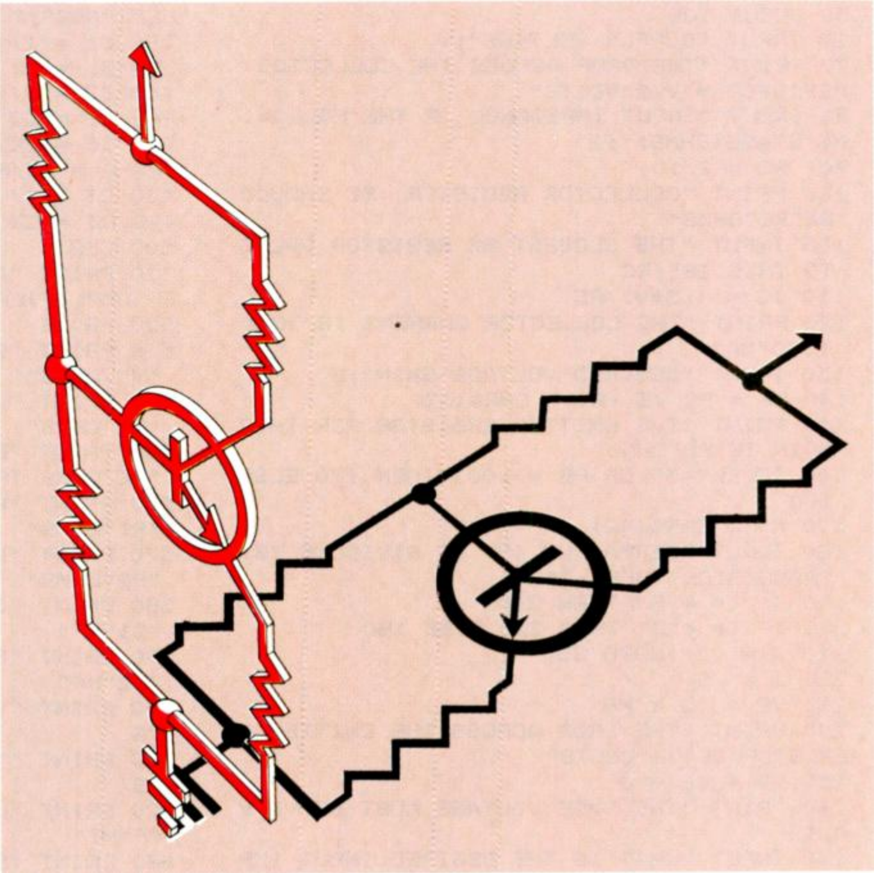
The FCC has made no official sanction of any private-industry certification program. Public notices have been issued by the FCC to assist technicians in locating certification programs, but those have specifically stated, "The Commission does not approve, endorse, or officially sanction any private sector certification program..." However, in its Report and Order, docket 83-322, 49 Fed. Reg. 20658, the Commission did endorse the *concept* of private sector certification programs as a possible substitute for Commission testing of commercial radio operators.

The right certification

It is reasonable to expect that, as more and more jobs require certification of some kind in lieu of the old First-Phone, we're bound to see a plethora of private organizations offering their own version of private licensing. Bear in mind that certification that isn't specifically recognized by employers is worthless. If you want a particular kind of job, say in cellular phone, or even broadcasting, check with some large operations and specifically ask if they recognize or require private certification or licensing and, if so, from whom. If you choose to work in an area that requires private certification, bear in mind that as a general rule the higher the certificate for which you qualify, the greater the potential job opportunities.

For more information on how to get certified in various electronic technologies, you should contact the major private certification organizations listed in the box that can be found elsewhere in this article. Although those organizations are not-for-profit, they do have a reasonable fee for testing and processing. In particular, we suggest you enquire as to what study guides they specifically recommend. **R-E**

TRANSISTOR AMPLIFIER DESIGN



JACK CUNKELMAN

It's easy to design a simple transistor amplifier. Here's how.

WE WERE HAVING TROUBLE FINDING AN exact replacement transistor while repairing a piece of equipment recently. Figuring that an *exact* replacement was going to be impossible to find, we began to discuss what to do. And someone pointed out that there were only two kinds of bipolar transistors—NPN and PNP. Of course, values for various characteristics vary widely, even for a specific transistor; but in many circuits, a garden-variety device will work (and did in our case).

Designing and repairing transistorized circuits is much simpler than you might suspect. A well-designed circuit has built-in tolerance, so it's probably not device-sensitive. The most important characteristics to consider when substituting devices or designing a circuit from scratch are operating frequency and power level.

What follows is the design procedure we went through to solve an audio-gain problem. Try it when you need a little extra gain for that next audio project.

An audio amp

This particular project involved injecting the audio from a TV receiver into a stereo system. The audio-output portion of the TV-audio receiver was abandoned because of its poor frequency response and high distortion. Instead, we wanted to come right off the detector into a quality audio amplifier and speaker. So, after picking off the audio at a convenient point in the set (in this case, from a potentiometer), we wanted to feed it to the auxiliary input of the stereo amplifier.

The amplifier we used required an input of 1 volt rms, but a quick check with an AC VTVM indicated that our picked-off audio signal was only 0.1-volt rms. Obviously, an amplifier with a gain of 10 was needed.

Scanning the literature on transistor amplifiers revealed that a common-emitter amplifier with a voltage-divider bias circuit would solve our problem nicely. Such a circuit is shown in Fig. 1. Some of that circuit's characteristics include: moderate input impedance, moderate voltage gain, inverted output, and input/output impedance and gain that depend only slightly on transistor beta.

There are, of course, several rules that must be followed in using a common-emitter amplifier, including:

- With a positive supply use an NPN transistor.
- With a negative supply use a PNP transistor.
- The supply voltage must not exceed the transistor's V_{CE} rating.
- The power-dissipation rating of the transistor must not be exceeded.
- The beta of the transistor should be 100 or higher.

In our example the following facts are known:

- Our amplifier had a single-ended 12-volt power supply.
- We need a voltage gain of 10.
- The input impedance of the amplifier should be about 15K, the same as the potentiometer from which audio was taken.
- The impedance of the stereo amplifier's auxiliary input is about 50K.

As is the case in most circuit designs, a few facts are known, and the rest must be calculated or picked using a few "rules of thumb." We will learn how to make the calculations next.

Doing the math

For maximum undistorted output swing, we will make the quiescent collector voltage ½ the supply voltage. See Fig. 2. The drop across R_C must therefore be 6 volts.

The value of R_C, the collector load resistance, is chosen considering output impedance, gain, and collector current. If possible, the output impedance should be lower than the impedance of the circuit we are feeding by a factor of 10 or more. Doing so will avoid circuit loading. So let's make R_C equal to 4700 ohms, which is about 50K/10.

LISTING 1

```
10 CLS
20 REM TRANSISTOR AMPLIFIER CALCULATIONS
30 REM BY JACK CUNKELMAN
40 REM APRIL 1986
50 GOSUB 900
60 INPUT "SUPPLY VOLTAGE";V
70 PRINT "THE DROP ACROSS THE COLLECTOR
RESISTOR ="V/2"VOLTS"
80 INPUT "INPUT IMPEDANCE OF THE FOLLOWI
NG STAGE(OHMS)";Z
90  RC = Z/10
100 PRINT "COLLECTOR RESISTOR, RC SHOULD
 BE"RC"OHMS"
105 INPUT "THE CLOSEST 5% RESISTOR VALUE
 TO THIS IS";RC
110 IC = (.5*V)/RC
120 PRINT "THE COLLECTOR CURRENT IS"IC *
 1000"MA"
130 INPUT "DESIRED VOLTAGE GAIN";G
140 RE = RC /G :R$ = CHR$(32)
150 PRINT "THE EMITTER RESISTOR FOR THIS
 GAIN IS"RE"OHMS"
160 IF RE<=39 OR RE =>1001 THEN 170 ELSE
 180
170 R$ = CHR$(42)
180 INPUT "GERMANIUM (G) OR SILICONE (S)
 TRANSISTOR TYPE";T$
190 IF T$ ="G" THEN 210
200 IF T$ ="S" THEN 220 ELSE 180
210 J = .2 :GOTO 230
220 J = .6
230 VE = IC * RE
240 PRINT "THE DROP ACROSS THE EMITTER R
ESISTOR IS"VE"VOLTS"
250 VB = VE + J
260 PRINT "THE BASE VOLTAGE MUST BE"VB"V
OLTS"
270 INPUT "WHAT IS THE DESIRED INPUT IMP
EDANCE FOR THIS STAGE"; IZ
280 R2 = IZ*RE*100/((RE*100)-IZ)
290 PRINT "THE BIAS RESISTOR, R2 IS"R2"O
HMS"
300 INPUT "THE CLOSEST 5% RESISTOR VALUE
 TO THIS IS";R2
310 VD = V - VB : I2 = VB / R2
320 IB = IC/B
330 R1 = (V - VB)/(IB + I2)
340 PRINT "THE BIAS RESISTOR, R1 IS"R1"O
HMS"
350 INPUT "THE CLOSEST 5% RESISTOR VALUE
 TO THIS IS";R1
360 PRINT "CALCULATION OF THE INPUT AND
OUTPUT CAPACITOR VALUES"
370 INPUT "LOWEST FREQUENCY THIS AMP SHO
ULD PASS";F
380 C1 = 1/(3.2*F*IZ)
390 C1 = C1 * 1E+6
400 C2 = 1/(3.2*20*Z)
405 C2 = C2 * 1E+6
410 IE = VE/RE : RJ = .03/IE
420 A = RC/RJ
430 C3 = 1/(6.2*F*RJ)
440 C3 = C3 * 1E+6
500 CLS
510 PRINT "PARAMETERS FOR A COMMON EMITT
ER AMPLIFIER STAGE"
520 PRINT
530 PRINT "SUPPLY VOLTAGE..............
."V"VOLTS"
540 PRINT "COLLECTOR RESISTOR (RC) .....
."RC"OHMS"
550 PRINT "EMITTER RESISTOR (RE)........
."RE"OHMS "R$
560 PRINT "BIAS RESISTOR (R1)..........
."R1"OHMS"
570 PRINT "BIAS RESISTOR (R2)..........
."R2"OHMS"
580 PRINT "INPUT CAPACITOR (C1).........
."C1"MF"
590 PRINT "OUTPUT CAPACITOR (C2)........
."C2"MF"
600 PRINT "VOLTAGE GAIN.................
."G
610 PRINT "TRANSISTOR BETA..............
."B
620 PRINT "LOW FREQUENCY LIMIT..........
."F"HZ"
630 PRINT "EMITTER BYPASS = "C3"MF FOR A
 GAIN OF ...."A
700 INPUT "RUN AGAIN..Y OR N";R$
710 IF R$ ="Y" THEN 10
720 IF R$ ="N" THEN END ELSE 700
900 PRINT "CALCULATIONS FOR A COMMON EMI
TTER AMPLIFIER STAGE"
910 PRINT
1000 INPUT "TRANSISTOR BETA IF KNOWN (O
IF UNKNOWN)";B
1010 IF B = 0 THEN B = 100
1020 RETURN
```

Collector current, I_C, is equal to 0.5 V_{CC}/R_C, or 6/4700 = 1.28 mA. That current is certainly low enough that we will not exceed any collector-current ratings, so let's go on.

To achieve maximum stability, the emitter resistor should be in the range of 40 to 1000 ohms. Voltage gain (A_V) = R_C/R_E, so R_E = R_C/A_V In our case R_E equals 4700/10, or 470 ohms. That falls within the range of acceptable values.

The current through the emitter resistor consists of the collector current plus the base current. The base current here is significantly smaller than the collector current, so it can be ignored for the next calculation.

The voltage drop across the emitter resistor = $I_C \times R_E$, or 1.28 mA × 470 ohms = 0.602 volts. The base voltage must exceed the emitter voltage by 0.6 volts for a silicon transistor and by 0.2 volts for a germanium transistor. We'll use a silicon transistor in our circuit, so the base voltage must be 0.6 + 0.602 = 1.202 volts.

The input impedance of the circuit equals R2 in parallel with the emitter resistor times beta; input impedance will vary with the transistor's beta. For our example, assume we are using a transistor with a beta of 100. We want the input impedance to be about 15000 ohms. Solving for R2, we find:

$$Z_{IN} = (R2 \times R_E \times \beta)/[R2 + (Re \times \beta)]$$

$$R2 = (Z_{IN} \times R_E \times \beta)/[(R_E \times \beta) - Z_{IN}]$$

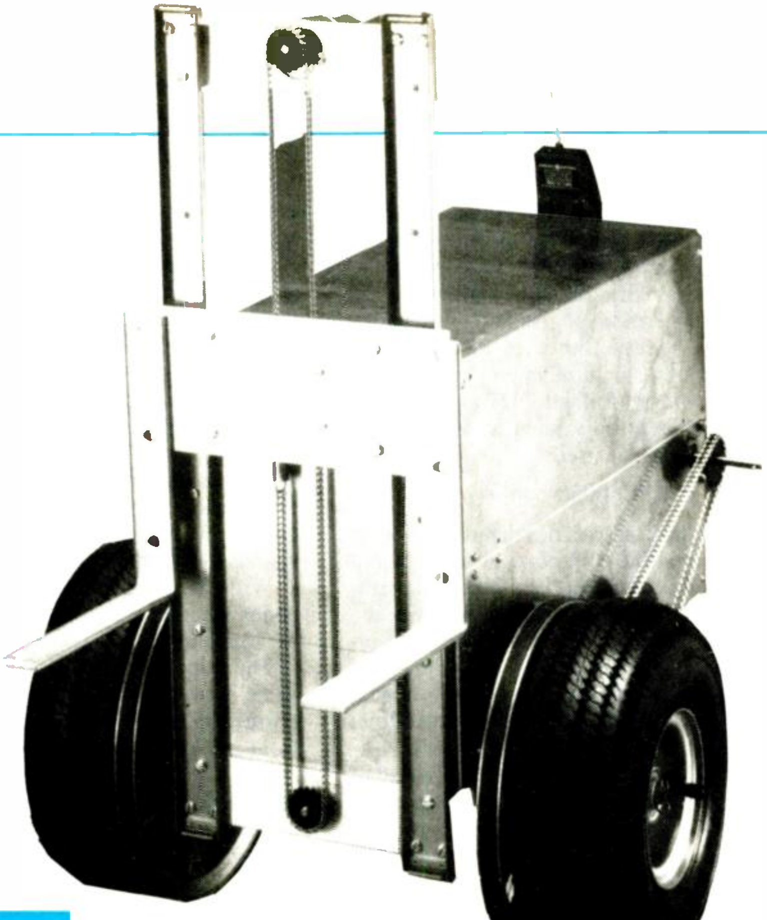
$$R2 = (15000 \times 470 \times 100)/[(470 \times 100) - 15000]$$

$$R2 = 22{,}030 \text{ ohms}$$

We can use a 22K resistor. In general, if input impedance is not critical, for maximum stability R2 can be 10 to 20 times R_E.

The drop across R2 must be 1.20 volts, so the current through R2 is 1.20/22,000, or 0.054 mA. Therefore, R1 must drop the rest of the supply voltage, which is 12 − 1.20 = 10.8 volts. The current flowing

continued on page 77



R-E ROBOT

The robot's command language

Part 9 NOW THAT WE'VE ASsembled the robot's hardware, it's time to dig into the software. In this article we'll describe the R-E Robot's command language, RCL (*R*obotic *C*ontrol *L*anguage). It's an easy-to-learn and easy-to-use language written in FORTH. Don't be scared by FORTH: you can use RCL without being an expert at programming in the language. And, as you learn RCL, you'll learn (painlessly) the basics of how FORTH works, so that, if you want to, you can go on and learn the language itself. To give you a chance to see RCL in action, we'll present a robot-based mail-delivery system. You can study our program to learn how RCL works, and you can also use it as the basis of your own program.

How difficult is RCL? Not very. For example, suppose you wanted the robot to move in the forward direction 3.4 feet at a speed of 2 miles per hour. You would simply type in the following code:

```
RERB 2 MPH 3.4 FEET FORWARD
```

RCL includes commands to move the robot forward and backward, to turn left and right, to move its manipulator up and down, and to open and close a gripper. You can combine a sequence of commands and store them for execution at a later time. In addition, commands can also be executed immediately from the keyboard.

Real-time control

The R-E Robot consists of a computer-controlled set of electromechanical devices. The assembly is broadly known as a *motion-control system*.

Real-time motion control requires real-time sensing and processing. One way to ensure proper sensing and processing is to force the computer to execute a control loop at regular intervals. That control loop will be the computer's highest priority. Everything else the computer does will be secondary, and it will have to do those other things as it finds time.

A simple way to implement the control loop is to have a clock IC generate an interrupt at regular intervals. Each time the clock interrupts the microprocessor, it will execute the control loop, and then it will return to whatever it was doing before the interrupt occurred. The amount of time the computer spends executing the control loop must be less than the time interval between interrupts.

RCL basics

The software that controls the robot is built up layer by layer. The most primitive words must be defined first; more-complex words are defined using the previously defined words; at the top level are the RCL words that make motion control easy. As each word is defined it can be tested and debugged. When it is debugged, the next layer may be defined.

Notice that you are defining words, rather than writing a program, as with most computer languages. That's not just a matter of semantics; it's also a way of looking at a programming problem. The problem can be broken down into a series of smaller problems, and then those problems can be broken down further, and so on, until you have a set of problems that can be programmed. Each little problem becomes a FORTH word, which in turn becomes part of another FORTH word, so that eventually all we have to do is say something like

```
TURN-LEFT
```

The real-time control portion of RCL consists of the hardware interface, interrupt control, following-error monitoring, velocity control, and position control.

Low-level words

The most-primitive words deal with the robot's hardware: turning the motors on and off, setting the direction in which each motor rotates, and enabling the speed-control circuits. To control the hardware, values must be written to and read from various registers on the robot's control board. Those registers are read and written using the microprocessor's I/O statements (IN and OUT). In RCL, to write an eight-bit value to an output port, the word PC! is used:

PC! (value port ----)

That statement specifies that *value* is to be output to I/O port *port*. A word about notation is in order. The stack diagram, enclosed in parentheses, represents the parameters required by the word PC! Input parameters appear to the to the left of the dashes, and output parameters appear to the right. In this case there are no output parameters.

FORTH words in general (and those of RCL in particular) make extensive use of the stack, both for parameters supplied to a word, and those that it may produce. The top of the stack is always the parameter furthest to the right. In the preceding example, the stack diagram shows that the value to be written must be pushed on the stack followed by the port to which it is to be written. The word PC! removes these parameters from the stack, uses them, and leaves nothing on the stack. Other words may leave one or more values on the stack.

Motor-control words

Several words operate the speed-control circuits and the relays. For example, ENABLE and DISABLE write an appropriate value to turn on or off a particular function of the hardware. STOP-LEFT, STOP-RIGHT, and STOP use DISABLE to turn the relays off. FORWARD, REVERSE, CW, and CCW enable the proper relays to allow the motors to turn in the desired direction. CW and CCW allow turns to be made by enabling the wheels to turn opposite to each other. GO and COAST enable and disable the speed-control circuits and the motor-drive current as well.

