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Electronics publishers since 1908

FEBRUARY 1983 Vol. 54 No. 2

ON THE COVER

Once considered a dream, the computer-controlled airplane has become a reality, with the introduction of the Boeing 757/767 aircraft into commercial service. This month, we'll take you into the cockpit of that fascinating airplane, and show you the systems and features that help make it one of the most sophisticated in the sky.

You don't always need a long antenna to get good VLF reception. The active antennas shown here are just one meter long but often outperform ones many times their length. Find out more about active antennas, beginning on page 63.

If you are one of those that love to spend hours at a time with your home videogames, your hands are probably taking a beating. Give them and yourself a break, and build this controller for your Atari VCS system. The story starts on page 42.

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VIDEO ELECTRONICS

DAVID LACHENBRUCH
CONTRIBUTING EDITOR

HOME VCR EDITOR

The era of precise home-videotape editing has arrived with the introduction of small editing controllers by Panasonic (see photo above), Quasar, and Canon, with more similar products to come. The essentially similar machines control 2 VHS recorders, permit access to the desired part of the tape numerically by keyboard, synchronized with the recorders' tape counters. The system has a switch that automatically sets the end point of the editing. Video and audio editing capabilities are independent, permitting the user to dub new audio onto existing video or vice versa. List price is about $200.

CAMCORDERS

The hottest thing in broadcast equipment this year is a combination camera/VCR, sometimes called the "camcorder," and the recent National Association of Broadcasters equipment show was dominated by enough of them to spur a call for standardization. All of the camcorders are built around new video-recording systems using consumer videocassettes and broadcast-quality cameras. Many of the new units use the standard VHS quarter-inch cassette, but speeded up to produce a picture of breathtaking quality though limiting recording time to 20 minutes per cassette. RCA and Panasonic worked jointly on that system; RCA calls its camcorder *Hawkeye,* while Panasonic uses the tradename *Recam.* Hitachi and Ikegami also showed combinations using the same system.

Sony's camcorder, *Betacam,* uses a standard Beta cassette, however; again, recording time is 20 minutes. The newest camcorders use the little quarter-inch Funai *CVC* cassette that is used in Technicolor's portable VCR. To improve the picture quality, those camcorders also speed the cassette up, resulting in recording times of from 8 to 15 minutes per quarter-inch cassette. Camcorders using the *CVC* cassette—all incompatible—were shown by Hitachi, Ikegami, and Bosch Fernseh. The Hitachi unit and one by Nippon TV Network used three solid-state MOS image sensors in place of pickup tubes. Hitachi and Ikegami gave prospective customers the choice of quarter-inch and half-inch cassette systems. RCA and Panasonic, meanwhile, have requested that a camcorder VCR standard be established using their VHS-cassette format.

VHD DISC SUSPENDED

The third—or is it fourth?—postponement of the debut of Japan's VHD grooveless capacitance videodisc system for the American and European markets was announced by developer VHD, citing the state of the economy. The VHD disc plant in California was closed and all personnel of two VHD companies in the United States dismissed. In Europe, where two disc plants were in pilot operation, some minimal activity will continue, according to sources there. JVC was still talking of a possible launch in Japan in 1983 at press time. VHD adherents in the U.S. are GE, JVC, Panasonic, Quasar, and Sharp. No date has been set for introduction of the system here or in Europe.

BETA HI FI ON WAY

The Beta group has approved the compatible Beta Hi Fi system (see **Radio-Electronics,** September 1982 issue), and recorders and prerecorded tapes for the system will be available here this year. In addition to the standard longitudinal soundtrack, the new format has a high-fidelity stereo FM audio signal contained in the helical video track. **R-E**