Speed control

Hardware on the control board is responsible for controlling speed (accelerating and decelerating). The hardware makes the software system much simpler than it would be if the software were required to maintain speed alone. The phase-locked loop on the control board maintains the desired motor speed under varying loads. The software only has to set the speed, and to accelerate and decelerate the base unit.

The speed at which each motor runs is determined by the frequency of a signal that is generated by counter 0 of the 8253 timers. Setting the number of counts in the counter determines the period of a squarewave output. The phase-locked loop circuitry responds to the frequency corresponding to that period.

The frequency of the signal applied to the 8253's on the motor-control board is the 2-MHz system clock divided by 16, or 125 kHz. Therefore a count is generated every 8 microseconds (1/125,000). The 8253 is programmed to generate a squarewave whose period corresponds to the value loaded into the counter. So, if the counter is loaded with the value 125, the total period would be 125 × 8 microseconds, or 1 millisecond, which corresponds to a frequency of 1000 Hz.

With a 500-count-per-revolution encoder, the motor speed would be 1000/500 = 2 revolutions per second, or 120 rpm.

The counter can be loaded with any value between 1 and 65,536 (0 actually), corresponding to frequencies ranging from 125 kHz to just under 2 Hz.

Interrupt control

Motor speed must be updated many times per second to produce smooth acceleration and deceleration. The update rate is set by the interrupt-control routines to 100 times per second (i. e., there are 10 ms between interrupts). The 80188 microprocessor has three built-in timers that can generate interrupts. Timer 0 is used by the BIOS and the DOS to maintain a time-of-day clock. The BIOS is set up to generate interrupt 01Ch every time timer 0 counts down to 0. If we change the count value in timer 0 we can use it to generate the motor-control interrupt. However, the time-of-day clock will count in 10-millisecond periods instead of the usual 55-millisecond periods, so a set of time-of-day words will have to be defined for the new rate. In addition, we'll have to install a new BIOS-level interrupt handler to maintain compatibility with MS-DOS.

First of all, we must define the interrupt routine we want to execute. Then we can install that routine so that it is executed each time the interrupt is generated by the timer.

The word INT-OFF disables interrupt generation by the timer so that we can change the interrupt vector, or disable it. INT-ON turns timer-interrupt generation back on. SET-TIMER takes a count that sets the period for the timer. The input frequency to the timer is 2 MHz/3, yielding a period of 1.5 microseconds per count. If the count is set to 6667, the timer will count down to 0 every 10 milliseconds and generate an interrupt.

GET—CS is a special word that is used to return the code segment in which the FORTH system is executing. SET-INT sets the interrupt vector to the word we want to execute each time the interrupt is generated.

INSTALL performs all the tasks necessary to link a new interrupt handler into the microprocessor's interrupt vector in low RAM. After executing INSTALL the interrupt-control word will be executed every 10 milliseconds, and will continue to do so until the system is turned off, the interrupt is disabled, or a new interrupt routine is installed.

Position-counter words

The hardware position counters must be initialized by the robot's software. In addition, the position counters are only 16 bits wide, so the robot won't move very far before the counters overflow. So it's necessary to extend counter length with software. If we look at the counters often enough, they will not overflow. The software maintains a 32-bit position counter.

Because the counter routines must be executed many times per second, the time required to execute those routines is important. So all counter routines (and several others) have been written as CODE words. To experiment with those words, you'll have to know 80188 assembly-language programming.

The high-level words for reading the counters are ?CNT1 and ?CNT2 to read the positions of motor 1 and motor 2, respectively. The hardware causes the 16-bit counters in the 8253 IC's to decrement for each encoder count that is in the proper direction. The difference between a motor's forward and reverse counts gives the absolute position of the motor.

Following-error words

To detect a problem with the motors, it is necessary to compare actual speed with expected speed. If the two differ by more than a small percentage, an overload condition exists, so the motors could overheat and be destroyed. The following-error words constantly monitor the motors and detect a stalled motor by comparing the current motor position with the expected position. If the difference is too great the motors are turned off immediately. This also means that if you specify a value of acceleration that is too high, a following-error will be detected, and the motors will be shut down.

Numeric input

FORTH normally works with 16-bit signed integers. Such numbers can range in value from −32768 to +32767. In addition, a decimal point may be included anywhere in a number and FORTH will treat it as a signed double-precision integer with a possible range of −2,147,483,648 to +2,147,483,647. The position of the decimal point is kept in a system variable, DPL. If a number without a decimal point is entered, the system sets DPL to −1. If a number is entered with a decimal point, DPL will contain the position of the decimal point relative to the least significant digit entered. A number may have a maximum of four digits to the right of the decimal point. The FORTH system converts the input number to a signed integer representing the integer part and a signed integer representing the fractional part. The pair of single precision numbers each carries a sign bit; the numbers can be used alone or together.

Table 1 illustrates how various numbers are stored. Keep in mind the fact that the decimal-point position stored in DPL is correct only for the last number entered by the user from the keyboard. Numbers compiled into a definition do not affect the value of DPL after compilation. You must be in the decimal base (base 10) when entering numbers with decimals.

The word FIXED converts the last number input to an integer and a fraction. FIXED gets the value from DPL and puts it on the stack, then it calls (FIXED). We defined the separate word (FIXED) to do the actual conversion, because it can be made more general—it can convert any number, even if it was not entered from the keyboard.

EXTRACT strips the fraction digits from the number one by one until all have been removed. That leaves the integer part of the number on the TOS (*Top Of Stack*) with the digits beneath it. The digits are reassembled into a single number with BUILD. SCALAR produces a value that is used to adjust the fraction to the proper range. If the unscaled fraction is 9, we need to know whether it is 9000/10,000, 9/10,000, or another value.

The word FRACTION takes a fraction, an integer, and a multiplier and creates a double-precision integer. So the value −932.015 converted by FIXED is a fraction and an integer. Taking these two numbers and a multiplier of 1000 would give us the double precision number −932015 as follows:

TABLE 1—NUMERIC STORAGE

Input	Value	Size	DPL
725	725	16	−1
−1	−1	32	0
1.2	12	32	1
−9.999	−9999	32	3
38.04	3804	32	2

```
932.015 FIXED 1000 FRACTION.
```

FRACTION is used by many other words to convert values for internal use.

User-input conversion words

Several words convert user-input values to more basic units the hardware can use for the move commands.

Distances are entered in units of INCHES, FEET, MILES and DEGREES. INCHES takes the value specified and converts it to internal form. The input value and a scale factor are saved for later conversion. FEET takes a distance in feet and MILES takes a distance in miles. The scale factor is set appropriately for each word in terms of the number of inches each word represents. DEGREES calculates how far each motor must move to make the specified turn.

Speed can be entered in miles per hour by using the word MPH, inches per second by IPS, feet per second by FPS, and feet per minute by FPM. Each of those words stores the value and an appropriate scale factor for later conversion.

G converts the input value (in terms of the acceleration due to the earth's gravity, i.e., 32.2 ft/sec/sec) to a count that is used to accelerate or decelerate the motors, if necessary, each time speed is updated by the interrupt routines.

Motion

To move from one point to another, the motors must be accelerated and decelerated. By allowing the user to set a value for acceleration, deceleration, and maximum speed, the behavior of the robot can be controlled precisely.

Before a move is actually made, the software does a series of calculations to determine the top speed that can be attained, and the positions at which acceleration should end and deceleration should begin in order to attain a trapezoidal velocity curve, as shown in Fig. 1.

Calculated speed may be less than desired speed, but that is not a problem for short moves. Maximum speed will be used for moves that are long enough to allow the motors to accelerate to their maximum velocity. For short moves, acceleration is more important than maximum speed.

To perform a move, breakpoints on the trapezoidal velocity curve must be found. The points where acceleration ends and deceleration begins, as well as the end point position, must be calculated.

The robot is a speed-controlled system, so the acceleration and deceleration breakpoints must be used to calculate what speed will be achieved by accelerating at the specified value of acceleration to the breakpoint position. That new speed is saved with the breakpoint position. The same values of speed and distance are used to calculate the breakpoint where deceleration is to begin.

Trapezoidal velocity control

To perform a move, the robot must be accelerated from a speed of zero to top speed, and then decelerated at the appropriate point to arrive at the desired position. The simplest system would just set the speed of the motors, turn the motors on until the end point was reached, and then turn the motors off. That type of approach assumes instantaneous acceleration and deceleration, but in an actual

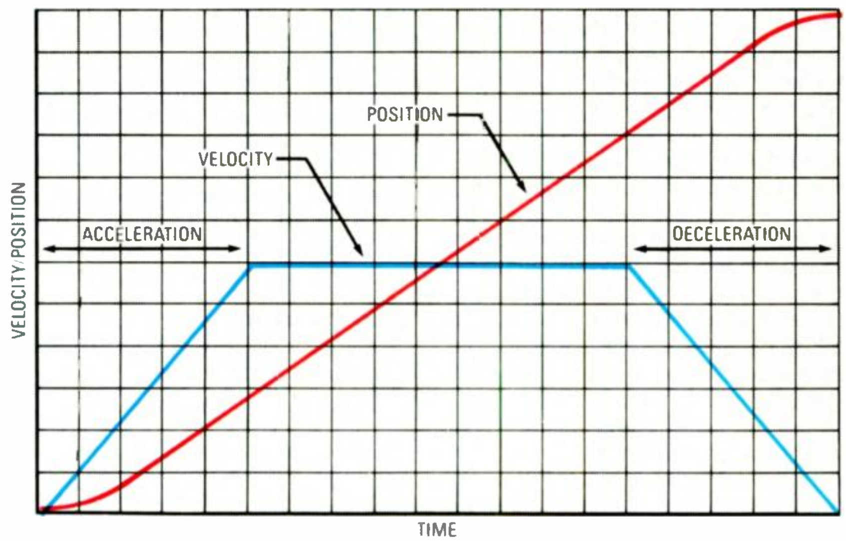


FIG. 1—ACCELERATION AND DECELERATION BREAKPOINTS must be calculated in order to move the robot from one point to another.

system it's not practical. Therefore, we have to take into account the acceleration that actually can be achieved by the system. In practical terms, acceleration might be a fraction of G, or it could be several G's, depending on the size of the motors in relation to the size of the load.

To accelerate and decelerate the robot, velocity actually must be changed many times per second. In general, the robot starts with a velocity of zero and then accelerates at a constant rate to the top speed. Then it must decelerate at a constant rate until it stops at the final position.

The velocity-versus-time profile is also shown in Fig. 1, but superimposed on the velocity trapezoid. Note that the position profile is not simply a straight line. In terms of calculus, position is the integral of speed over time. The basic equations of motion are as follows:

$$V = V_O + AT$$

$$D = V_OT + \frac{1}{2}AT^2$$

where V stands for velocity, A for acceleration, T for time, and D for distance. V_O refers to starting velocity.

From the previous equations we can derive an equation that describes the distance required to accelerate from one speed to another:

$$D = (V^2 - V_O^2) / (2A)$$

We can use that equation to compute the distance required to change speeds.

For a short move, the distance required to accelerate to the desired speed and then decelerate to a stop may exceed the distance to move. In such a case, deceleration must begin at some speed less than maximum.

The word DISTANCE takes the original speed and the desired speed (both in rpm) and calculates the distance in inches that will be required to change speeds. The word COUNTS changes the distance from inches to position-encoder counts. The word EXPECTED converts the user-input distance to position-encoder counts. The word SPEED converts the user-input maximum speed into rpm.

The word BREAKPOINTS calculates the positions on the velocity trapezoid to stop accelerating and begin decelerating. The acceleration and deceleration segments can't be more than half the total move distance, so the distance to accelerate from 0 to the input speed is calculated and compared to half the move distance. The minimum of these two values is then used as the acceleration distance. The breakpoint positions are saved in arrays for use during the move.

After the robot starts moving, the breakpoint positions are compared against the current position every time the control loop executes to determine when acceleration should stop and deceleration should begin. If the move distance is long enough, there will be a period during which the motors run at maximum speed. For a short move, acceleration will stop before maximum speed is attained, and deceleration will start immediately after acceleration stops.

Command language

The RCL includes a simple command set to allow movement of both the base unit and the arm.

The base-movement commands allow forward and backward motion, and left and right turns. Maximum speed, acceleration rates, and move distance may all be altered by user input. After each move is complete, a new move command can be executed. By defining FORTH words we can chain several move commands together in a motion sequence. We'll discuss such a sequence shortly.

The arm commands move the arm up and down, and open and close the jaws.

Command syntax

In general, a command consists of a device name, a speed value, a distance value, and the command:

[DEVICE] [*n* SPEED] [*n* DISTANCE]
COMMAND

where bracketed quantities indicate optional values that will be: the value entered with the command; the last value if a new value is not included; or a default value if this is the first time the particular command is issued. The value of *n* depends on the command. DEVICE may be RERB for the base unit or ARM for the arm unit.

Base commands

The general syntax for the base-movement commands is as follows:

[RERB] [*n* SPEED] [*n* DISTANCE]
COMMAND

COMMAND may be one of the following: FORWARD, BACKWARD, LEFT, or RIGHT. SPEED may be one of the following: MPH, IPS, FPS or FPM. DISTANCE may be one of the following: INCHES, FEET, MILES or DEGREES.

The command G is used to set the acceleration constant used to change speed; the constant is expressed in G's of acceleration. Any acceleration may be specified, up to the maximum acceleration the system can achieve. The acceleration may be specified in a separate command.

Arm Commands

The basic syntax for the arm-movement commands is as follows:

[ARM] [*n* DISTANCE] COMMAND

COMMAND may be one of the following: UP, DOWN, OPEN, or CLOSE. DISTANCE may be INCHES or FEET. DISTANCE is the amount specified in the COMMAND direction relative to the current position.

The example program shown in Listing 1 illustrates how you can combine several RCL commands to cause the robot to traverse a square. The sequence first sets the acceleration constant to 0.1 G. Then the RERB device (i. e., the base) is selected to move at 25.5 inches per second. Then it moves 3.5 feet forward and makes a left turn. The latter actions are repeated three times so that the robot ends up where it started.

Here's a short routine that moves the arm down and then back up:

```
ARM 3.1 INCHES DOWN 2 INCHES UP
```

By defining FORTH words we can create macros to perform various functions. For example, Listing 2 shows a macro that will cause the robot to traverse a box of any size.

Example program

Now let's show how the robot could be used to collect and deliver office mail. Figure 2 shows the office layout that we will use in the example program. Trays for incoming and outgoing mail are attached to the robot.

The overall sequence of operations goes like this: The robot starts from a "nest," and travels around the corridors, waiting at several locations for people to retrieve and deposit mail and then returns to the mail room.

We defined several low-level FORTH words for the program. To allow the robot to wait for different time periods, we defined several words to execute time delays. See Listing 3. The first is MS, which waits for the specified number of milliseconds. The next is SECONDS, which uses MS to delay the specified number of seconds. The last is MINUTES, which uses SECONDS to delay the specified number of minutes.

LISTING 1

```
.1G   ( 3.22 ft/sec/sec)
RERB  25.5 IPS
3.5 FEET FORWARD 90 DEGREES LEFT
3.5 FEET FORWARD 90 DEGREES LEFT
3.5 FEET FORWARD 90 DEGREES LEFT
3.5 FEET FORWARD 90 DEGREES LEFT
```

Next we define several words for convenience and to improve the readability of the source code. The robot will announce its arrival at each place it stops. That is done by sounding a beep. The word ATTENTION generates the beep.

WARNING, sounds several short beeps. It is used to avoid running over anyone when the robot is ready to move.

Since all the turns in our model office are at right angles, it's convenient to define left and right 90° turn words, TURN-LEFT and TURN-RIGHT. When the robot starts its trip it must back out of the

continued on page 80

COMPUTER DIGEST

VOL. 4 NO. 8 AUGUST 1987

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Great graphics, super speed

DESIGN PC BOARDS ON YOUR PC

New programs make it easy

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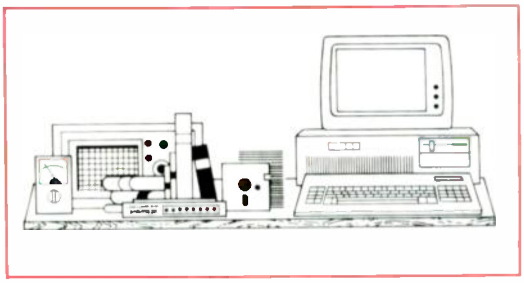
CONTENTS AUGUST 1987

Vol. 4 No. 8



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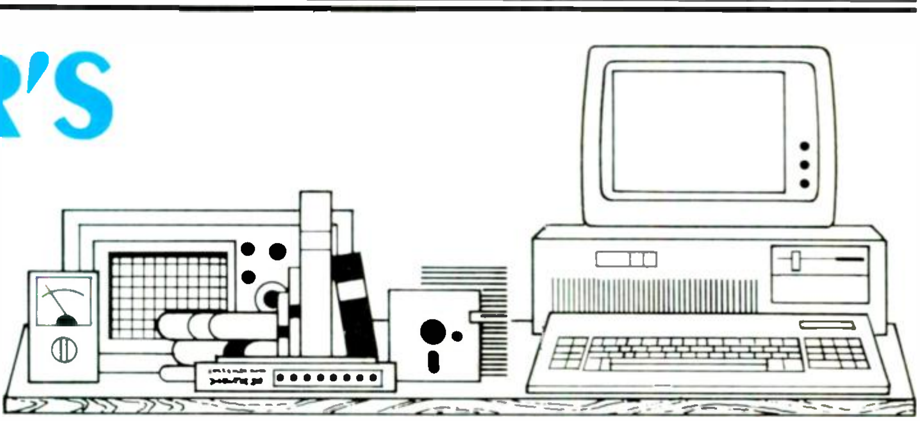
EDITOR'S WORK-BENCH



68000 UPDATE

We've just finalized arrangements with Peter Stark, a long-time member of the microcomputing community, to do a series of articles that will be of great interest to anyone interested in Motorola's 68000 family of microprocessors, and to anyone who wants to learn about computer-system design from the ground up. The series will center around a gradually upgradable CPU board that has been custom-designed specially for readers of **ComputerDigest.** A minimal system can be brought up for about $200; it requires only a serial ASCII terminal or any personal computer and a communications program to operate.

The computer can be populated on-board to include one megabyte of RAM, floppy-disk controller, battery-backed clock, Winchester interface, serial and parallel ports, and more. It will also include 3–5 IBM-compatible expansion slots, in which you can plug a monochrome IBM PC display adapter. In addition, the motherboard will accept an IBM PC keyboard. (Of course, it will also accept low-cost clone components as well.) Using a PC display adapter and keyboard will allow you to easily create a low-cost stand-alone development system.

The bare-bones system will include an EPROM-based monitor program called HUMBUG, which derived its tongue-in-cheek name from a series of different BUG programs, all of which were based on Motorola's original MIKBUG program, which was used in early 6800 (hundred, not thousand!) machines. HUMBUG has a number of commands for examining and displaying memory, etc. In addition, we hope to include a small version of BASIC in EPROM.