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

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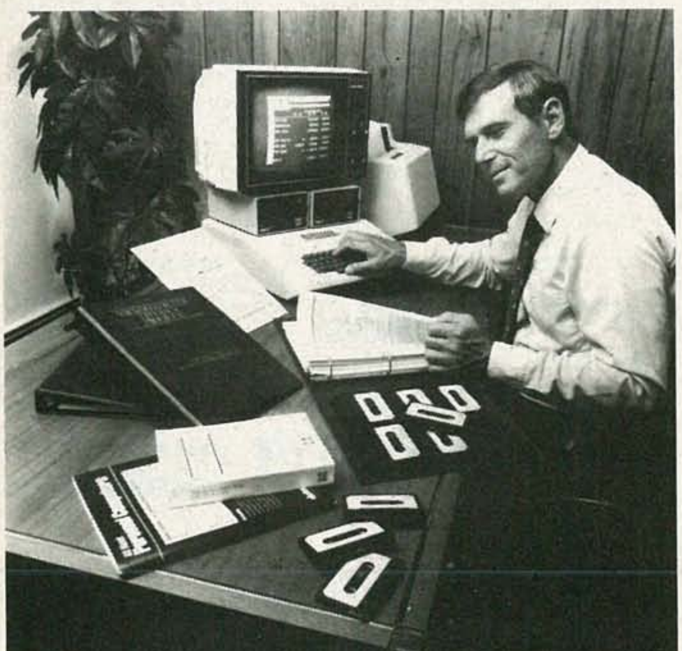
WHAT'S NEWS

Computer know-how taught by tape

A unique "Microcomputer Literacy Program" aimed at "Executives, Managers, and Professionals" is being offered by the McGraw-Hill Continuing Education Center. Designed to make it possible for the student to select the right computer for his business or profession, the course helps the person with little knowledge of computers to avoid picking an instrument too large or elaborate for the job to be done. The student also learns to avoid "the greater mistake of paying too little" and winding up with equipment that is inadequate for his needs, and can gain an understanding of computer technology that will aid him in using the equipment.

The program consists of two large looseleaf binders of printed text and worksheets, nine one-hour cassettes, a 600-page microcomputer dictionary, a detailed microcomputer rating manual, and a computer demonstrator. That unique device consists of a slotted mask on which a microcomputer program is printed. By sliding the mask down from one program to the next, the progress of a program through the computer is visualized in a way impossible to grasp from a text. The voice instruction via the tapes, plus the printed text and reference material, combine the advantages of a correspondence and a residential course.

The introductory price is $129.50. Purchasers are allowed a 15-day review period on a money-back basis. More information may be obtained by writing or telephoning David Dasenbrock, McGraw-Hill Continuing Education Center, 3939 Wisconsin Avenue, N.W., Washington, DC 20016 (Telephone 202-244-1600).



THE COMPUTER LITERACY PROGRAM, by McGraw-Hill, combines the advantages of a residential and a correspondence course by using audio tape and printed material together. The program is designed to teach computer possibilities, potential, and limitations to executives and professionals, enabling them to select and use microcomputers intelligently.

Fuzzbuster seizure challenged in D.C.

Electrolert, Inc., maker of the *Fuzzbuster* radar detector, has sued the District of Columbia, its mayor, and the metropolitan police chief. Joining in the suit are Poptronics Electronics, a Maryland retailer, and George Sadler, a Maryland radar-detector owner whose instrument was seized by the Washington police. The District's Commissioners' Order 61-2026 prohibits simple possession of any device that can detect police radar, or the use or sale of such devices.

The suit charges that the Order is unlawful, discriminatory, arbitrary, and unconstitutional, and cites three clauses of the U.S. Constitution in support.

The Commerce Clause restricts any legislative activity that interferes with interstate commerce. Radar detectors may be purchased and used legally in practically all other jurisdictions of the country, the plaintiffs declare.

Citing the Supremacy Clause, the plaintiffs state that Congress has remanded all authority over radio transmission and reception to the FCC, which has addressed the issue of radar-detection devices and has not introduced legislation prohibiting their use. The plaintiffs therefore charge that state legislative activity in the area of radio reception is unconstitutional.

The complaint also contends that the Order violates the Due Process clause of the Fifth Amendment because it is vague, overbroad, arbitrary, and capricious.

Mr. Sadler, one of the co-plaintiffs, lives in Maryland. He was arrested for possession of a radar detector while passing through the District on one of his business trips. His detector was confiscated and he was fined $50.

The plaintiffs have asked the Court to declare the Commissioners' Order unconstitutional and illegal, to order the defendants to return his radar detector and the $50 fine to plaintiff Sadler, and to award the plaintiffs their costs and disbursements.

Electrolert states that since its inception in 1975, it has spent over $1 million in legal fees to defeat radar-detector bills at the State level, to institute judicial proceedings on behalf of individual motorists, and to institute legislation that calls for minimum performance for police radar. In the past two years, the company reports, it has been responsible for rendering a Virginia radar-detector law unenforceable and was instrumental in the introduction of a strict standard for police radar equipment and training in the State of Florida.

New ferrite material destroys vibration

Nippon Electric Co. has developed a "ferrite composite material" that absorbs vibration about 100 times as effectively as iron or aluminum. The new material is made up of ferrite grains 0.1 to 10 μm in size, and polyester resin.

The new material can be used for many applications that require control of noise or vibration. Those include microfabrication of LSI's, assembly of precision machines, stands for powerful microscopes or electron microscopes, and housings of audio equipment and computer peripherals.

NEC researchers report that the vibration-absorbing action appears to be due to mutual interference between the ferrite grains of high specific gravity and the elastic resin.

Direct broadcast STV authorized by FCC

In a move that may open a new era of space-age television, the FCC voted 6 to 1 to approve the application of Satellite Television Corp., a subsidiary of Communications Satellite Corp. (COMSAT) to build satellites that will eventually transmit three channels of television to all 50 states for a monthly fee, bypassing local TV stations.

Commissioner Anne Jones, who cast the dissenting vote, stated that the 1962 law that created COMSAT as a quasigovernmental corporation did not envision entering the entertainment field. (COMSAT operates the global communications network and is the U.S. representative to the International Satellite Organization.)

STC's programs would be scrambled and the subscriber would receive a decoder to unscramble the signals from his own rooftop receiver.

The National Association of Broadcasters announced on the same day that it would seek an immediate stay, pending legal appeal of the FCC's action. **R-E**

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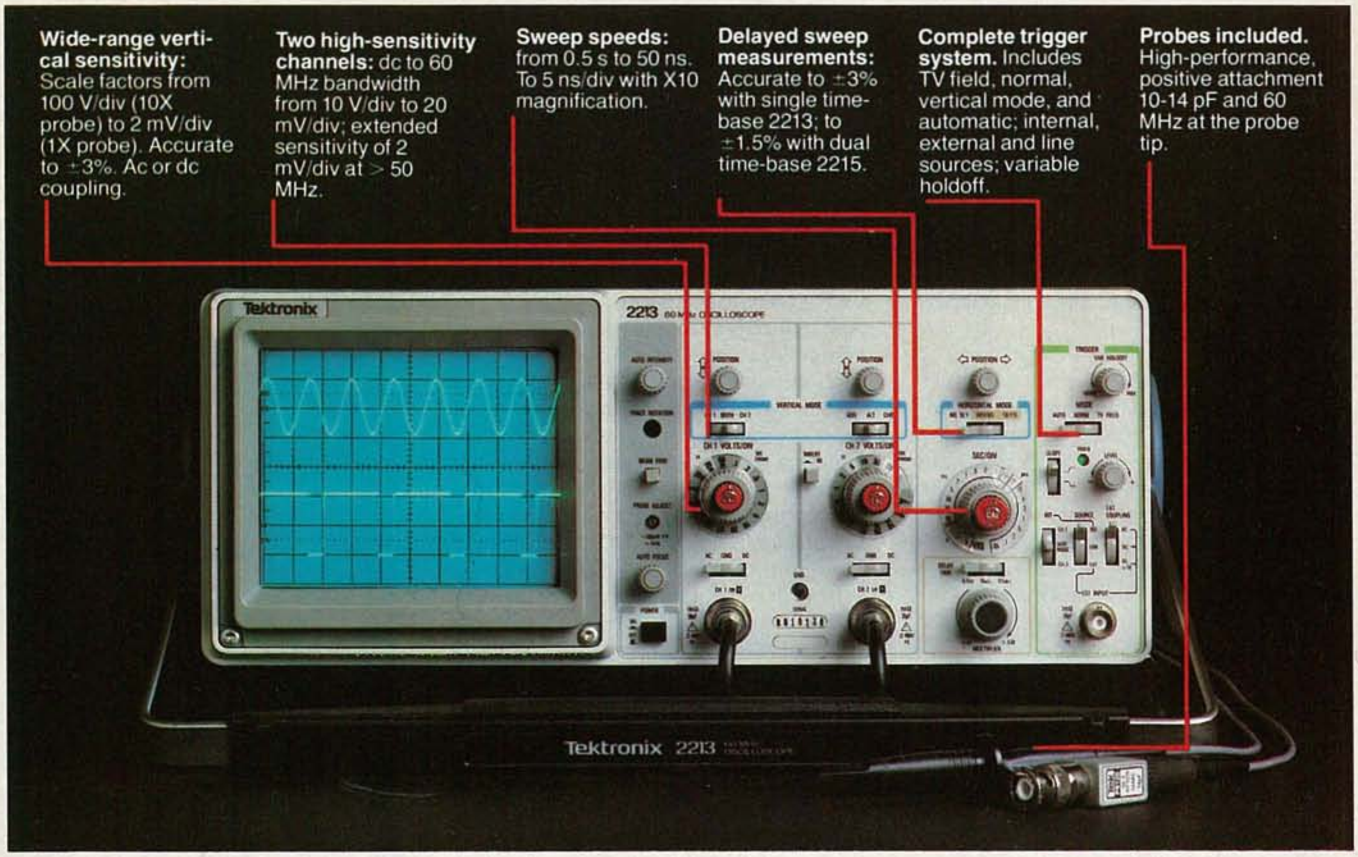