The expanded computer will run the SK*DOS operating system, and possibly others. The author of SK*DOS also happens to be the author of the series of articles, so you'll get a unique first-hand opportunity to learn about operating-system design. SK*DOS includes a 68000 assembler, a line editor, a 6809 emulator, floppy- and hard-disk support, extensive file-manipulation facilities, etc.

As for the MC68000 computer we presented in the March and May issues this year, we should have the promised information packet ready by mid to late summer. In addition, Peter Stark has adapted SK*DOS to run on the MC68000, although no formal system of distribution has been set up. We should point out, however, that the new (and as yet un-christened) machine will have better local support and distribution.

All in all, we're very excited about this project; we hope to begin the series in October or November. For more information, check our BBS (516-293-2283) occasionally, and watch these pages for announcements of progress.

IBM'S NEW MODEL 30 AND MODEL 50 PC'S

In case you missed it, IBM introduced four new personal computers last spring. They go by the name of Personal System/2, although only the three high-end machines (the Models 50, 60, and 80) have the new high-speed (and incompatible) Micro Channel bus, and only they will be able to take advantage of the new operating system OS/2, which we'll be lucky to see by early next year. However, the low-end machine (the Model 30) is not without merit; we examined one, and a Model 50.

All aboard

The new low-end machine can be viewed as a souped-up PC or XT, depending on whether you get it with two floppy-disk drives or a hard disk and a single floppy. It has a bus that is compatible with the old bus, and it's a fast (8 MHz) 8086-based machine that contains everything on the system board that you normally must add via expansion cards: 640K of RAM, serial and parallel ports, keyboard and mouse connectors, battery-backed clock, and video adapter. See Fig. 1. Other than the compact, lightweight system unit, the only thing you need to get a Model 30 running is DOS 3.30 and a monitor.

The video hardware is downward-compatible with the CGA (contrary to our report last month), and has two new modes of its own, including a stunning 256-color mode that allows you to create images like that shown on this month's cover (page 61). The other new mode provides 640 × 480 resolution in two colors, which should be great for CAD applications. The MCGA (Multi-Color Graphics Array) is not compatible with Hercules or EGA standards, but it may be upgraded (via a plug-in card) to the VGA (Video Graphics Array) video adapter, which we discuss below, that is standard with the other PS/2 machines. The VGA is EGA-compatible.

The Model 30 comes with a disk-based set-up/tutorial program that allows you to set time and date, park the hard-disk heads for moving the system, etc. The tutorial is extremely well-done, both in terms of the information presented and in the way it is presented. The graphics in the tutorial are simply stunning; they drew numerous *oohs* and *aahs* from our co-workers. The manual

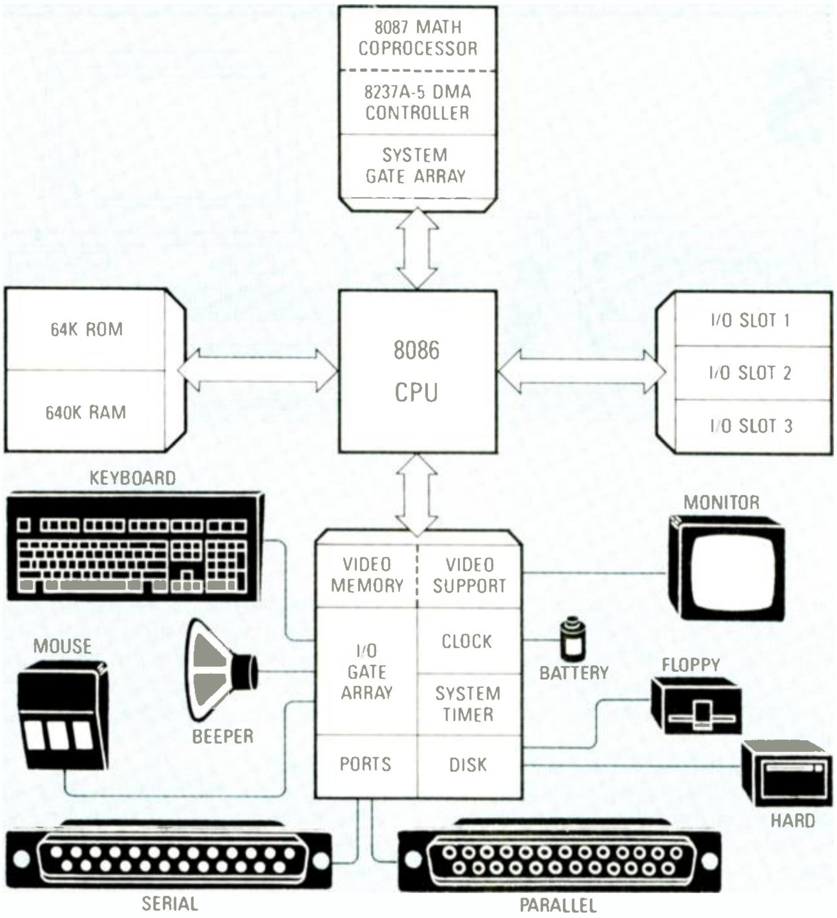


FIG. 1

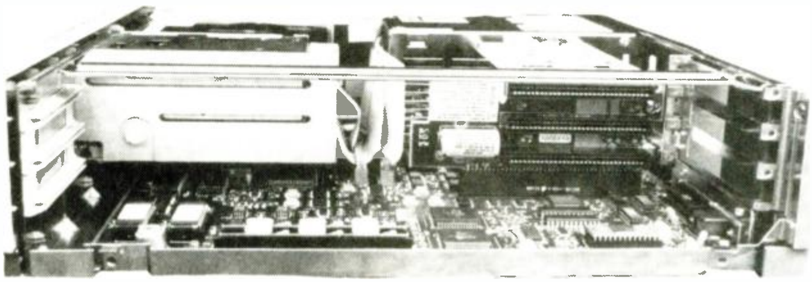


FIG. 2

is a slim booklet that will neither intimidate the novice nor bore the expert.

In our tests, we found no hardware or software incompatibilities. Our test unit ran an Ethernet adapter card and a 68000 coprocessor card without a hitch. Tested software includes AutoCad 2.6, WordStar 4.0, Dr Halo II (version 2.15, specially for the PS/2 line), SideKick 1.56b, Direc-Link, Brooklyn Bridge, Best Friend, PCED, and numerous small utilities.

The MCGA

The Model 30's video adapter provides better text quality than the old CGA, because each character is now displayed in an 8 × 16 box, rather than the CGA's 8 × 8 box. However, the screen still flickers when in the text mode. As many as four character fonts may be stored in the 0A0000h segment of RAM (formerly used by the EGA); one or two active fonts may be loaded and stored in a separate 8K static-RAM character generator. DOS 3.30 uses the new font capability to provide greater support for foreign languages; the new capability should also ease implementing any scientific and engineering word-processing programs.

The 0B8000h area of memory is still used as a video buffer, with characters and their attributes occupying alternate bytes of memory.

In graphics modes, 0B8000h is still used for storage in the old CGA-compatible modes; in the new 256-color and 640 × 480 modes (11 and 13, respectively), the video buffer begins at 0A000h. In the 256-color mode, each byte represents one pixel; in the high-res mode, each bit represents one pixel.

Model 30 memory mapping

According to the Model 30 *Technical Reference* manual, the BIOS can detect the presence of an alternate video adapter. When it does, it will disable the on-board MCGA and use the alternate adapter. However, the manual does not specify what type of adapter may be used in that way. So we don't know at present whether Hercules, EGA, and other adapters will function in the Model 30. But you can add the IBM PS/2 Display Adapter, which brings VGA-style graphics to the Model 30, as well as to the PC and XT models.

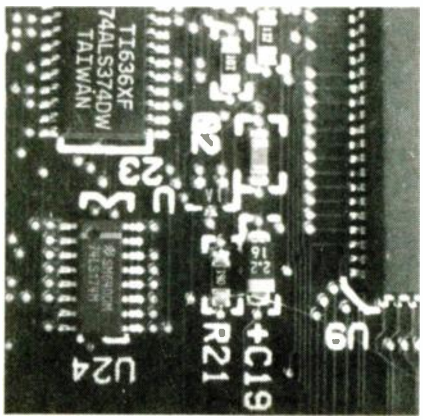
The Model 30's 640K RAM has been implemented as follows. The first 128K consists of four 64K by four-bit and two 64K by two-bit DRAM's, all of which are soldered to the motherboard. The next 512K consists of two 256K by nine-bit plug-in SIP RAM modules. Those modules are mounted on a slant; they're visible at the right side of the system unit in Fig. 2.

A special register (accessible at I/O port 6Bh) allows each 64K segment of memory from 40000h to 90000h to be disabled in case of conflict with memory on an expansion card or hardware error. In addition, a special bit in that register apparently allows one of the upper banks to be re-mapped to the lower 128K segment of memory in case there is a hardware problem there. The BIOS POST (Power-On Self Test) handles those duties automatically.

Model 30 hardware notes

The Model 30 has three horizontally mounted expansion slots; they're visible at the rear left in Fig. 2. The edge connectors for those slots are mounted to a board that in turn plugs into an edge connector on the motherboard. The expansion-slot board also carries the clock/calendar's backup battery; that battery is soldered to the board, and at present IBM only plans to replace that board as a unit when the battery wears out.

The BIOS now supports four serial ports; previous machines officially supported



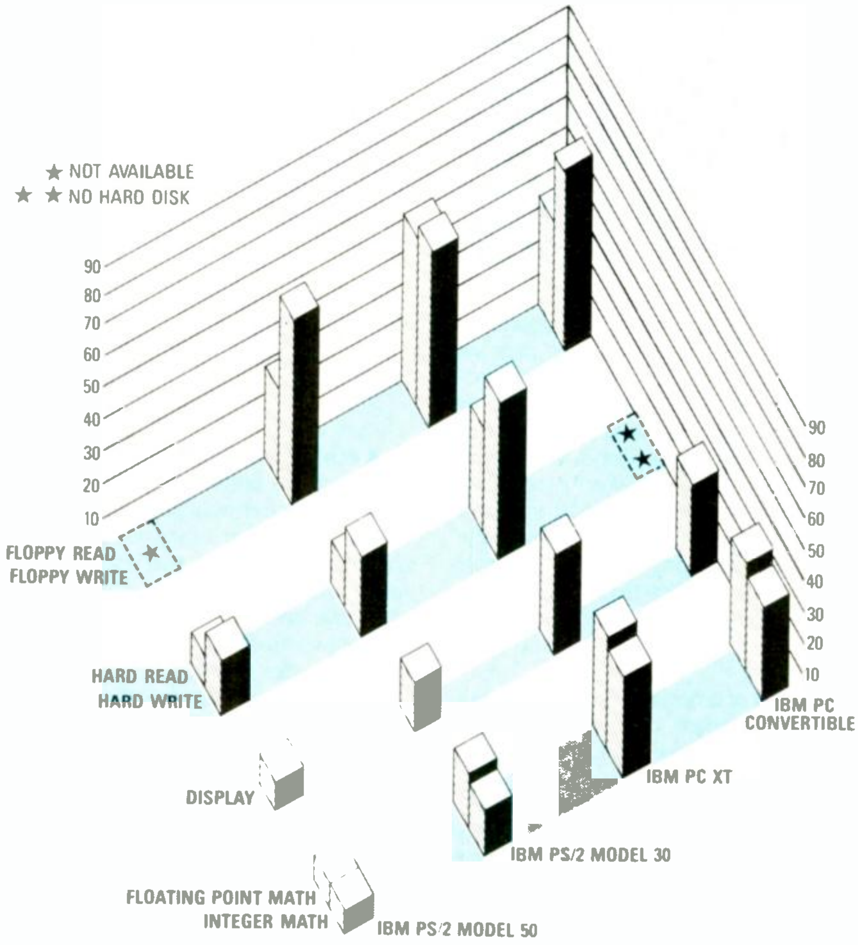


FIG. 4

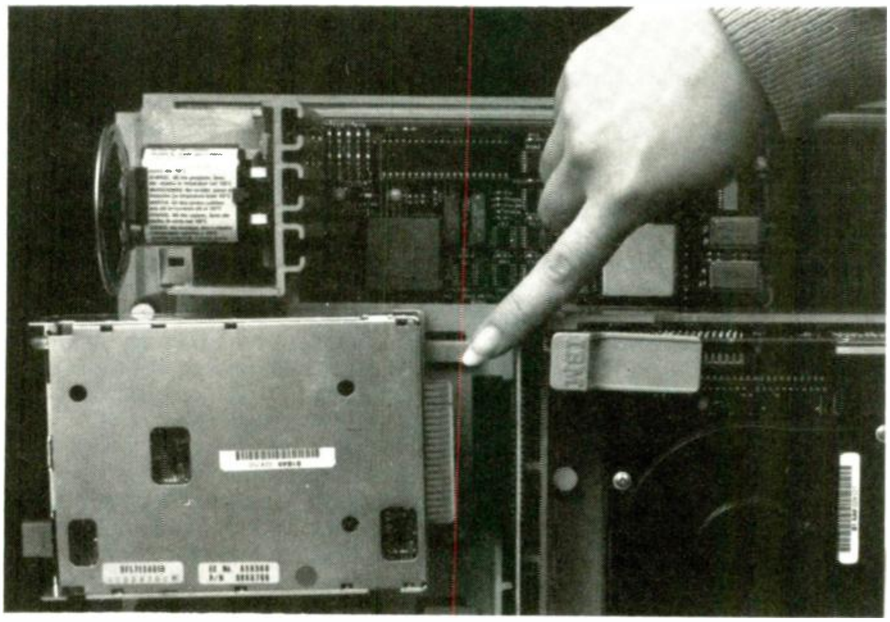


FIG. 5

only two The parallel port is now bi-directional, so you can connect the parallel ports of two machines together and exchange data between them In fact, IBM is selling a program/cable combination called the Data Migration Facility (DMF) that allows you to do exactly that. The DMF could be especially useful in transferring data from an old-style machine.

The keyboard and mouse ports are electrically interchangeable--either keyboard or mouse may be plugged into either port--the BIOS separates keystroke scan codes from Mouse codes

All the I O connectors are soldered to the motherboard No external disk-controller cards (for hard or floppy disks) are necessary The disk drive handles 720K 3½" disks, as used in the IBM PC Convertible and many other portables The power supply is rated at only 70 watts, but that should be sufficient for most users In addition, surface-mount technology is used extensively, as shown in Fig 3

The Model 50

The Model 50 can be viewed as a hybrid of an XT and an AT, with the Micro Channel bus (three slots) and OS/2 compatibility thrown in for good measure The model 50 has a 10-MHz one-wait-state 80286 microprocessor, which is faster than the AT's microprocessor, but it has a relatively slow, relatively small (20 megabytes) hard-disk drive like the XT

The floppy-disk drive can read the 720K format used by portables and the Model 30; it also can read and write a new 1 44-megabyte format. You cannot format a 720K diskette for 1.44-megabyte use, special diskettes are required. The Model 50 also includes a megabyte of RAM, and a full complement of I/O ports.

We tested the Model 50 and found it to be quite fast See Fig. 4 for a speed-comparison chart. The Model 50 ran all the software we tested it with WordStar 4 0, Dr Halo II version 2 15, numerous system utilities, including a special communications program that manipulates the serial port directly—and everything we tested worked without a hitch Of course, we couldn't test any expansion boards, because none are available yet

The VGA

The Model 50's Video Graphics Array hardware is compatible with all previous IBM display adapters (monochrome, CGA, EGA, and MCGA), and it adds several new display modes of its own, including.

- 640 × 480 graphics in 16 colors (the MCGA provides only two colors at that resolution);
- 720 × 400 alphanumeric in 16 colors or monochrome;
- 360 × 400 alphanumeric in 16 colors

Of course, the VGA can also run in the 256-color mode of the MCGA By way of comparison, the EGA provides 640 × 350 in 16 colors in graphics mode Apparently, the VGA is not compatible with the Hercules monochrome standard

It's worth pointing out that all supported modes will run on any PS/2 monitor. That differs from most present multi-mode video adapters, which can run in various modes, but only on appropriate monitors (TTL monochrome, color, or enhanced color) There's much more to say about the VGA, but, unfortunately, no space to do so at this time

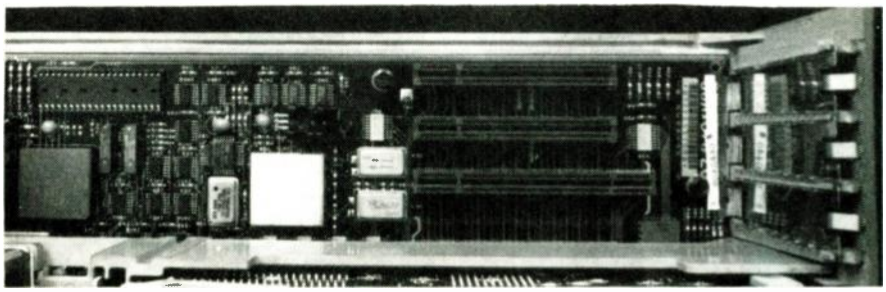


FIG. 6

Model 50 hardware notes

As with the Model 30, surface-mount IC's are used extensively; plug-in cards extend appropriate signals from the motherboard to the floppy- and hard-disk drives. One very interesting feature of the Model 50 is the modular way in which all the sub-sections snap together. For example, as shown in Fig. 5, the floppy-disk drive snaps into place, and the edge connector provides mechanical as well as electrical contact. (A plastic guide system beneath the unit locks it into place.) The hard-disk drive mounts in a similar manner, as do the bus-extender cards, and even the fan.

The Model 50 includes three Micro Channel bus slots (shown in Fig. 6); its sibling, the Model 60 (which we didn't evaluate), provides eight slots and a faster hard disk.

Monitor mania

There are several monitors available for all the new models; two are color displays (8512, 8513) and one is monochrome (8503) They all have the same resolution (720 × 400 in text mode, 640 × 480 in graphics mode); they differ mainly in price and size. Our cover shot was made with the 8512 monitor, a 14-inch model.

The new monitors are analog types, which means that they are incompatible with the previous standards, although NEC has announced that their MultiSync monitor is compatible with the addition of a cable adapter. The new monitors are plug-compatible with each other; the BIOS senses whether a color or a monochrome display is connected and routes signals accordingly If a monochrome monitor is attached and a color mode is active, the RGB signals are summed and output to the monitor via the DAC (Digital-to-Analog Converter) that controls green

It's unclear at present whether two monitors can function simultaneously; some CAD programs and debuggers use one screen for menus and control functions, and the other for program output.

New BIOS and DOS

The following discussion refers to the Model 30's BIOS and DOS 3 30 A new BIOS interrupt 10h function call (12h) provides a means of switching various video adapters on and off Again, it's unclear whether external Hercules, EGA, or other adapters are supported.

Another new BIOS interrupt function (Interrupt 15h, function 4Fh) allows you to intercept keyboard scan codes as they are generated (via interrupt 9). The new function allows you to change the scan code, or cause it to be ignored altogether. That function will aid remapping keys for foreign-language and technical word processing, but without resorting to illegal interrupt stealing as some word-processing and keyboard-enhancing programs do. Another keyboard function (Interrupt 16h, function 5) allows you to stuff the keyboard buffer with key codes as if those keys had been typed.

A number of other BIOS functions are not clearly documented, but seem to point in the direction of adding multi-tasking capabilities to the machine.

DOS 3.30 is not a major upgrade, but it is not insignificant either. It contains greatly expanded support for foreign-language character display, extended network support, and extended batch-file support, including a CALL command that allows one batch file to call another. (CALLing was possible but awkward in previous versions of DOS.) The new DOS also supports all disk formats, ranging from the single-sided single density (160K) 5¼ format of the original PC to the 1.44 MB format of the models 50, 60, and 80. DOS 3.30 runs on all past and present models of the PC.

Conclusions

All in all, the PS/2 machines represent real technological improvement in the PC family. They are not a radical departure from past systems, nor are they misplaced machines like the PC Jr and the PC Portable. Rather, they represent an incremental step in the evolution of the PC family. They're not the cheapest machines, but they set standards that others will follow. We applaud IBM's leadership efforts, and hope that it will continue in the course it has set itself.

Credits

Media Cybernetics (8484 Georgia Ave., Suite 200, Silver Spring, MD 20910, 800-446-HALO) graciously sent us a beta-test copy of version 2.15 of Dr. Halo, which supports the new video hardware; we used it to create our cover image. And thanks to AutoDesk, Inc. (2320 Marinship Way, Sausalito, CA 94965), for sending a test copy of AutoCAD version 2.6. Thanks to Andre Duzant for cover art, and to Herb Friedman for cover photography. R-E

MEMORY MINDER, DISK-DRIVE ANALYZER FROM J&M SYSTEMS

Mechanical devices are always the first to go. In particular, disk drives are a primary source of trouble. To help you spot a potential problem before it develops into a catastrophe, you can take your drives to a repair shop for testing. Or you can buy a disk-drive analysis program for about the cost of two trips to the repair shop and run the diagnostics yourself.

One such program is called Memory Minder. It's sold by J & M Systems, Ltd. (15100A Central SE, Albuquerque, NM 87123, 505-292-4182), and it lists for $114. The package consists of three parts: a manual, a disk containing the control program, and a special test disk. The program disk uses the test disk to check drive speed, head and clamping alignment, and several other factors.

How to run it

First you boot your machine directly from the Memory Minder program disk. It then displays a menu that lets you select parameters and run tests. After booting, the program disk is no longer needed; at that point, you insert the Digital Diagnostic Disk (DDD), manufactured by Dysan, into the desired drive. Disks are available for testing several types of drives.

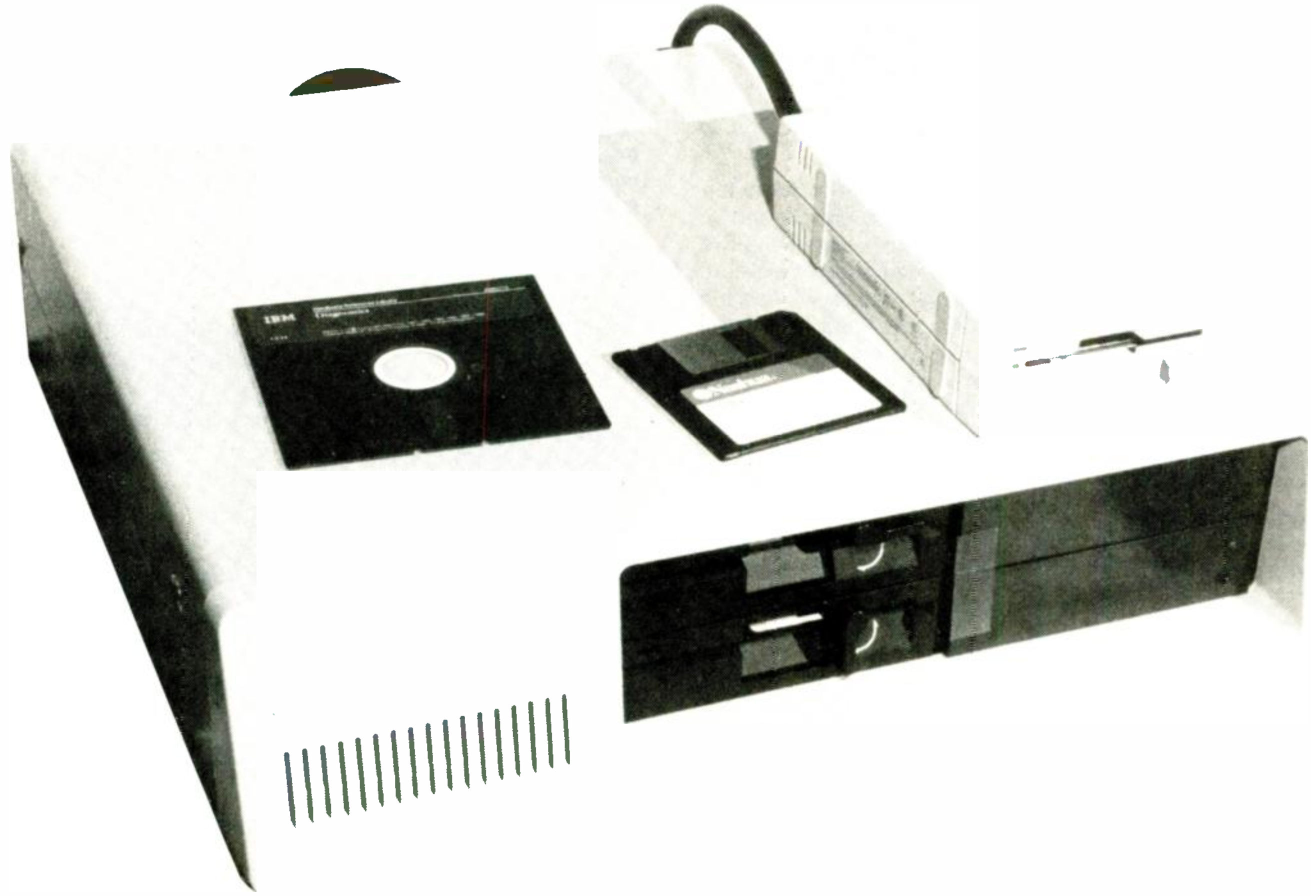
From the main menu you first run a clamp test (shown in Fig. 2), which tests the accuracy with which a diskette is clamped. If your drive can't pass the clamping test, chances are it can't pass any other tests either. (It's also possible that the DDD has gone bad, in which case it must be replaced for the healthy sum of $40.)

Then you run a quick test, whose screen appears as shown in Fig. 7). If your drive fails any aspect of the quick test, you can run more-detailed tests. For example, spindle speed may be measured directly in RPM, and, if speed varies from the standard (300 RPM for a 5¼-inch drive) by more than ±2%, the program tells you so.

Another test checks the drive's head alignment. J & M provides generic instructions for aligning a head, and wisely refers you to the manufacturer's alignment instructions. Other tests check other aspects of the drive's operation, and a special set of rou-

continued on page 72

MICRO-FLOPPY RETROFIT



Retrofit your PC or XT with a 3½-inch disk drive.

HERB FRIEDMAN

If you use an IBM PC or clone, you may be underwhelmed by all the fuss being made about 3½-inch disks. However, many portable computers, and all of IBM's new line of PC's, use 3½-inch disks. (See "Editor's Workbench" for reviews of two of the new PC's.) The small diskettes have many advantages over the 5¼-inch disk you're used to using, including

- Increased capacity (two to four times that of a standard 360K floppy disk)
- Greater reliability, because each disk is completely enclosed by a hard plastic shell
- Smaller, shirt-pocket size

5¼-inch disks are by no means obsolete, but chances are that the industry will move steadily toward use of 3½-inch disks, just as 8-inch disks were gradually supplanted by 5¼-inch disks. So in this article we'll show you how to retrofit your computer to use 3½-inch disks. Then you'll be ready to handle the upcoming new wave of software and data. We'll discuss installation of IBM's model 2683190 disk-drive retrofit kit for PC and XT model computers. Similar kits are available from clone manufacturers, but installation may differ, so your drive's instructions carefully.

What it is

The retrofit kit consists of a cabinet-mounted 3½-inch disk drive with attached signal and power cables, a Y-adapter that lets you tap

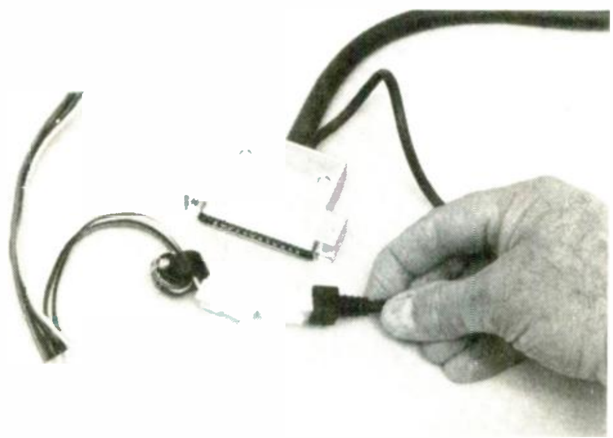


FIG. 1—THE CABLE FROM THE 3½-inch drive has its own power connection take-off that matches the miniature power socket on the supplied Y-adapter. The ring through which the adapter's power wire loops is a toroid choke that help suppress RFI.

power from your computer's internal disk-drive power connector (shown in Fig. 1), and a kit of three pre-punched metal brackets (shown in Fig. 2) that accept the Y-adapter's connector.

Installation is simple. First you mount the appropriate bracket on the rear apron of your computer. Then you install the Y-adapter in series with one of the existing internal disk-drive power connectors. Next, you push the small power connector through the hole in the bracket. That connector locks in position by means of mounting ears molded on the connector. Finally, you connect the cable from the 3½-inch disk drive to the controller card in your main computer.

With some PC's you won't need to install the power cable in series with the floppy power connector. The reason is that the power supplies in some PC's have four power connectors. So, if you haven't used used all four, just connect the Y-adapter to one of the unused connectors.

Use the bracket that causes the least inconvenience. For example, if you use the relatively large standard rear-slot bracket shown in Fig. 2, you must give up an entire slot. Some PC's have only five slots, so it may prove impossible for you to use the large bracket. In that case you could use the smallest bracket, which will mount in the small hole above the cassette port (yes, the original PC included a cassette interface). The medium-size bracket can be used in the extra slot above the keyboard port on an XT.

Clone panel layouts may vary, so you might have to use the full-size bracket and give up a slot. Or you might just cut a hole of your own in which to mount the small bracket.

Standard controller

To use the adapter, you must have an an IBM-type floppy-disk controller, the kind with a 37-pin D-connector on the mounting bracket (as shown in Fig. 3), in addition to the regular floppy-disk connector. The IBM controller accommodates four floppy-disk drives: two internal and two external drives. Because the retrofit kit connects to the computer via the external 37-pin connector, you cannot use a multi-function disk controller (the kind that combines a disk controller, serial and parallel ports, a joy-stick interface, and a clock), because it has no connector for external floppy-disk drives. The controller itself needn't be an actual IBM device; having the external connector is the important point.

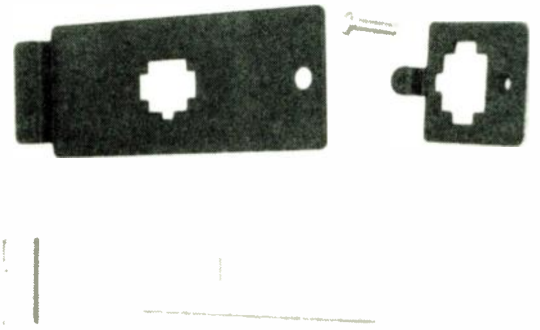


FIG. 2—THE RETROFIT KIT is supplied with three different brackets for the power sockets. Use the one that's most convenient for you, but remember that the standard bracket (the large one) may force you to give up use of one expansion slot.

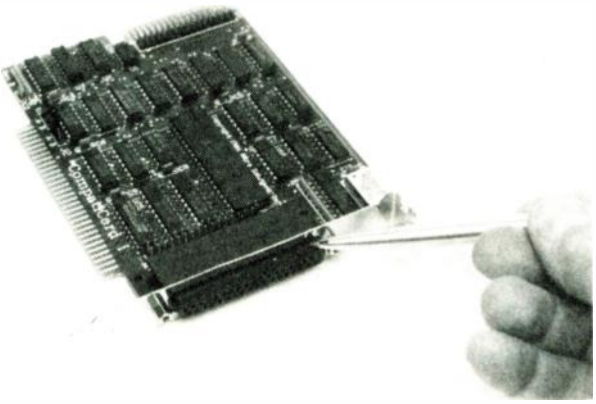


FIG. 3—IBM-TYPE DISK CONTROLLER cards have a 37-pin socket on the rear for external disk drives (C: and D:). The retrofit cable must connect to that socket.

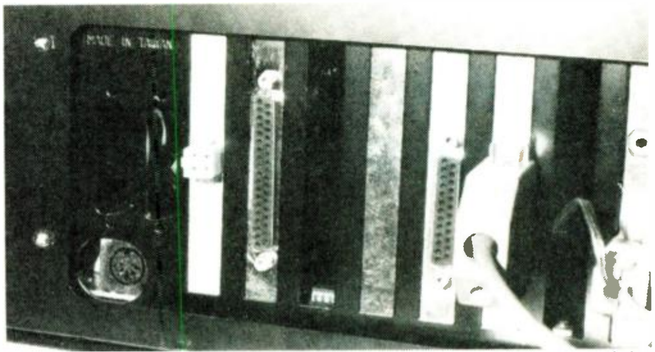


FIG. 4—THIS IS A TYPICAL CLONE INSTALLATION. The disk-controller socket and the 3½-inch drive's power socket are on adjacent brackets.

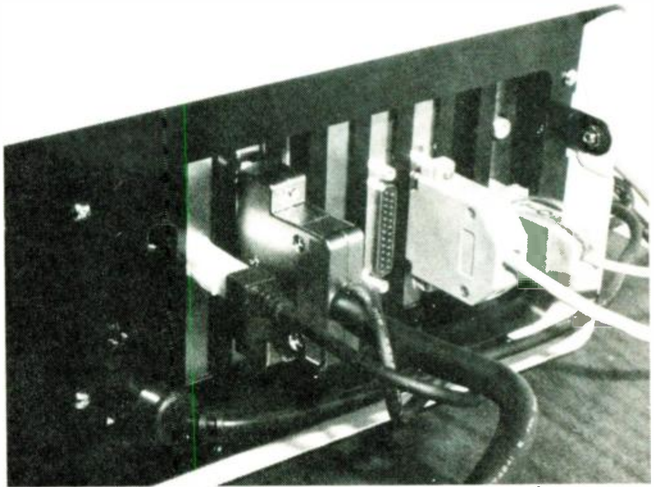


FIG. 5—CONNECTORS IN PLACE AND READY FOR USE. The 37-pin D-connector is a real heavyweight, so be certain that you tighten its mounting screws to ensure reliable operation.

Figure 4 shows an XT clone ready to connect the 3½-inch disk drive. The external disk-drive connector is adjacent to the miniature power connector installed in the slot furthest left.

To install the 3½-inch drive, simply plug the appropriate connectors from the drive in the appropriate jacks, as shown in Fig. 5.

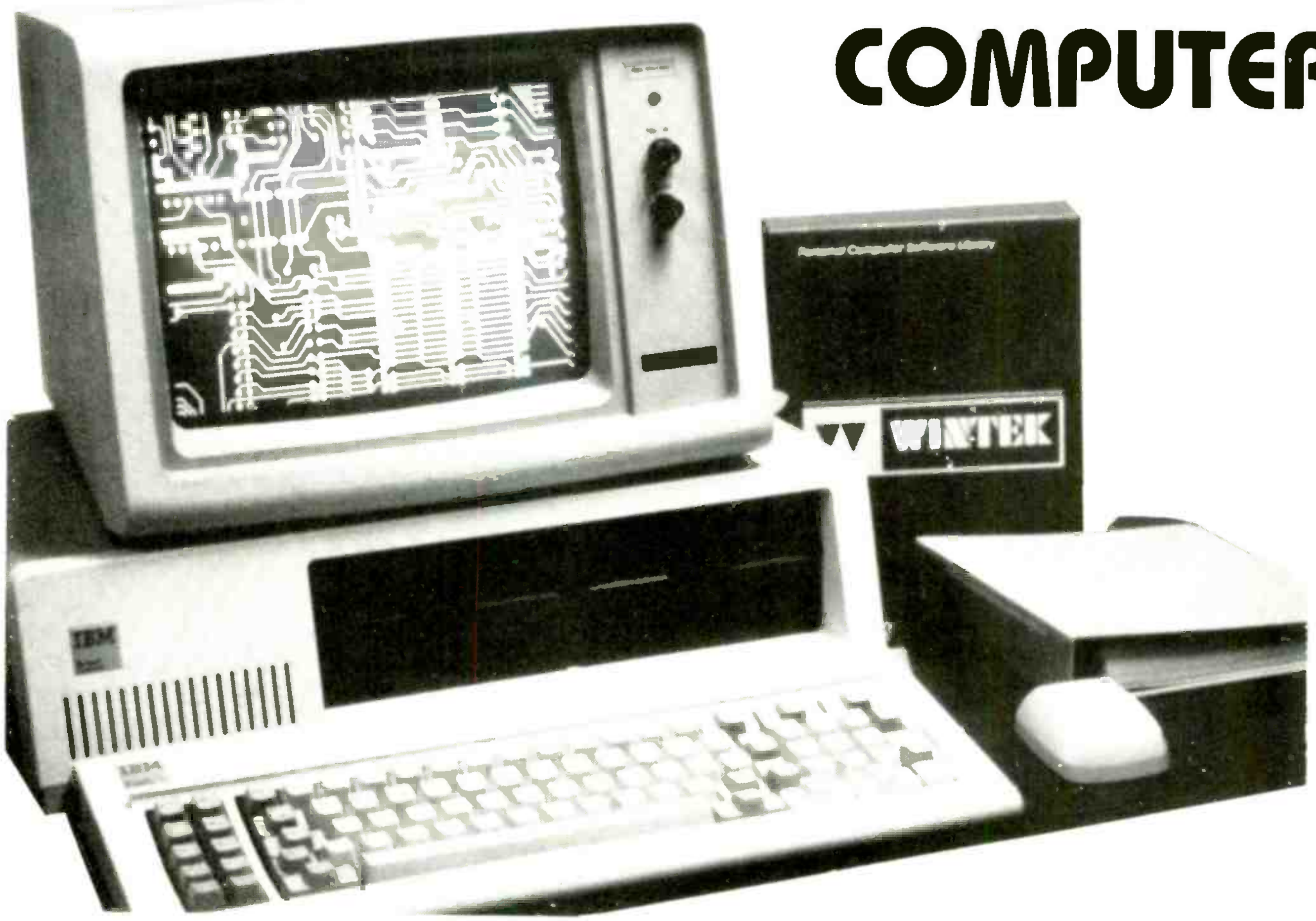
Device driver

Before you can use your new drive you must tell the computer that it's there by adding a device driver to your computer's CONFIG.SYS file, the configuration file that's automatically read when the computer boots. For example, adding the line:

DEVICE = DRIVER.SYS /D:2

to your CONFIG.SYS file will allow you to access a 3½ inchdisk drive as the next available drive (D: on an XT). IBM's device driver comes only with DOS versions 3.20 and 3.30. (Some clone manufacturer's drives are available with drivers that work under DOS 2.11 —*Editor*) The device driver informs your computer that the 3½-inch drive exists, establishes its physical parameters, including number of tracks, sectors per track, number of heads, etc., and sets the drive's logical designation (D:, E:, F:, etc.).