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VIDEOGAMES

What's new in home videogames

DANNY GOODMAN, CONTRIBUTING EDITOR

THIS YEAR HAS SEEN THE INTRODUCTION of a confusing array of new home-videogame systems, as well as enhancements for existing systems, calculated to attract literally millions of new players to the home-videogame market. If you are one of those facing the potentially emotional decision of which system to buy, this new monthly column will be just what you're looking for. In this first one, we will look at some of the things to consider as you twiddle the controllers at the video counter.

Hardware

Game players today demand more realism from their systems. For sports and similar games that means the ability to input more strategy as well as realistic character, playing-field, and action graphics. In arcade-type games, players demand graphics that approach the color and detail of the high-resolution coin-operated units. While the home color-TV receiver cannot match the resolution of an arcade monitor, a home TV does an admirable graphics job with systems like Coleco's (200 Fifth Ave., New York, NY 10010) *Colecovision*, Video Technology's (68 Sung Wong Toi Road, Tokwawan, Kowloon, Hong Kong) *Creativision* (which was scheduled for December 1982 introduction), Arcadia's (324 Martin Ave., Santa Clara, CA 95050) *Supercharger* for the Atari (1265 Borregas Ave., Sunnyvale, CA 94086) *VCS*, and Atari's *5200* deluxe system. By way of comparison, the *5200* has the same graphics resolution as Atari's *400/800* home-computer systems.

One system that can produce true arcade-type graphics is the cartridge-programmable *Vectrex* vector-scanning home-game from General Consumer Electronics (233 Wilshire Blvd., Santa Monica, CA 90401). That is the only home system, at least until now, capable or reproducing the outline-formed characters used in such arcade games as *Asteroids* and *Tempest*. To accomplish that feat, the game uses its own vector-scanning video monitor (more on the *Vectrex* system next month).

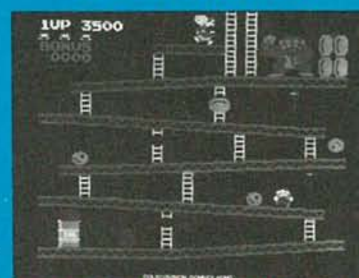
The newer systems all use all-in-one hand controllers. As the *Intellivision* controllers proved, a keypad used in conjunction with a joystick or direction-control disk, is an effective way of communicating with the game computer. The Atari *5200* also allows you to vary speed using the joystick; for instance, the faster you push the joystick to the right the faster your screen character moves to the right and so on. The effect here is similar to using an arcade-style track ball (such as those found in games like *Centipede* or *Missile Command*).

All manufacturers now realize that the success of their systems depends largely on the amount of games available for it. And if there is one undisputable fact about home-videogames, it is that there is more support for the Atari *VCS* than any other system (and perhaps more than for all of them combined!). The reason is simple: game-cartridge developers have many millions more hungry *VCS*-users to satisfy than users of any other home system. But that large existing library can prove to be a considerable obstacle to any new system that is introduced. After all, few buyers would be willing to invest in a new system with little support, considering what else is on the market. What Coleco has done to offset that problem is come out with a system adapter that will allow their *Colecovision* system to use Atari *VCS* cartridges, and Atari is planning to introduce a similar adapter for their own *5200* system sometime this year.

The introduction of those adapters makes sense for many reasons. First of all, any new system will have only a modest offering of its own games at the outset—one company can do only so much in a limited time. With adapters, the unit is immediately usable with an already existing library of cartridges. Next, for the game owner wanting to upgrade to a more advanced system, a substantial investment in game cartridges (usually much more than the actual cost of the console) won't be wasted when switching to a new unit. If all home game-consoles featured adapters for most other systems, the consoles could compete solely on the basis of features such as controllers, computer add-ons, creative graphics, sound effects, and the like.

There is also suddenly an interest in serving what is known as the videogame hardware aftermarket—otherwise known as add-ons for your videogame. Electronic speech modules (*Intellivision, Odyssey 2*, and Atari *5200*) and hand controllers of all kinds (mostly for the *VCS*) are already joining game organizer-type cases and cartridge racks on your dealer's shelves. Many of the newer systems provide expansion connectors for future add-ons. As with computers, expandablity means that a system will be able to grow with you, as well as with changing technology.

Coleco's Donkey Kong for Colecovision



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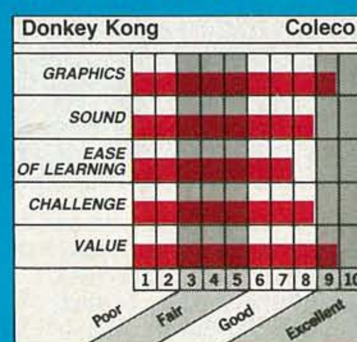

Coleco's *Colecovision* comes packaged with the home version of the most popular non-combat arcade game since *Pac-Man*: *Donkey Kong*. The game looks simple—move your mustached character, named Mario, up various girders and ladders to rescue a "fair damsel" who has been abducted by the fierce Kong. But successful execution requires split-second coordination, plus an eye for mazes. In that regard, Coleco's cartridge is no different from the original.

Players of the arcade game will be quick to tell Coleco's from the original, however. For one thing, there are only three different boards, instead of four (the easy Mud Factory scene is gone). But

continued on page 10

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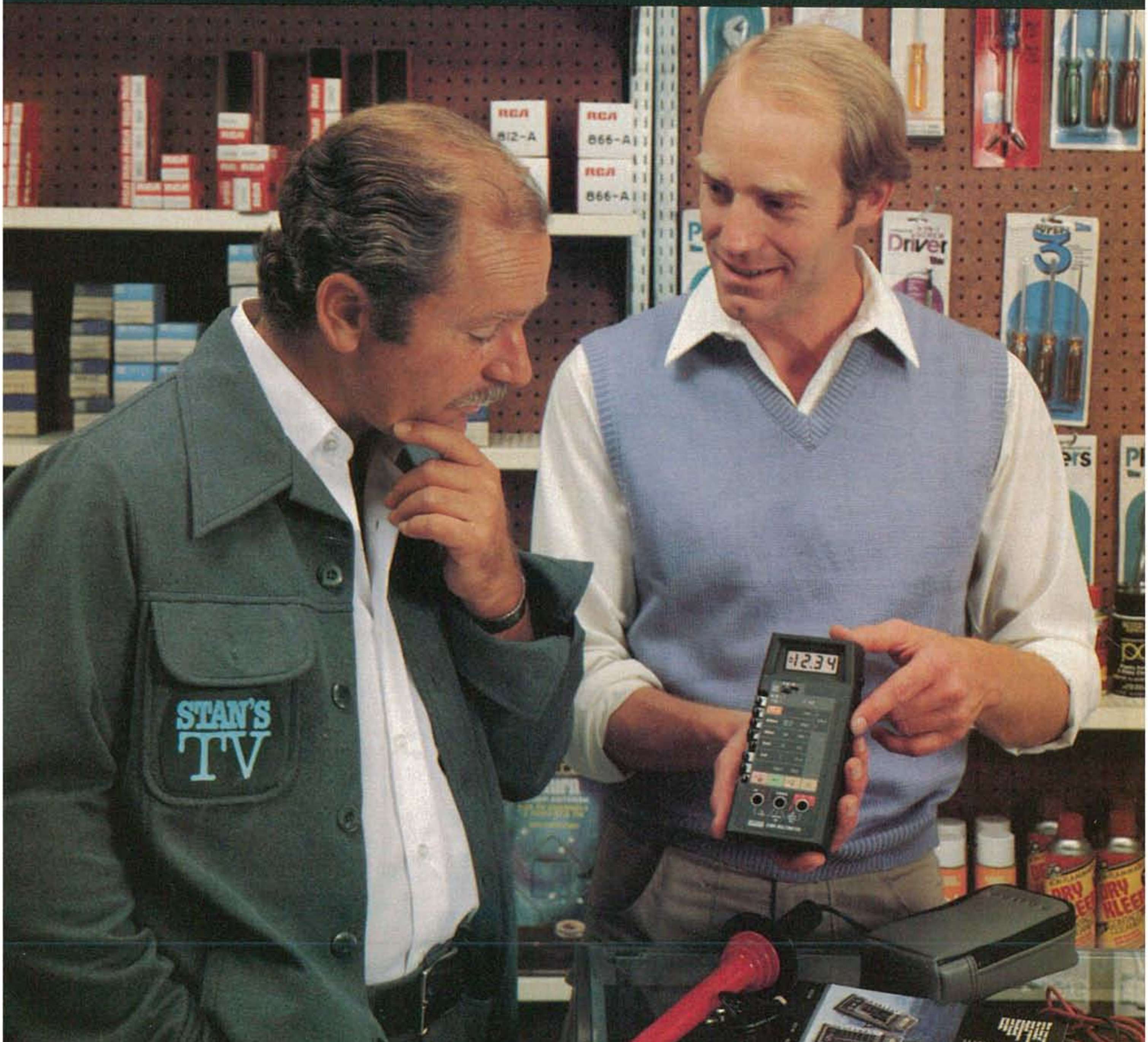