DESIGNING PC BOARDS ON YOUR COMPUTER



ROBERT GROSSBLATT

Last time, in the June issue, we examined CAD (Computer Aided Design) in a general way, seeing what kinds of things you can do (or should be able to do) with any worthwhile CAD package. This month we'll look at several specific packages, focusing on those that are of special interest to the electronics enthusiast.

There are a number of packages on the market, and both price and performance vary considerably. However, none of the packages we reviewed are inexpensive. As we've seen, a layout program must contain several different but integrated parts, so a complete package represents a substantial investment in development time. In addition, the potential market is small, certainly much smaller than the markets for word-processing and database programs. So development costs and market size translate into relatively high prices.

smARTWORK

The Wintek Corporation markets a package called smARTWORK, which probably is the most popular of the "inexpensive" routing packages. It has a graphics editor, router, and is capable of producing high-quality output. The program is an "interactive" router—what we call a point-to-point router. After you place the components, you can draw traces yourself or tell the router which points you want connected together. smARTWORK will do its best to lay in the traces.

The Wintek program only does the PC-board layout; there's no way to draw the schematic, generate a netlist, and have the router read the file. So using smARTWORK is in some ways similar to doing a layout by hand on graph paper.

smARTWORK is simple to use. After loading the program and creating a file, you begin your layout by placing the doughnuts and pads. The coordinates of the cursor are always shown on the bottom of the screen; that makes it simple to put a component in a precise location in the workspace. There are a variety of pad shapes available, as well as commands to create various patterns for IC's (SIP and DIP layouts, for example) headers, and so on, automatically.

The finished layout is really the parts-placement diagram for the board you're designing, so it's a good idea to work out a rough idea of where things are to be placed before you start smARTWORK. Doing so will make it easier to avoid going beyond the edge of the board as well as to take into account any of the special placement considerations we've already mentioned. It's easy to make adjustments to the board when you begin routing the traces because smARTWORK's graphics editor has a set of commands to let you move, stretch, delete, and fill.

When you start routing traces, smARTWORK will let you do either a single- or a double-sided board, with an optional silk-screen layer However, keep in mind the fact that the program can only handle two routing layers If you want to do multilayer boards, you'll have to use another package Each layer can contain two trace widths, thin and fat, and although you can choose between three preset thin widths, you can only use one on each layer. The fat width, 50 mils, is the only one available, but you can produce a fatter trace by laying two or more traces near each other.

Routing can be done either by hand or by using the routing algorithm built into the program. However you do it, chances are that you'll want to rearrange traces as the layout develops—and that's where you'll appreciate the power of the graphics editor. It's easy to change anything on the board—it's really as simple as moving text around in a word processor.

When the design is complete, you can get hardcopy from a dot-matrix printer in either actual board size or double size. There are commands to control the intensity, rotation, and size of the printed output As shown in Fig. 1, a much higher-quality printout can be obtained by using a plotter; smARTWORK supports several. Whichever device you use, smARTWORK will generate camera-ready art for photochemical board fabrication. Wintek can supply you with information about hardware compatibility.

Wintek markets another program called HiWIRE, a graphic schematic-drawing editor, and they're currently working on software that will let the two programs share common data files. Contact them directly at the address shown in the sidebar for more detailed information

Another company (Creative Electronics) is marketing a program (smARTCAD) that converts smARTWORK files into AutoCAD format. (We discuss AutoCAD below.) When you do convert a file, each side of your PC board will be on a separate layer, and you can use any AutoCAD editing command to do things you just can't do with smARTWORK. For example, you can:

- Add text in any size and font.
- Place pads for odd-sized components.
- Increase board size beyond 10 × 16 inches.
- Use a different grid spacing.
- Prepare a solder mask.

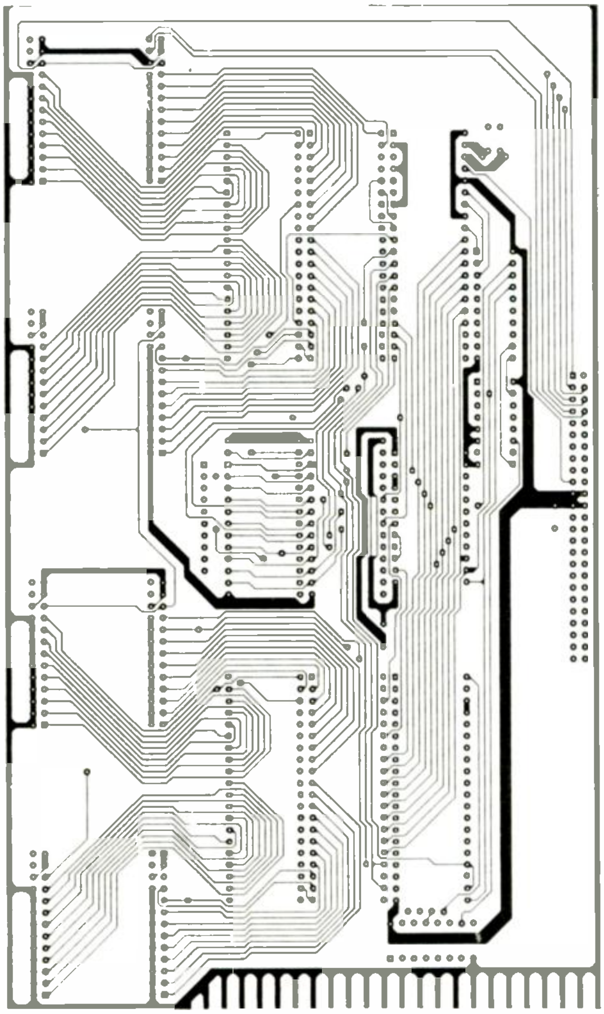


FIG. 1—SMARTWORK produces high-quality camera-ready work when used with a good plotter.

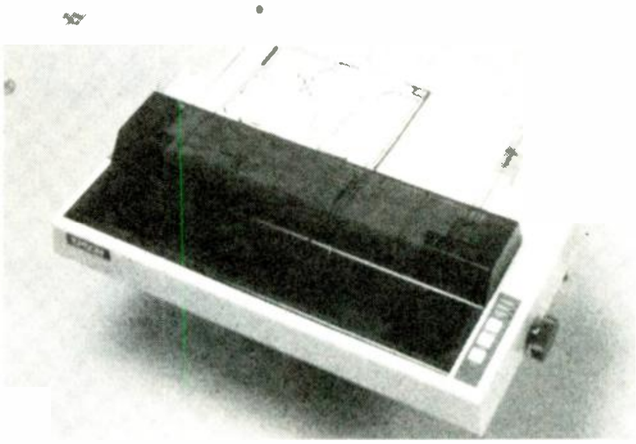


FIG. 2—SMARTWORK also produces quality copy on a dot-matrix printer.

Project:PCB

A new low-priced entry is called Project:PCB; it's made by DASOFT Designs, Inc., and it has many features that are missing from smARTWORK, including a means for schematic capture and a true auto-router. The circuit diagram can be entered with a graphics editor; the program can extract the netlist directly from the drawing. You can also enter and edit connections in text form directly from the keyboard. The software comes with a limited component library, but you can use a parts editor to build new parts that can then be called up automatically when you're entering a schematic.

In fact, Project:PCB actively encourages you to create symbols and share them with others; the company has set up a bulletin board (415-486-0862) where users can share custom parts and libraries, and where the company will post information on updates, bug fixes, new versions, etc.

To use Project: PCB, first you create the schematic. When it's finished, you use the layout editor in a graphics mode to define the overall shape of the board and to place the components. Then you're ready to route the board. It can be done automatically with Project:PCB by selecting the Route option on the menu, or you can enter traces manually before turning the router loose on the layout. One of the nicest features of the program is the ability to tell the router to do only a single net and then stop. That means that you can pre-route power and ground lines, for example, before going on to the rest of the board.

The router goes over the board twice. But you can set it up to do only one side of the board and then stop. That gives you the opportunity to try to improve the layout by hand, and then have the router go through that side again. Doing the layout that way can be valuable, because feedthroughs are the inescapable consequences of double-sided boards, and plated-through holes are difficult to do at home and expensive to do commercially.

Project:PCB can deliver hardcopy to a variety of plotters, but printer output is limited to text dumps of the various data files that are generated by the program. If you have one of the plotters supported by the program you'll get beautiful camera-ready artwork that's perfect for board production.

The program has more stringent hardware requirements than smARTWORK. Much of the equipment (mouse and plotter, for example) that is optional with smARTWORK is required to run

Project:PCB. But Project:PCB has a much more extensive graphics package, as well as an auto-router.

Autoboard

At the other end of the price/performance spectrum is a program called Autoboard. It is designed for serious production. It has every feature we've already discussed, and many, many more. In fact, comparing it to the packages we've been discussing is like comparing a Ford to a Ferrari—they're in different leagues altogether. Of course, the added capabilities don't come for nothing.

In order to concentrate all their energy on the routing package, the Great Softwestern Company decided to look elsewhere for the graphics editor. That was a wise decision.

Autoboard, in addition to its auto-router, is a collection of overlays, script files, menus, macros, and drawings to turn AutoCAD into an electronics graphics package. It goes without saying that AutoCAD is one of the most powerful and most supported graphics editors on the market. So one of the great strengths of Autoboard is that it makes full use of AutoCAD. The schematic and board layout are entered in AutoCAD; Autoboard's custom menu system makes it simple to do so.

While building the schematic or the board, you can use any of AutoCAD's awesome range of commands to edit the drawing you're working on. The parts library from Autoboard is extensive, and you can create new parts by building their definitions in a word processor—a straightforward procedure that's described in the manual.

Autoboard is designed for commercial board fabrication, so it has some impressive capabilities:

1. It can route boards up to 16 layers thick.
2. It can handle more than 1000 components on a board.
3. More than 40 buses can be defined.
4. You can have as many IC arrays as you want.
5. More than 1000 pins can be tied together.

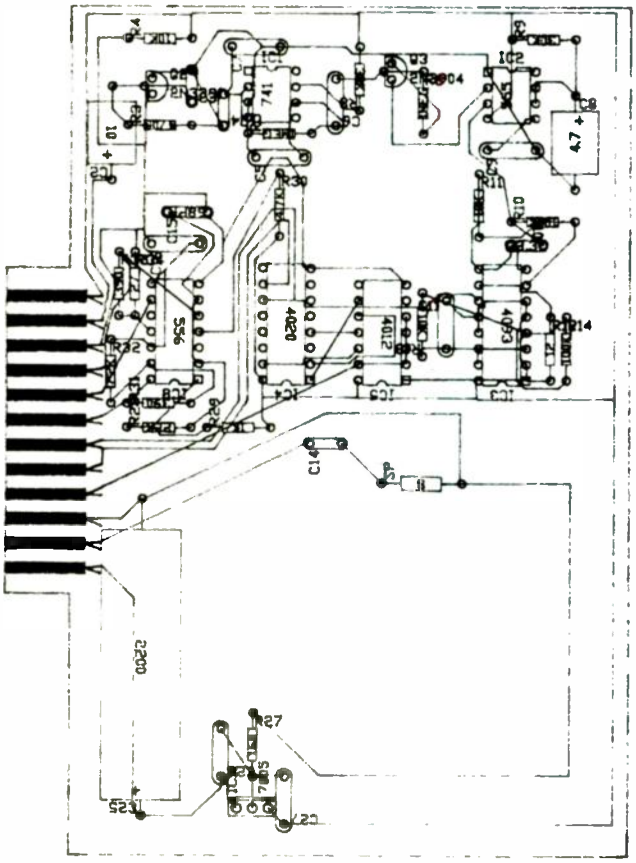


FIG. 3—AUTOBOARD routed this board automatically using a schematic created with AutoCAD.

TABLE 1—PROGRAMS DISCUSSED

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

6. Board dimensions can be up to two feet square.

The fourth item in that list deserves a little explanation. Some IC's (memory devices, for example) are put on a board as a block, and the traces that connect them are laid out in a standard fashion. Autoboard has built-in algorithms to generate those traces, and there are routines in the graphics editor to place the IC's on the board with proper spacing.

The best way to indicate how Autoboard works is to describe the process of creating a board. Remember that you must own a copy of AutoCAD (and know how to use it!) in order to use Autoboard.

The first step, as with Project:PCB, is to tell Autoboard about the schematic you're using. There are a series of batch files that do all the setup work for you (open data files, call up AutoCAD, and load a series of custom menus and scripts). Parts are chosen from menus along the right side of the screen; AutoCAD prompts you for orientation and location. As you move the cursor around the screen, the part you're working with drags along until you place it. Next you're asked for the part's number and value. Last, AutoCAD draws the part on the screen along with the other information.

When the parts are all placed and identified, you connect them together using either AutoCAD's Line command or the Line macro in the Autoboard menus. There's a difference. Autoboard's Line command will automatically place the line in the correct layer for the software that reads the drawing file and generates the list of connections. You can switch between layers using the normal AutoCAD commands, but it's simpler to use the macros.

When the drawing is sized, titled, and completed, a special command converts the schematic information to a netlist for use by the rest of the program; it also makes sure you don't have any unconnected components or lines. If it finds any, it lets you know by listing them on the screen as text—but that's not all.

One of the layers that Autoboard defines when it sets up AutoCAD is called the Warning layer. If there are any uncommitted pins, unterminated lines, etc., Autoboard will return you to AutoCAD, and the points in question will have small red circles around them.

EDITOR'S WORKBENCH

continued from page 66

tines aid in performing a traditional alignment by allowing you to position the head to any track.

Each test is activated from its own screen from which you can select the drive to test, the head (Ø or 1) to test, and the location on the DDD to test. You can print any screen by choosing the appropriate menu item. In addition, a setup screen allows you to establish specific operating characteristics, including disk type, serial-port parameters, main or alternate test tracks, etc. (The alternate tracks on the DDD are provided so that you can continue to use the disk after the first set wears out.)

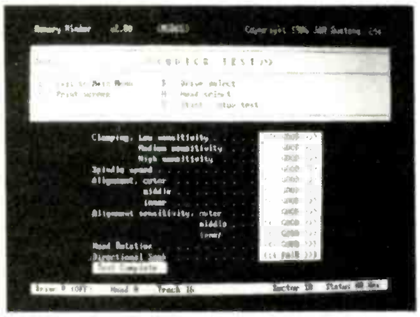


FIG. 7

Recommendations

Memory Minder is rather expensive for hobbyist use. However, if you split the cost among several persons, each of whom might use the program two or three times a year, Memory Minder is worthwhile. The manager of a small office with a number of PC's could easily justify the cost of the program, and if he uses it conscientiously, it could prevent valuable data from being lost, and thereby make an employee very happy.

What to do with the information Memory Minder provides is another story. If you have no experience aligning disk drives, it's probably best to leave well enough alone, unless you're willing to experiment and possibly pay the consequences. But as a diagnostic aid, Memory Minder is a well-thought-out, easy-to-use product. R-E

MICRO-FLOPPY DISK DRIVES

continued from page 68

You can access the disk like this: The 3½-inch drive is automatically assigned the next available drive letter (after all floppies and hard disks, if any). For example, if your hard disk is drive C:, the 3½-inch drive becomes drive D:. If you have two hard drives, C: and D:, the 3½-inch drive becomes drive E:. If you have no hard disk, but you do have a RAM disk set up as drive C:, the 3½-inch drive again becomes drive D:.

Logical and physical

You may wonder whether you can copy a file from one 3½-inch diskette to another without going through an intermediary device such as a hard disk, a RAM disk, or even a 5¼-inch floppy disk. You can (using DOS 3.20 or DOS 3.30). What you do is enter the device driver program into the CONFIG.SYS file twice. For example:

```
DEVICE = DRIVER.SYS /D:2
DEVICE = DRIVER.SYS /D:2
```

The computer is then fooled into thinking that there are two *physical* 3½-inch drives with different *logical* designations (D: and E:, for example). DOS will prompt you to switch disks when that is appropriate.

That's not as complicated as it may sound. It's really the same capability we've always had with the IBM, but extended to handle more drives and more types of drives. If you've ever copied a file from A: to B: on a machine with only a single floppy-disk drive, you know how it works.

For example, assume that you have a single floppy drive and a hard disk. The floppy functions as drives A: and B: and the hard disk functions as drive C:. You can install two device drivers that tell the computer that the 3½-inch drive will function as both D: and E:. Now there's no problem copying files between separate 3½-inch disks via a single drive. The computer will prompt you when to swap disks.

You might prefer to do it this way: Use the motherboard's DIP switch to program four floppies, even if you have only two. The hard disk automatically becomes drive E:. Configure the device driver so the 3½-inch drive is C: That will leave D: free for use as a RAM disk. Then the entire disk lineup will be A: and B: as 5¼-inch floppies, C: as a 3½-inch floppy, D: as a RAM disk, E: as the hard disk, and F: as the second logical designation for the 3½-inch floppy.

Setting up the device driver can become somewhat complicated, but bear in mind that, when it's over, to interchange data between any combination of disk drives, you can use the normal DOS COPY command.

One final point: There are a number of different 3½-inch disk formats. For example, the Tandy Model 100 disk drive has one format, the Macintosh computers have another, and IBM now has two of its own, both high-density (1.44 megabyte) and low-density (720K). The high-density format is used only in the new Models 50, 60, and 80; the low-density format is used in the new Model 30, IBM's laptop, as well as laptops from a number of manufacturers (including Zenith, Toshiba, etc.) The upgrade described here can read only the low-density IBM format.

COMPUTER DESIGNED PC BOARDS

continued from page 71

To correct a mistake, you can connect an uncommitted point using the Dot command, which draws a small blue circle there and informs Autoboard that you want a connection. If the pin was left open by design you can just ignore the warning.

The next step is to define the board and place the parts. Once again, Autoboard has a set of files that customize AutoCAD with menus and macros. After the board outline is defined, you can begin laying the parts out in much the same fashion you did when the schematic was drawn. Picking a part from a menu allows you to drag it around the screen and place it exactly where you want it.

It's a tremendous help to use AutoCAD's Zoom command to zero in on a location if you're placing a small part. The drawing of the part you drag around the screen will be enlarged by the same amount, so you'll be able to judge relative placement and size. Once you've picked the insertion point, you'll be asked for the name of the part and its value. They must be consistent with those you used in the schematic entry phase, because Autoboard's router uses those names to identify the parts and also the connections in the netlists.