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VIDEOGAMES

continued from page 8

even so, the game is perhaps the most true-to-arcade home-videogame cartridge around.

The graphics are outstanding. You not only can see Mario's mustache, but the lattice work in the bright pink girders is crisp, and the color variations and contrast (the black background helps), like Mario's brown coveralls, and the white streaks to indicate cylindrical objects, are unlike that found on any other home game I've seen. And the sound package includes the familiar background rhythm, whistle-like tune when Mario hops over barrels, and more.

One or two (alternating) can play at a time and there are four levels of difficulty; the easiest one starts you off with five Marios, the rest start with three. Completing skill level one (the easiest one) requires rescuing the girl five times. The sequence of board scenes is Ramps, Rivets, Elevators, Rivets, and Elevators. At level one you also get 1000 extra bonus points, which gives you more time to navigate the trickier obstacles (the bonus points decrement as time ticks away) The game can be reset from the hand controllers.

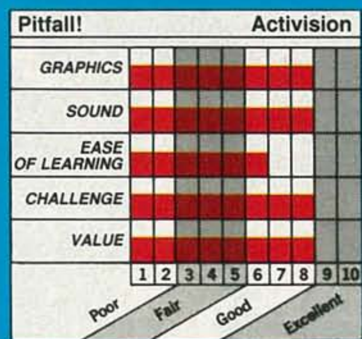
While it's not hard to learn what *Donkey Kong* is all about, the newcomer, nevertheless, will need a lot of practice to get the hang of running and jumping over the moving and stationary obstacles (make a mistake and you lose your Mario). You'll also discover several areas that can be tricky; especially watch out for the edges of girders (Mario can easily fall off to his demise) or the area around Kong.

The Elevators board is the most difficult to get used to. Arcaders may be interested to know that the bouncing hammer obstacles are replaced in the home version by an extra flame at the girder levels surrounding the girl.

While some of the charm of the original—like Kong's grabbing the girl between boards and watching the girders collapse in the Rivets board—had to be sacrificed for the smaller memory of a home game, Coleco managed to keep some of the "cute" effects (Mario can pick up the girl's scattered personal belongings for bonus points) and interest of the original where it counts; while you're playing the game. This first offering for *Colecovision* is certainly a good omen for the rest of their library.

Activision's Pitfall! for Atari

CIRCLE 102 ON FREE INFORMATION CARD



I wouldn't have believed it could come from an Atari *VCS* if I hadn't been watching it with my own eyes: a comic-book human character is running across a jungle-like scene, swinging on vines over a pond, leaping over pit-like traps, climbing up and down ladders, and finally tiptoeing across a lagoon on the heads of hungry crocodiles.

The game is *Pitfall!* from Activision (3255-2 Scott Blvd., Santa Clara, CA 95051), and the character's name is Pitfall Harry. What Harry is doing is searching the jungle for as many of the lost treasures of Enarc as he can in twenty minutes without giving up his own life to scorpions, quicksand, and those darned crocodiles, to name a few. Every time he runs off the screen, a new scene appears with different hazards—in fact, 256 different scenes have been programmed into the cartridge.

Design of this solitare game is attributed to Activison's David Crane (thus the treasures of Enarc) and is one of the most original and graphically interesting *VCS* cartridges available. The sound package even includes an electronic Tarzan call while Harry swings on a vine. The novice player will need some time to get the coordination down to run and jump for swinging vines, race over vanishing pits, jump over several obstacles, and gingerly dance across the crocodile lagoons.

What's most interesting about this game is that no matter how good you get at avoiding obstacles, you're never quite sure that you haven't missed some underground passage shortcut (jump over scorpions down there) or have found the fastest way to overcome an obstacle (like making it over the crocodile lagoon in one mad rush while the crocodiles' mouths are shut). Expert players will be glued to the set for hours, experimenting and memorizing successful patterns.

You'll have to work hard to reach the first treasure (a money bag)—perhaps a minute and a half—but the longer you keep Harry alive, the quicker he'll find the others (rings, silver/gold bars, etc.). So be prepared for a twenty-minute adventure each time you reset.

Also available from Activision is a version of *Pitfall!* for Intellivision game systems. Although the graphics might be a letdown when compared to other Intellivision games, the game play certainly won't be. *Pitfall!* is a stimulating adventure game on any system. **R-E**

"If it works, my fortune's made. It's a TV attachment that interferes with CB radios and power tools!"

SATELLITE/TELETEXT NEWS

GARY ARLEN
CONTRIBUTING EDITOR

DBS SERVICE PLANNED

Direct Broadcast Satellite service is getting off to an earlier-than-expected start thanks to a number of recent actions, some of which could put the first DBS signals on the air this year. In the wake of the recent FCC interim action authorizing DBS service, several companies have plunged ahead with projects involving a number of innovative approaches. For example, United Satellite Television plans to use 10 transponders on Canada's Anik C satellite for at least a year until its transmissions can be moved to a new GTE GSTAR bird, due to be launched in 1984. Initial use of Anik C means that signals can be picked up by fairly small, inexpensive earth stations in the U.S. USTV, a joint venture among Pop Satellite Inc., General Instruments, and Citicom Broadcasting, plans to offer five channels for each East and West feed, including two pay-TV channels, a broadcast retransmission signal, and two ad-supported channels.

Another familiar satellite-industry name—Satellite Syndicated Systems (best known for its Satellite Programming Network and as the retransmission carrier of Superstation WTBS)—has come up with its own plan for a DBS system to be operative by the late 1980's. The 4-satellite, 6-channel system will primarily offer pay-per-view programming, as well as education, teletext, and audio services. The 4-phase SSS plan relies upon substantial participation from the cable industry; by 1986 SSS proposes an Eastern time zone DBS service and the company plans to launch its own DBS bird by 1988.

Meanwhile, Satellite TV Corp., the Comsat subsidiary that pioneered the DBS concept, is moving ahead with its own plans for a major DBS service. The company is planning to build its major hub of DBS activity at a new uplink near Las Vegas. The STC center, which will employ about 100 people, will handle all program scheduling, editing, reproduction, and technical quality control. It will be in operation by STC's proposed 1986 launch date.

VIDEOTEX STANDARD PROPOSED

A compromise standard for international videotex and teletext—tentatively called UPL (*Un*ified *P*resentation *L*ayer)—has been proposed by a group of U.S. business and government officials, who are trying to hammer out a U.S. position on a technical format. The proposal, developed at a State Department meeting, is a variant of the North American Presentation Level Protocol, which was proposed by AT&T. Among the technical compromises in the UPL is one that would permit use of display standards of either 40 rows by 24 lines (the European preference) or 40 by 20 (the format adopted by AT&T, Canada's Telidon, and other services).

The compromise format urges U.S. equipment manufacturers to include UPL IC's in their products which would make videotex/teletext terminals compatible with any format. The IC's—if and when they become available—would automatically switch between formats, depending on which was being transmitted at the time. However, foes of the compromise suggest that the UPL IC's—if they can be built—would cost more than 20 times as much as conventional single-standard microprocessors.