When you complete the layout, you can hand-route some traces if your circuit has requirements you're afraid won't be properly addressed by the router. Next you'll want to turn the auto-router loose; that's done simply by giving it the name of the board you want routed.

Autoboard is an open system in that all the menus and script files (and many other parts of the program) can be customized to fit your requirements. The same is true, to a lesser extent, of the router. There are a series of "switches" you can set in the router that control things like the number of allowable layers, minimum and maximum pad and trace widths, spacing, time limits, and so on. That is easily done by editing a configuration file with a word processor. The router automatically looks for that file when it starts to run. If it can't find it, it uses its default values.

There's something magical about watching the router in operation because it constantly reports its progress on the screen. Our example board was one that had already been done by hand (we showed it last time), and it was amazing, to say the least, to watch Autoboard do in 15 minutes what had taken two days to do by hand. The only consolation was that *all* connections were made in the hand-routed board, but Autoboard missed five (out of a total of 115). That's not a bad percentage, and it's a safe bet that tweaking the configuration file could result in a success rate of 100%.

The last thing the router does is call up AutoCAD, draw the board on the screen, and display all the traces it has finished. It creates a separate "rats-nest" layer for the missed routes and draws them on that layer in a different color. It also creates a text file with a .BAD extension that lists all the connections it missed. By the time reach this point, you're in AutoCAD looking at the routed board with each board layer in a separate AutoCAD layer (including separate ones for the pads and the silkscreen). Now is when you'll appreciate the fact that Autoboard works inside AutoCAD. You can use any AutoCAD command to do anything you want to any layer—you have complete control of the drawing.

When you're happy with the layout, you can use any of AutoCAD's normal output commands. So you can create a text file that describes the board (for conversion to FutureNet, Gerber, etc.), or you can print it, plot it, etc. AutoCAD knows how to talk to virtually every printer and plotter ever made, so you can be confident it will talk to yours. And AutoCAD files are one of the few standards for graphic data. As for input devices, some sort of digitizing tablet is tremendously helpful in drawing both schematics and layouts. And, as with printers and plotters, AutoCAD knows how to talk to just about all of them. The keyboard, of course, can be used alone or in conjunction with a digitizing tablet.

Conclusions

Each of the packages we've been talking about is a well-thought-out piece of software, and each is updated occasionally. All the graphics produced for this article were done on an IBM PC XT with a Sigma Designs Color400 Video Board, an SR-12 monitor from Princeton Graphics, and a Summamouse from Summagraphics. And a very special bit of thanks must go to Dennis Jump for standing by the phone.

SATELLITE TV

continued from page 29

end up selling the TV viewers a better picture in order to attain an international standard.

Why an international fuss about the technical nitty-gritty that goes into a TV picture? Because there is a crying need for a universal television standard. High-tech communication systems, such as satellites, can now beam a TV picture from any part of the world to any TV set, so there must be a convenient way for everyone to view programming from any spot on the globe. Since there are three widely-used television standards now in use—NTSC, the North American or US standard; PAL, the basic all-Europe standard; and SECAM, the joint French-Russian standard—the exchange of television programming such as the Olympics, and news feeds, and even family programming, has been a burden because the equipment that converts one TV standard to another is expensive and prone to failure.

While it is possible to manufacture a receiver capable of receiving the three types of TV signals, they are, and are likely to remain, prohibitively expensive. Multi-standard receivers, such as those that are available in small quantities in Europe and the Middle-East, are not cost-effective because a major portion of the circuitry must be duplicated, even triplicated, to accommodate the different transmission standards.

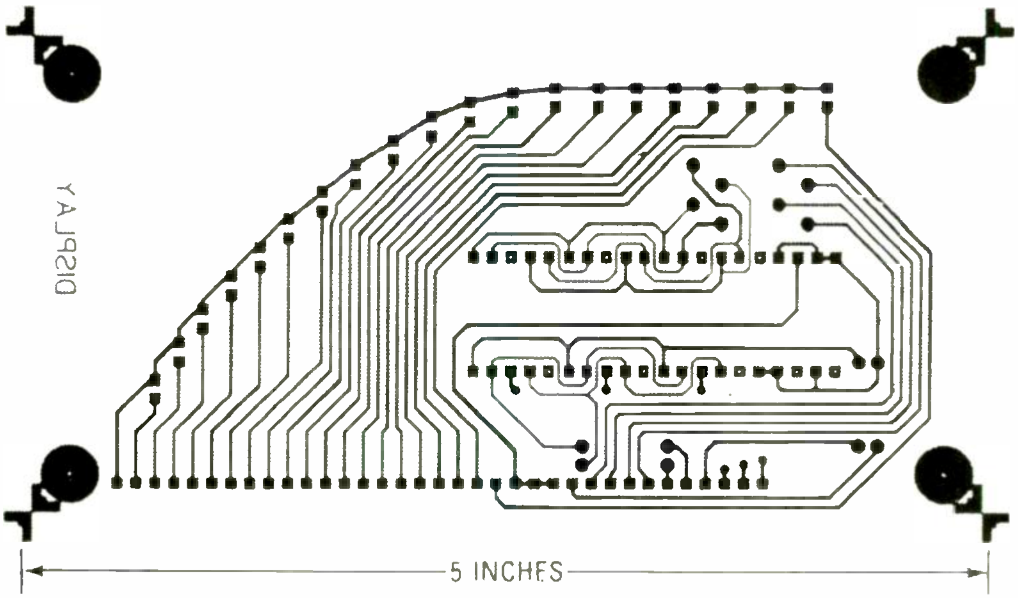
Whose HDTV?

Television formats, as we know them today, originated in the 30's and 40's. (NTSC color was appendixed to an existing black-and-white standard in the 50's.) Even if we could conveniently and inexpensively interchange the signal formats, all of the systems, NTSC, PAL, and SECAM, realize approximately half of the picture definition that's possible using 1980's technology.

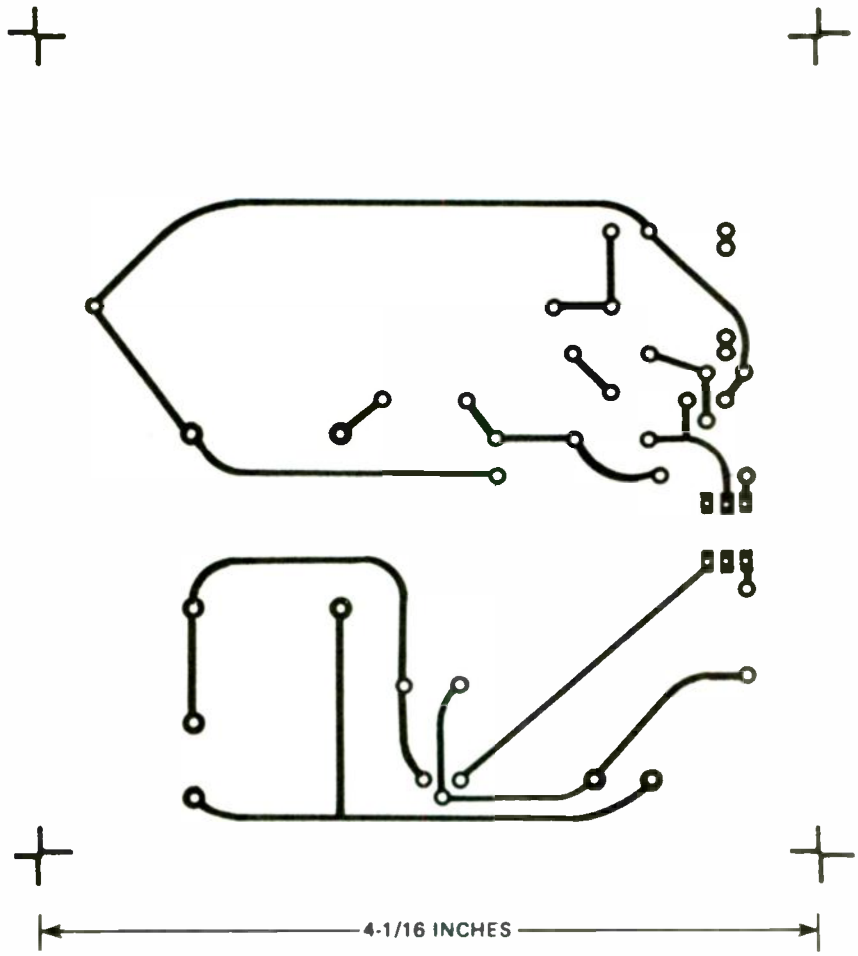
Although present technology makes a 1,000- to 1,200-line video transmission system do-able at consumer prices—European, Japanese, and North American firms all have such systems operating—like the NTSC/PAL/SECAM developments, no two of the presently developed systems share the same standards, so we're back with the same old problem.

Many engineers believe that there is general worldwide acknowledgment that we must avoid entering the era of HDTV with three different "national standards," and that since the present-day transmission standards are ready to be replaced, a serious effort should be made to adopt new standards it will resolve the 50-year old problems related to multiple, non-compatible systems. Unfortunately, it will require uncommon resolve to push the strong nationalistic instincts into the background in favor of a single, worldwide-technology standard. If it happens, it will be the first time that the world has agreed on an important broadcasting standard. **R-E**

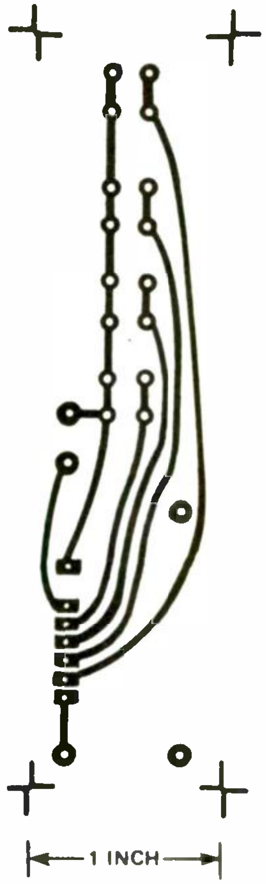
PC SERVICE



USE THIS BOARD to assemble the digital tachometer's display board. The article appeared in the June 1987 issue.



THE MAIN BOARD for the digital timer is shown here. You can find the story beginning on page 45.



THE DISPLAY BOARD for the digital timer is shown here.

PC SERVICE

AMP DESIGN

continued from page 56

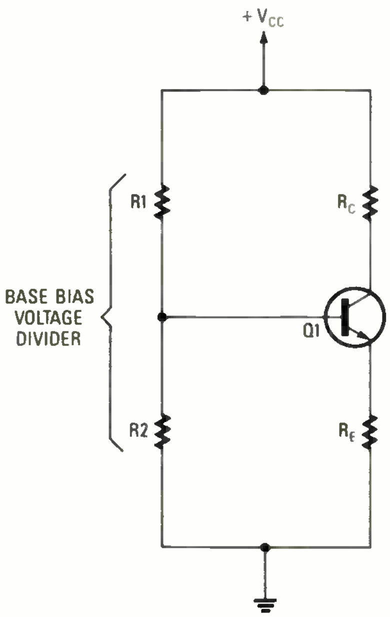


FIG. 1—A COMMON-EMITTER AMPLIFIER was the ideal solution to our design problem.

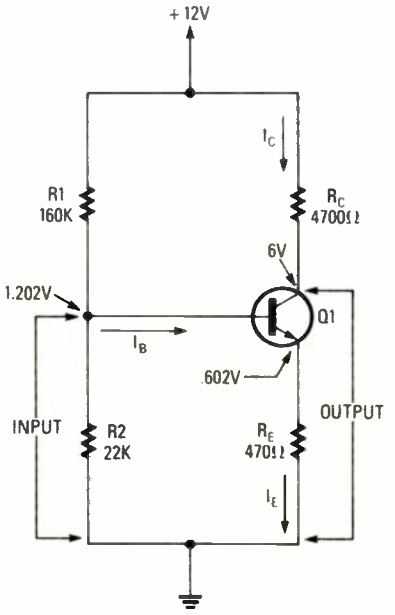


FIG. 2—SIMPLE CALCULATIONS yielded the component values shown here.

through R1 is a combination of the voltage-divider current plus the base current.

The base current is equal to the collector current divided by beta. It is found from:

$$I_B = 1.28/100 = 0.0128 \text{ mA}$$

So the total current through R1 is 0.054 mA + 0.0128 mA = 0.067 mA, and R1 = 10.8/0.067 mA = 160,000 ohms.

Resistor R1 is the most critical resistor in the circuit. To ensure maximum voltage swing, it should bring the quiescent collector voltage to one half the supply volt-

= 10.8/0.067 mA = 160,000 ohms.

Resistor R1 is the most critical resistor in the circuit. To ensure maximum voltage swing, it should bring the quiescent collector voltage to one half the supply volt-age. After building the circuit, the value of R1 may have to be varied slightly to achieve that voltage swing.

We now have a circuit we can test.

Interfacing

Connecting the circuit to the outside world will require capacitor coupling. That serves to isolate the AC signal from any DC bias voltages. Figure 3 shows our complete circuit with input and output coupling capacitors. The values of those capacitors were calculated using $C = 1/(3.2 \times f \times R)$, where C equals the capacitor value in farads, f equals the frequency at which response will be down 1 dB, and R equals the impedance on the load side of the capacitor.

To calculate the value of C1, the amplifier's input impedance (15K) is used for R. To calculate the value of C2, the input impedance of the next stage (50K) is used for R.

The value of C1 can now be calculated for a drop of 1 dB at 20 Hz: $C1 = 1/(3.2 \times 20 \times 15000) = .00000104$ farad = 1.0 µF. The value of $C2 = 1/(3.2 \times 20 \times 50000) = .00000031$ farad = 0.33 µF.

To increase the gain of the stage, you could bypass R_E with a capacitor, as shown in Fig. 4. Nothing comes for free, however. The price you pay for increased gain is lower input impedance, which will vary widely with beta. If that variation is not a problem, a significant gain increase can be realized by adding the bypass capacitor. Our original circuit has a gain of 10; if the emitter is bypassed the gain becomes $R_C/0.03/I_E = 4700/(0.03/0.00129) = 4700/23 \approx 200$.

The value of the bypass capacitor in farads is calculated from the formula $C = 1/(6.2 \times f \times R)$. Again f is the low-frequency limit in Hz, and R is the dynamic emitter resistance $(0.03/I_E)$. In our example, if we stick to a 20-Hz lower limit we have $C = 1/[6.2 \times 20 \times (0.03/0.00129)] = .000344$ farads = 344 µF. A 350-µF unit can be used.

Computerized calculations

It only seems natural to put the computer to work to lessen the drudgery of doing repetitive mathematical calculations. The BASIC program shown in Listing 1 is written to do just that. In addition, it serves as a sort of scratch pad for your designs, and allows you to do several "what-if" calculations easily. The program was written for a Commodore 64,

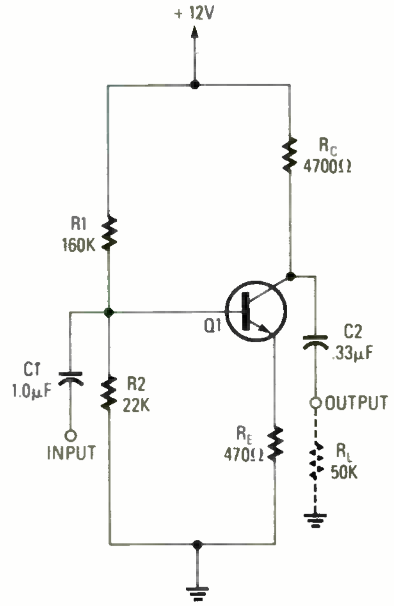


FIG. 3—CAPACITOR COUPLING is required to interface the amplifier to the outside world.

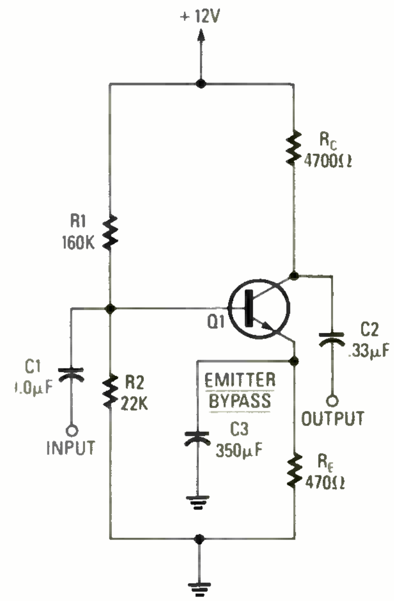


FIG. 4—INCREASE GAIN by bypassing the emitter resistor as shown here.

but it can be modified to run on any other system.

A few thoughts on components before we finish: Using 5% resistors allows closer adherence to the calculated values. Because of their temperature stability and low leakage specifications, silicon rather than germanium transistors are preferable for this type of circuit.

Finally, you've no doubt noticed that we have yet to specify a specific transistor. That's because for this type of application it really doesn't matter! Almost any small-signal device will do fine. **R-E**

COMMUNICATIONS CORNER

continued from page 31

dB greater than the signal received by a single antenna. A special detector samples the signal-to-noise ratio of the received signal on a half-cycle basis. If out-of-phase multipath reception at one antenna causes the signal-to-noise ratio to fall below a minimum value, the detector automatically inserts the delay line by opening the electronic switch, thereby flipping the phase of the signal from antenna B by 180°, which in turn causes the delayed signal to add once again to that of antenna A.

To avoid constant switching back and forth, which might distract the listener, the detector is designed so that it maintains the phasing as long as the received signal is strong enough to be usable. Only if new or changing multipath signals degrade the "out of phase" signal to an unacceptable value will the detector cause the delay line to switch out.

Some of you familiar with selective fading on the high-frequency shortwave bands will wonder what happens to the receiver's volume level when the signal varies within the allowed range (before it falls low enough to activate the delay-line switching). The answer is that nothing happens; there is no change in volume level. On the shortwave frequencies, all signals are AM or single sideband (which, of course, is only a variation of AM), so the volume level from the speaker will vary if the signal level breaks away from control of the AGC (Automatic Gain Control) or the AVC (Automatic Volume Control); that's a condition absolutely bound to occur during selective fading.

But wireless sound equipment uses FM modulation, whose received volume level depends on deviation, not signal strength. Only if the signal falls to an almost-useless level is there any effect on an FM signal's volume level, and the receiver squelch circuits will mute the sound long before the listener hears a change in volume level caused by the received signal strength. R-E

Radio-Electronics mini-ADS

R-E ROBOT

continued from page 60

LISTING 2

```
: BOX      ( feet ---- )
     RERB
          25.5 IPS
          2DUP (FEET) FORWARD
     90 DEGREES RIGHT
     2DUP (FEET) FORWARD
     90 DEGREES RIGHT
     2DUP (FEET) FORWARD
     90 DEGREES RIGHT
     2DUP (FEET) FORWARD
     90 DEGREES RIGHT;
```

LISTING 3

```
: MS   ( milliseconds ---- )
  0 ?DO 33 0 DO LOOP   LOOP ;

: SECONDS   ( seconds ---- )
       0 ?DO 1000 MS LOOP ;

: MINUTES   ( minutes ---- )
       0 ?DO 60 SECONDS LOOP ;
```

LISTING 4

```
: ATTENTION ( ---- )
     BEEP BEEP 1 SECONDS ;

: WARNING ( ---- )
     5 0 DO BEEP 1 SECONDS LOOP ;

: TURN-AROUND ( ---- )
     RERB 10 IPS 180 DEGREES
     LEFT ;

: TURN-LEFT ( ---- )
     90 DEGREES LEFT ;

: TURN-RIGHT ( ---- )
     90 DEGREES RIGHT ;

: AHEAD ( feet ----)
     FEET FORWARD ;

: COLLECT ( minutes ---- )
     ATTENTION MINUTES WARNING ;
```

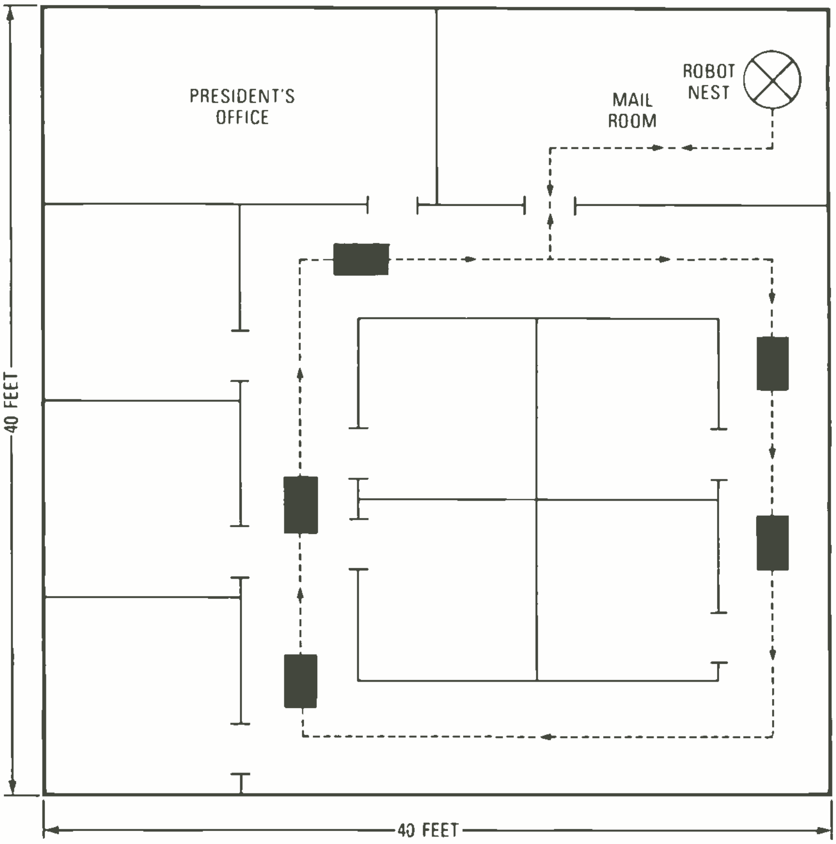


FIG. 2—MODEL OFFICE FOR THE EXPERIMENTAL TRIP program that is shown in Listing 5.

LISTING 5

```
: TRIP      ( ---- )
            WARNING        RERB           20 IPS         3 FEET
            BACKWARD       TURN-AROUND    2.5 AHEAD
            TURN-RIGHT     12 AHEAD       TURN-LEFT
            5 AHEAD        TURN-LEFT      36 IPS
            10 AHEAD       TURN-RIGHT     2 COLLECT
            7 AHEAD        2 COLLECT      8 AHEAD
            TURN-RIGHT     25 AHEAD       TURN-RIGHT
            3 AHEAD        2 COLLECT      11.5 AHEAD
            4 COLLECT      11.5 AHEAD     TURN-RIGHT
            ATTENTION      3 COLLECT      ( President)
            14 AHEAD       TURN-LEFT      4.5 AHEAD
            TURN-RIGHT     12 AHEAD       TURN-LEFT
            10 IPS         5.5 AHEAD
```

recharging area and turn around to go forward. The word TURN-AROUND makes a 180° turn. The word AHEAD is shorthand for a forward move. COLLECT combines the ATTENTION, WAITING, and WARNING functions, because we always use them together. The definitions of those words are shown in Listing 4.

A trip consists of backing out of the recharger and exiting the mail room, making a clockwise trip around the office, stopping at several points (including a long stop at the president's office), and finally returning to the mail room. The word TRIP executes the entire program; it is shown in Listing 5.

TRIP only causes the robot to make one excursion around the office, but we want the robot to make several trips during the day, without having to tell it to do so each time. We can schedule the trips when desired using the words AM, PM, and WAIT-UNTIL. WAIT-UNTIL simply waits in a delay loop until the current time is identical to the desired time. AM and PM set the desired time. Time is specified in hours, so minutes must be expressed as fractional hours. For example, 8.5 AM is 8:30 am. The entire MAILBOT program is shown in Listing 6.

LISTING 6

```
: MAILBOT   ( ---- )
        8.5 AM WAIT-UNTIL TRIP
        9.5 AM WAIT-UNTIL TRIP
       10.5 AM WAIT-UNTIL TRIP
       11.5 AM WAIT-UNTIL TRIP
        1.5 PM WAIT-UNTIL TRIP
        2.5 PM WAIT-UNTIL TRIP
        3.5 PM WAIT-UNTIL TRIP
        4.5 PM WAIT-UNTIL TRIP
```

You can extend RCL to deal with additional hardware and to provide greater software flexibility. FORTH gives you the freedom to experiment and add to the capabilities of the system. **R-E**

STEREO RECEIVER

continued from page 44

The IC's AGC function was not used in the design. Instead, pin 16 was terminated by R40 and C33.

A 10.7-MHz tuned circuit is formed by L7, C38, and C37. Resistor R41 acts as a swamping resistor to obtain the wide bandwidth of the quadrature circuit, C37, C38, and L7. Drive voltage from pin 8, IF out, to pin 9, quadrature detector input, is delivered via L6. The value of that inductor is somewhat critical for proper squelch-circuit operation. It should be between 18–22 µH. We had an 18-µH unit on hand so it was used.

A load for the AFC circuit is provided by R43, and R42 biases the audio circuit in the IC. Capacitor C38 is used to tune the quadrature circuit to 10.7 MHz. It is adjusted for best received audio and zero DC voltage across R43.

Recovered total modulation is present at pin 6. It contains the FM baseband and the SCA signal. The baseband audio is taken off through R44 and C39.

The baseband-audio amplifier is built around Q6, a 2N3565. It is set up for a nominal gain of about 5 (the ratio of R44 to R46 is the approximate gain of this stage). Resistors R45 and R46 bias Q6 to about 6 volts at 1 milliampere. R47 is a load resistor. About 2 volts of baseband audio is present at the collector of Q6.

Audio from Q6 is fed to two separate circuits. One circuit is an SCA demodulator; the other is an FM stereo decoder.

SCA demodulation

Audio from Q6 is fed to an SCA take-off R-C high-pass filter made up of C40, R48, R49, C41, C42, and R65. That filter substantially attenuates audio components below 50 kHz.

The SCA demodulator, IC2, is an LM565 phase-locked loop. It contains a VCO (Voltage Controlled Oscillator) and phase detector comparator. If a signal of sufficient amplitude (about 100 millivolts) is fed into pin 2 or 3 of that device, and its frequency is sufficiently close (say within ±30%) to the VCO frequency, the VCO will lock to the input frequency and track it; that is, the voltage that controls the VCO will follow any changes in the frequency of the input signal. The control voltage for the VCO is present at pin 7 and is a linear function of the input-signal frequency. Therefore, the LM565 can function as an FM detector with no external inductive components required. (At the SCA-subcarrier frequencies of 67 or 92 kHz, inductors can become rather large and somewhat costly. It is therefore to our advantage to eliminate those coils, and their alignment.)

The LM565 is biased by external resistors R51, R52, R53, and R54. The VCO frequency is determined by C43 and the resistance of R72 and R55. The setting of R72 is adjusted so that the VCO frequency, which can be measured at pin 4, is near 67 kHz.

Adjustment of R72 is not critical, and simply adjusting it for clearest SCA reception is adequate. (If 92 kHz operation is desired, R55 should be changed to about 6.8K.) Capacitor C44 is used as a loop filter for the phase-locked loop. Audio appears at pin 7 of the LM565. A de-emphasis network made up of R56, C45, R57, and C46 will suppress any 67-kHz components and attenuate high-frequency noise.

An audio-amplifier stage, Q7, brings up the detected audio level to about 500 mV. From the amplifier, the signal is sent to the selector switch, S2, for routing.

FM decoding

Audio from Q6 is also sent, via blocking capacitor C49, to IC3, an LM1310N FM-stereo multiplex decoder. The LM1310N contains a VCO, a phase-locked loop for regenerating the 38-kHz stereo subcarrier, a lock detector used as a stereo-indicator circuit, and a decoder circuit for deriving the left and right audio channels. The internal VCO operates at 76 kHz and the 19-kHz and 38-kHz signals are derived from an internal frequency divider. No indicators are required and alignment consists simply of adjusting R73 for a 19-kHz signal at pin 10.

Getting back to the circuit, C53, R62, and C54 form a compensating network for IC3's internal phase-locked loop. Capacitor C50 is the loop filter for the phase-locked loop. The network made up of C55, R63, and R73 control the center frequency of the internal VCO, which should be 76 kHz. The 19-kHz pilot signal (derived from an internal divider) is available at pin 10 for test purposes. Audio output appears at pins 4 (left) and 5 (right). Resistors R64 and R65 serve as loads for the internal audio amplifiers. FM-audio de-emphasis is provided by C56 and C57. The right and left audio from pins 4 and 5 is fed to S2.

The audio amplifiers in this circuit, IC4 and IC5, are LM386N's. They each provide about a 0.5-watt output, adequate for driving an eight-ohm speaker. Do not use speakers that present less than an eight-ohm load.

The entire receiver draws about 125 milliamps at 12-volts (the recommended supply voltage). The supply should be regulated and have good filtering. A suitable power supply is shown in Fig. 3.

Next time

That's all the room we have for now. Next time we'll show you how to build, align, and use the receiver. The PC pattern will be presented at that time. **R-E**

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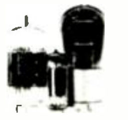

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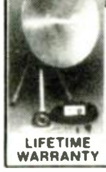

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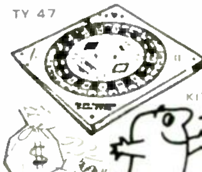

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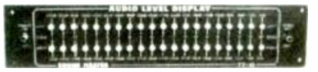

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TL064CN	1 00	LM393	40	LM1808	1 75
TL072	1 00	LF398A	3 00	AD2700LD	4 95
TL082	90	LF411	1.25	LM2901	95
TL084	1.00	AD506JH	2.50	CA3018	1 95
LM201	75	537	1 50	CA3045	1 20
LM301/74	8.35	LM555	.29	CA3078AT	1 50
LM307	45	LM556	45	CA3080	85
LM308	.65	558	1.10	CA3089E	1 75
LM310	1 10	564	1 75	CA3094	1.30
LM311	45	565	90	CA3130	90
LM318	1.00	566	1 25	CA3140	75
LM319	1 10	567	75	SG3524	1 25
LM324	35	NE570	2 50	SG3543	70
LM339	50	NE592	.95	SG3544	1 00
LM348	65	709CH	80	UNL3701E	1.75
LF351	45	711CH	.60	CA3822	.75
LF353	55	733	.95	LM3909	80
LF355	35	741CV	19	4136	85
LF356	85	747	50	SD5000	1 75
LM358	45	LM79BCT	60	N5534	75
LM370	1 60	DAC0800	2.95	N5596A	1 50
LM380	.85	LM1310	1 40	SD6000	1 00
LM384	1.60	MC1330	1 00	8038	3 95
		MC1355	.70	8700CJ	5 95
		MC1391	1 00	LM13080	95

C/MOS

74C00	25	74C915	1 10	4027	35	4072	20
74C02	25	74C921	3 50	4028	65	4076	55
74C04	25	4001	19	4029	65	4077	28
74C08	25	4002	20	4030	35	4081	20
74C10	25	4006	65	4034	1.40	4082	20
74C14	55	4007	20	4035	65	4093	45
74C20	25	4008	85	4040	65	4099	1 40
74C32	35	4009	35	4041	75	4501	95
74C42	1 10	4010	35	4042	55	4503	45
74C74	55	4011	19	4043	85	4506	75
74C76	60	4012	25	4044	65	4510	65
74C83	1 20	4013	35	4045	85	4511	65
74C85	1 25	4014	65	4046	85	4512	75
74C86	35	4015	28	4047	65	4514	95
74C93	1 00	4016	28	4049	28	4515	1 60
74C154	3 00	4017	45	4050	28	4516	75
74C157	95	4018	65	4051	65	4518	85
74C161	95	4019	35	4052	65	4520	75
74C174	95	4020	.55	4053	65	4528	75
74C175	95	4021	65	4060	65	4529	1 40
74C245	1 75	4022	65	4066	28	4538	95
74C901	35	4023	25	4068	35	4539	1 50
74C902	40	4024	48	4069	19	45418	1 20
74C903	80	4025	25	4070	28	4553	1 75
74C907	75	4026	1 25	4071	20	4583	90
						4585	75

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74S05	29	74S113	50	74S182	2 00
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74S09	40	74S133	45	74S194	1 30
74S10	29	74S135	85	74S195	1 30
74S11	35	74S138	75	74S240	1 40
74S15	35	74S139	75	74S241	1 40
74S20	29	74S140	50	74S244	1.25
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74S42	85	74S158	90	74S373	1 65
74S51	35	74S161	1 25	74S374	1 65
74S74	45	74S163	1 25		

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74LS02	17	74LS114	33	74LS242	65
74LS03	17	74LS123	.45	74LS243	65
74LS04	17	74LS125	35	74LS244	65
74LS05	17	74LS126	35	74LS245	75
74LS08	17	74LS132	39	74LS246	1 40
74LS09	17	74LS136	35	74LS247	75
74LS10	17	74LS137	90	74LS243	65
74LS11	20	74LS138	39	74LS251	45
74LS12	27	74LS139	39	74LS253	45
74LS13	25	74LS145	70	74LS257	39
74LS14	36	74LS147	1 00	74LS258	45
74LS15	25	74LS148	90	74LS259	1 20
74LS20	17	74LS151	39	74LS260	45
74LS21	22	74LS153	39	74LS266	55
74LS22	22	74LS154	1 50	74LS273	75
74LS26	23	74LS155	55	74LS279	39
74LS27	23	74LS156	45	74LS280	1.70
74LS28	26	74LS157	35	74LS283	55
74LS30	17	74LS158	20	74LS290	.80
74LS32	17	74LS160	29	74LS293	80
74LS37	26	74LS161	49	74LS298	65
74LS38	26	74LS162	49	74LS320	2 00
74LS40	17	74LS163	49	74LS322	3 00
74LS42	35	74LS164	45	74LS323	2 40
74LS48	65	74LS165	65	74LS365	39
74LS51	17	74LS166	95	74LS366	39
74LS54	22	74LS169	90	74LS367	39
74LS73	25	74LS170	80	74LS368	39
74LS74	24	74LS173	49	74LS373	75
74LS75	29	74LS174	39	74LS374	75
74LS76	29	74LS175	39	74LS377	75
74LS83	45	74LS181	1 40	74LS386	45
74LS85	45	74LS190	49	74LS390	1 10
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7402	.29	.19	7486	.45	.35
7404	.35	.25	7489	2.05	1.95
7405	.39	.29	7490	.49	.39
7406	.39	.29	7493	.45	.35
7407	.39	.29	74121	.45	.35
7408	.35	.25	74123	.59	.49
7410	.35	.25	74125	.55	.45
7414	.49	.39	74126	.75	.65
7416	.45	.35	74143	4.05	3.95
7417	.45	.35	74150	1.35	1.25
7420	.35	.25	74154	1.35	1.25
7430	.35	.25	74158	1.59	1.49
7432	.39	.29	74173	.85	.75
7438	.39	.29	74174	.65	.55
7442	.55	.45	74175	.65	.55
7445	.79	.69	74176	.99	.89
7446	.89	.79	74181	1.95	1.85
7447	.89	.79	74189	2.05	1.95
7448	2.05	1.95	74193	.79	.69
7472	.75	.65	74198	1.85	1.75
7473	.45	.35	74221	.99	.89
7474	.45	.35	74273	2.05	1.95
7475	.49	.39	74365	.69	.59
7476	.45	.35	74367	.69	.59

74LS

Part No.	1-9	10+	Part No.	1-9	10+
74LS00	.29	.19	74LS165	.75	.65
74LS02	.29	.19	74LS166	.99	.89
74LS04	.35	.25	74LS173	.59	.49
74LS05	.35	.25	74LS174	.49	.39
74LS06	1.09	.99	74LS175	.49	.39
74LS07	1.09	.99	74LS189	4.59	4.49
74LS08	.29	.19	74LS191	.59	.49
74LS10	.29	.19	74LS193	.79	.69
74LS14	.49	.39	74LS221	.69	.59
74LS27	.35	.25	74LS240	.79	.69
74LS30	.29	.19	74LS243	.79	.69
74LS32	.35	.25	74LS244	.79	.69
74LS42	.49	.39	74LS245	.89	.79
74LS47	.99	.89	74LS259	.99	.89
74LS73	.39	.29	74LS273	.89	.79
74LS74	.35	.25	74LS279	.49	.39
74LS75	.39	.29	74LS322	4.05	3.95
74LS76	.55	.45	74LS365	.49	.39
74LS85	.59	.49	74LS366	.49	.39
74LS86	.35	.25	74LS367	.49	.39
74LS90	.49	.39	74LS368	.49	.39
74LS93	.49	.39	74LS373	.79	.69
74LS123	.59	.49	74LS374	.79	.69
74LS125	.49	.39	74LS393	.89	.79
74LS138	.49	.39	74LS590	6.05	5.95
74LS139	.49	.39	74LS624	2.05	1.95
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74LS158	.45	.35	74LS645	1.09	.99
74LS163	.59	.49	74LS670	1.09	.99
74LS164	.59	.49	74LS688	2.05	1.95

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74S08	.35	74S196	2.49
74S10	.29	74S240	1.49
74S32	.35	74S244	1.49
74S74	.45	74S253	.79
74S85	1.79	74S287*	1.49
74S86	.35	74S288*	1.49
74S124	2.95	74S373	1.49
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74F

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74F04	.39	74F157	.95
74F08	.39	74F193	3.95
74F10	.39	74F240	1.39
74F32	.39	74F244	1.39
74F74	.49	74F253	.99
74F86	.59	74F373	1.39
74F138	.89	74F374	1.39

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CD4008	.89	CD4081	.25
CD4011	.19	CD4082	.25
CD4013	.29	CD4093	.35
CD4016	.29	CD4094	.89
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CD4018	.59	CD40107	.69
CD4020	.59	CD40109	1.49
CD4024	.49	CD4510	.69
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6504A CPU	1.95	6569 VIC PAL	~~14.95~~ 10.95	318019-03 Basic ROM-C128	15.95
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6802	3.49
6810	1.25
6821	1.29

6500/6800/68000 Cont.

Part No.	Price
6840	3.95
6843	2.95
6845	2.95
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6852	~~3.95~~ 2.49
6875	8.95
MC68000L8	11.95
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8088	6.49
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8116	4.95
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8253-5	1.95
8254	4.95
8255A-5	1.69
8257-5	2.49
8259-5	1.95
8272	4.49
8279-5	2.95
8741	10.95
8748D (25V)	9.95
8748H (HMOS) (21V)	10.95
8749	9.95
8751	39.95
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ADC0809CCN	3.95
ADC0816CCN	14.95
ADC0817CCN	8.95
DAC0808LCN	1.95
DAC1008LCN	6.49
AY-3-1015D	4.95
AY-5-1013A	~~3.95~~ 2.95

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4116-15	16,384 x 1	(150ns)	.89
4128-20 (Piggyback)	131,072 x 1	(200ns)	~~4.49~~ 3.25
4164-120	65,536 x 1	(120ns)	1.75
4164-150	65,536 x 1	(150ns)	1.15
4164-200	65,536 x 1	(200ns)	.95
TMS4416-12	16,384 x 4	(120ns)	~~4.25~~ 3.75
8118	16,384 x 1	(120ns)	.69
41256-120	262,144 x 1	(120ns)	3.95
41256-150	262,144 x 1	(150ns)	~~2.95~~ 2.75
50464-15	65,536 x 4	(150ns) (4464) (41464)	4.95
511000P-10	1,048,576 x 1	(100ns) 1 Meg	~~39.95~~ 27.95
514256P-10	262,144 x 4	(100ns) 1 Meg	~~44.95~~ 29.95

STATIC RAMS

2016-12	2048 x 8	(120ns)	1.69
2102-2L	1024 x 1	(250ns) Low Power (91L02)	1.95
2114N	1024 x 4	(450ns)	.99
2114N-2	1024 x 4	(200ns)	1.05
2114N-2L	1024 x 4	(200ns) Low Power	1.49
21C14	1024 x 4	(200ns) (CMOS)	.49
2149	1024 x 4	(45ns)	~~4.95~~ 3.49
5101	256 x 4	(450ns) CMOS	1.95
6116LP-2	2048 x 8	(120ns) Low Power CMOS	2.95
6116P-3	2048 x 8	(150ns) CMOS	1.89
6116LP-3	2048 x 8	(150ns) Low Power	1.95
6264LP-12	8192 x 8	(120ns) Low Power CMOS	4.25
6264P-15	8192 x 8	(150ns) CMOS	3.59
6264LP-15	8192 x 8	(150ns) Low Power CMOS	3.75
6514	1024 x 4	(350ns) CMOS (UPD444C)	~~4.49~~ 3.95
43256-15L	32,768 x 8	(150ns) Low Power	~~24.95~~ 17.95

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TMS2516	2048 x 8	(450ns) 25V	4.95
TMS2532	4096 x 8	(450ns) 25V	~~5.95~~ 6.95
TMS2564	8192 x 8	(450ns) 25V	8.95
2708	1024 x 8	(450ns)	4.95
TMS2716	2048 x 8	(450ns) 3 voltage	9.95
2716	2048 x 8	(450ns)	3.75
2716-1	2048 x 8	(350ns) 25V	4.95
27C16	2048 x 8	(450ns) 25V (CMOS)	6.49
2732	4096 x 8	(450ns)	3.95
2732A-20	4096 x 8	(200ns) 21V	4.25
2732A-25	4096 x 8	(250ns) 21V	3.95
2732A-45	4096 x 8	(450ns) 21V	3.75
27C32	4096 x 8	(450ns) 25V (CMOS)	6.49
2764-20	8192 x 8	(200ns) 21V	4.25
2764-25	8192 x 8	(250ns) 21V	3.75
2764A-25	8192 x 8	(250ns) 12.5V	4.25
2764-45	8192 x 8	(450ns) 21V	3.49
27C64	8192 x 8	(450ns) 21V (CMOS)	5.49
27C64-15	8192 x 8	(150ns) 21V (CMOS)	6.49
27128-20	16,384 x 8	(200ns) 128K 21V	5.95
27128-25	16,384 x 8	(250ns) 128K 21V	5.25
27128A-25	16,384 x 8	(250ns) 12.5V	4.95
27C128-25	16,384 x 8	(250ns) 21V (CMOS)	5.95
27256-20	32,768 x 8	(200ns) 256K (12.5V)	6.95
27256-25	32,768 x 8	(250ns) 256K (12.5V)	5.95
27C256-25	32,768 x 8	(250ns) 256K (CMOS) (12.5V)	8.95
27512-25	65,536 x 8	(250ns) 512K (12.5V)	19.95
68764	8192 x 8	(450ns) 25V	15.95
68766	8192 x 8	(350ns) 25V	16.95
74S387	256 x 4	PROM O.C.	1.29
74S471	256 x 8	PROM T.S.	4.95
N82S123	32 x 8	PROM T.S.	2.49

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74HC08	.29	74HC244	.79
74HC10	.29	74HC245	.89
74HC14	.49	74HC253	.59
74HC30	.29	74HC259	.65
74HC32	.29	74HC273	.79
74HC74	.39	74HC373	.79
74HC75	.39	74HC374	.79
74HC76	.45	74HC393	.75
74HC85	.79	74HC595	1.19
74HC86	.39	74HC688	.79
74HC123	.89	74HC4040	.89
74HC125	.49	74HC4049	.59
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74HC138	.49	74HC4060	1.09
74HC139	.49	74HC4511	1.29
74HC154	1.19	74HC4514	1.19
74HC163	.65	74HC4538	.89
74HC174	.69	74HC4543	1.19

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74HCT08	.29	74HCT175	.69
74HCT10	.29	74HCT240	.99
74HCT32	.29	74HCT244	.99
74HCT74	.49	74HCT245	1.19
74HCT86	.49	74HCT373	1.19
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74C00	.29	74C174	.79
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74C04	.29	74C221	1.49
74C08	.35	74C240	1.29
74C10	.35	74C244	1.29
74C14	.49	74C373	1.49
74C32	.35	74C374	1.49
74C74	.59	74C912	7.95
74C85	1.39	74C915	1.39
74C86	.35	74C920	9.95
74C89	5.19	74C921	9.95
74C90	.99	74C922	3.95
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LM747CN	.59	7815T (LM340T-15)	.49
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14 pin LP	.12	14 pin WW	.65
16 pin LP	.13	16 pin WW	.69
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2102L-4	1024x1	(450ns)(LP)	.99
2112	256x4	(450ns)	2.99
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2114L-2	1024x4	(200ns)(LP)	1.49
2114L-15	1024x4	(150ns)(LP)	1.95
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HM6116-4	2048x8	(200ns)(CMOS)	1.89
HM6116-3	2048x8	(150ns)(CMOS)	1.95
HM6116LP-4	2048x8	(200ns)(CMOS)(LP)	1.95
HM6116LP-3	2048x8	(150ns)(CMOS)(LP)	2.05
HM6116LP-2	2048x8	(120ns)(CMOS)(LP)	2.95
HM6264P-15	8192x8	(150ns)(CMOS)	3.89
HM6264LP-15	8192x8	(150ns)(CMOS)(LP)	3.95
HM6264LP-12	8192x8	(120ns)(CMOS)(LP)	4.49

LP=Low power

DYNAMIC RAMS

4116-250	16384x1	(250ns)	.49
4116-200	16384x1	(200ns)	.89
4116-150	16384x1	(150ns)	.99
4116-120	16384x1	(120ns)	1.49
MK4332	32768x1	(200ns)	6.95
4164-200	65536x1	(200ns)(5v)	1.19
4164-150	65536x1	(150ns)(5v)	1.29
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2732	4096x8	(450ns)(5V)	3.95
2732A	4096x8	(250ns)(5V)(21V PGM)	3.95
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27C64	8192x8	(250ns)(5V)(CMOS)	5.95
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27256	32768x8	(250ns)(5V)	7.49

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

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PE-14T	YES	9	8,000	$119.00
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8087-2	169.95
8087	129.00
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8088-2	9.95
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8155-2	3.95
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8755	14.95
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8200

8203	24.95
8205	3.29
8212	1.49
8216	1.49
8224	2.25
8237	4.95
8237-5	5.49
8250	6.95
8251	1.69
8251A	1.89
8253	1.89
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74LS00

74LS00	.16	74LS165	.65
74LS01	.18	74LS166	.95
74LS02	.17	74LS169	.95
74LS03	.18	74LS173	.49
74LS04	.16	74LS174	.39
74LS05	.18	74LS175	.39
74LS08	.18	74LS191	.49
74LS09	.18	74LS192	.69
74LS10	.16	74LS193	.69
74LS11	.22	74LS194	.69
74LS12	.22	74LS195	.69
74LS13	.26	74LS196	.59
74LS14	.39	74LS197	.59
74LS15	.26	74LS221	.59
74LS20	.17	74LS240	.69
74LS21	.22	74LS241	.69
74LS22	.22	74LS242	.69
74LS27	.23	74LS243	.69
74LS28	.26	74LS244	.69
74LS30	.17	74LS245	.79
74LS32	.18	74LS251	.49
74LS33	.28	74LS253	.49
74LS37	.26	74LS256	1.79
74LS38	.26	74LS257	.39
74LS42	.39	74LS258	.49
74LS47	.75	74LS259	1.29
74LS48	.85	74LS260	.49
74LS51	.17	74LS266	.39
74LS73	.29	74LS273	.79
74LS74	.24	74LS279	.39
74LS75	.29	74LS280	1.98
74LS76	.29	74LS283	.59
74LS83	.49	74LS290	.89
74LS85	.49	74LS293	.89
74LS86	.22	74LS299	1.49
74LS90	.39	74LS322	3.95
74LS92	.49	74LS323	2.49
74LS93	.39	74LS364	1.95
74LS95	.49	74LS365	.39
74LS107	.34	74LS367	.39
74LS109	.36	74LS368	.39
74LS112	.29	74LS373	.79
74LS122	.45	74LS374	.79
74LS123	.49	74LS375	.95
74LS124	2.75	74LS377	.79
74LS125	.39	74LS378	1.18
74LS126	.39	74LS390	1.19
74LS132	.39	74LS393	.79
74LS133	.49	74LS541	1.49
74LS136	.39	74LS624	1.95
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74LS139	.39	74LS645	.99
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74LS157	.35	81LS96	1.49
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74HC109	.79	74HC374	2.29
74HC112	.79	74HC390	1.39
74HC125	1.19	74HC393	1.39
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74HCT08	.69	74HCT194	1.19
74HCT10	.69	74HCT240	2.19
74HCT11	.69	74HCT241	2.19
74HCT27	.69	74HCT244	2.19
74HCT30	.69	74HCT245	2.19
74HCT32	.79	74HCT257	.99
74HCT74	.85	74HCT259	1.59
74HCT75	.95	74HCT273	2.09
74HCT138	1.15	74HCT367	1.09
74HCT139	1.15	74HCT373	2.49
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74HCT157	.99	74HCT393	1.59
74HCT158	.99	74HCT4017	2.19
74HCT161	1.29	74HCT4040	1.59
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74F00	.69	74F74	.79	74F251	1.69
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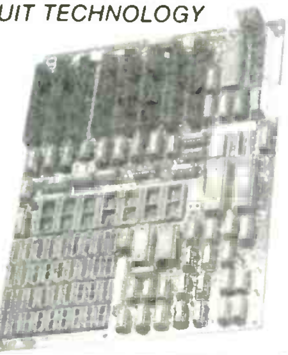

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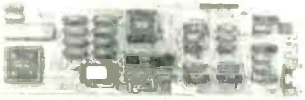

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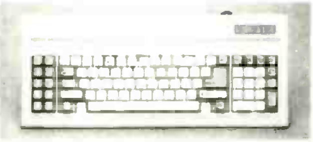

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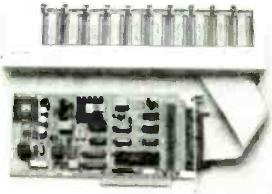

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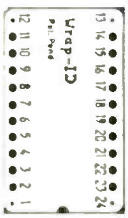

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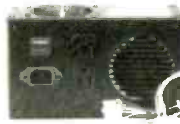

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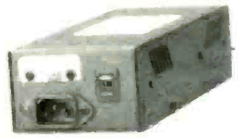

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22	50V	.05	.001µf	50V	.05
27	50V	.05	.0022	50V	.05
33	50V	.05	.005	50V	.05
47	50V	.05	.01	50V	.07
68	50V	.05	.02	50V	.07
100	50V	.05	.05	50V	.07
220	50V	.05	.1	12V	.10
560	50V	.05	.1	50V	.12

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.01µf	50V	.14	.1µf	50V	.18
.047µf	50V	.15	.47µf	50V	.25

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47	35V	.18	100	35V	.25
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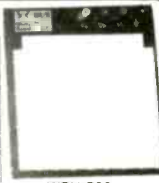

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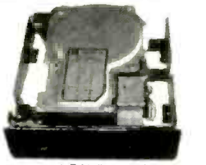

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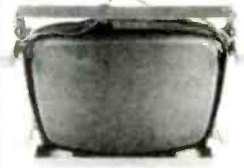
15" COMPOSITE VIDEO MONITOR



15", green phosphor, high resolution (12 lines center) and bandwidth from 10Hz to 30Hz ± 3dB. Operating volt.: 120/240VAC, 50/60Hz., 65VA max.
Mfr — Motorola — Alpha Series
Item #10044 **$34.95** New

5¼" FULL HT. DISK DRIVES 48 TPI

(IBM® Compat.)
Double sided/double density, full height drive. 48 T.P.I., 80 tracks.
Mfr — Tandon TM100-2
Item #7928 **$79.95**
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96 TPI, DS/Quad Density
Mfr — CDC #9409T
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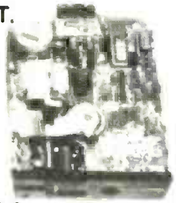
5¼" 1/2 HT. DISK DRIVE



DOS 3.2 Compatible
96 TPI, DS/QUAD DENSITY
Tandon TM55-4 DS/Quad
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2 for **$150.00**

Insides of the Commodore Computer

Commodore VIC 20 CPU board & mechanical keyboard. Guaranteed not to work. (For parts only.)
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Gives your Adam fast, reliable data storage and retrieval. Can hold up to 160K bytes of information. Uses industry-standard SS/DD disks. Connects directly to your Adam memory console. Comes with disk drive power supply, Disk Manager disk and owner's manual.
Mfr — Coleco, Model 7817
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12 VDC/110 VAC (w/built-in power supply). Green phosphor. Mtd. in metal housing. Schematic supplied. Mfr — Capetronic #DS-1030.
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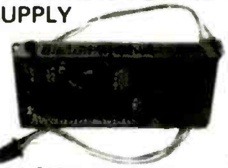
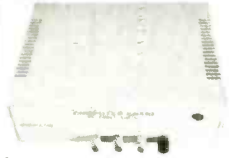
SWITCHING POWER SUPPLY



115 & 230V, 47-440 Hz.
Input: 90-135V/180-270V
Output: 5VDC @ 5.5A
+12VDC @ .4A
-12VDC @ .3A
Perforated metal case enclosure. Dim.: 9½"L x 3½"W x 2"H.
Mfr — General Instrument
Item #7983 **$14.95** New

COMPUTER GRADE POWER SUPPLY



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DC Output: -5V @ .5 amp.
+5V @ 3 amp.
+12V @ 6 amp.
Input 115V/60H. Dim.: 9¼"W x 3¾"H. (Rubber ft. incl.)
Item #9501 **$24.95** New

HI-POWER SWITCHING POWER SUPPLY

Output: +5.15V @ 70A
+12V @ 4A
+12V @ 4A
+5.2V @ 5A
Input: 115/230V nominal, .725KW cont. 47-63Hz. Enclosed in metal housing.
Dim.: 15"W x 2½"H x 6" deep.
Mfr — Todd Prod. #4XS8151A
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ADAM COMPUTER KIT — (Less printer.) Includes: Keyboard, digital data drive, 2 game controllers, power supply, all memory boards, and one cassette. No wiring necessary; hook-up diagram incl.
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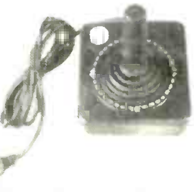

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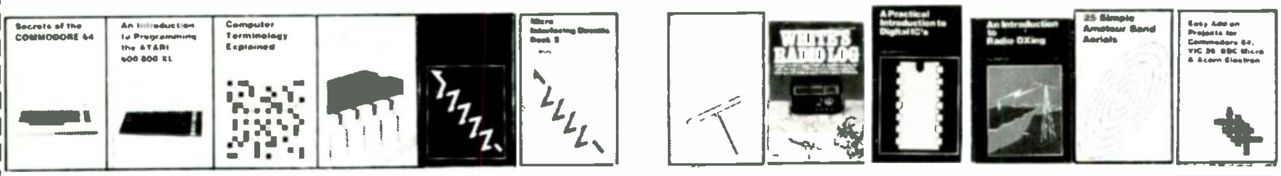

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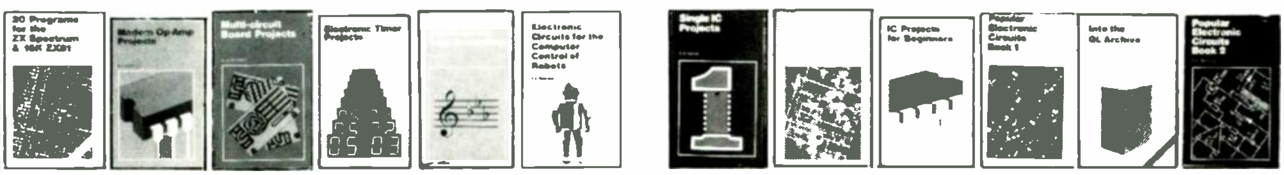

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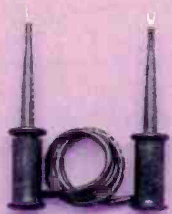

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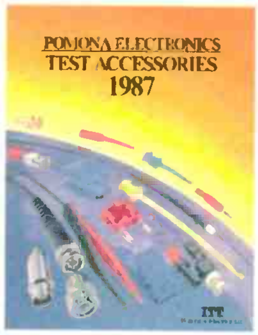

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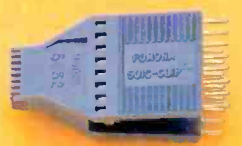
SOIC CLIP™ TEST CLIP: MODEL 5250 (8 PIN); 5251 (14 PIN); 5252 (16 PIN) SHOWN; 5253 (20 PIN); 5254 (24 PIN)



MOLDED BREAKOUT; SMD GRABBER™ TEST CLIPS TO FEMALE BNC: MODEL 5305

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