AROUND THE SATELLITE CIRCUIT

SPACE, the Society for Private and Commercial Earth Stations, has restructured its organization to reflect all aspects of the earth station industry more fully. Under the revisions, SPACE now has a consumer section composed of individuals who own and use earth stations; dues for members of that group are $35 per year, compared to fees ranging form $300 to $3600 per year for SPACE members in Manufacturing, Dealer, Distributor and Satellite-Master Antenna TV sections. (SPACE, 1920 N Street NW, Suite 510, Washington DC 20036).

Britain's first DBS satellite, Unisat, which is scheduled for 1986 launch, will carry data communications within Europe and possible a sidebeam to North America. Each Unisat bird will have either two DBS and four data channels, or one DBS circuit and six telecommunications channels. British Broadcasting Corp. will probably run the video-programming service of movies and other entertainment.

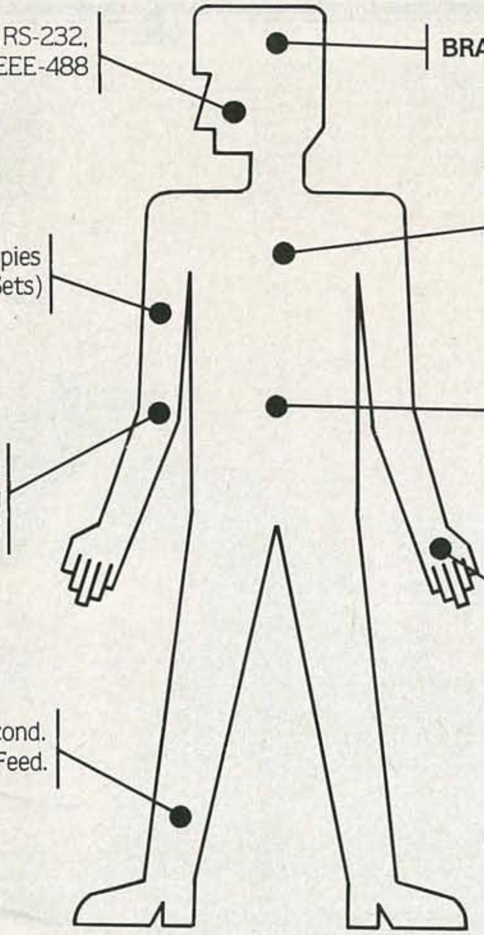
Satellite and aerospace technicians are enthusiastic about last November's launches of two satellites from *Space Shuttle V*. An SBS bird (for business-data communications) and an Anik bird (for multipurpose Canadian communications) were lofted into geostationary orbits from the Shuttle. More such launches are planned for future flights. **R-E**

The COEX

Anatomy of a Printer

FACE—Interface with RS-232, Centronics, Apple, IEEE-488

BRAIN—2K of Buffered Memory



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BACKBONE—9x7 Dot Matrix, Bi-directional Printing, Logic Seeking Carriage Control. Standard Underwood Ribbon.

FLEXIBILITY—Selectable Character Pitch, Line Spacing and Line Feed

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The EPSON Alternative

SPECIFICATIONS:

CHARACTER FORMATION PROCESS	Serial, impact dot matrix
STANDARD FONT	9 x 7 (7 needles), 6 x 6 for graphics printing
PRINTING DIRECTION	Bi-directional
NUMBER OF COLUMNS	80, 96 or 132. (40, 48 or 66 for enlarged characters)
CHARACTER SIZE	2.57 mm (.101") x 2.0 mm (.079") for standard 80-column line
CHARACTER DENSITY	5 CPI for 40 column, 10 CPI for 80 column, 12 CPI for 96 column and 16.7 CPI for 132 column
LINE SPACING	1/6", 1/8" and 1/12"
PRINTING SPEED	80 characters per second
NUMBER OF COPIES	2 (original plus 2 copies for cabonless sets)
PAPER WIDTH	8" to 10" for friction-fed paper and 3" to 10" sprocket-fed paper
INKED RIBBON	Standard Underwood spool type 1/2" (13 mm) wide by 11.5 yards (10.5 m) long
DIMENSIONS	387 mm (15.3") wide by 309 mm (12.2") deep by 124 mm (4.9") high. With tracto-feed assy. height is 171 mm (6.7")
POWER CONSUMPTION	90 watts maximum operation 25 watts standby
WEIGHT	8.5 Kg (19 lbs.)

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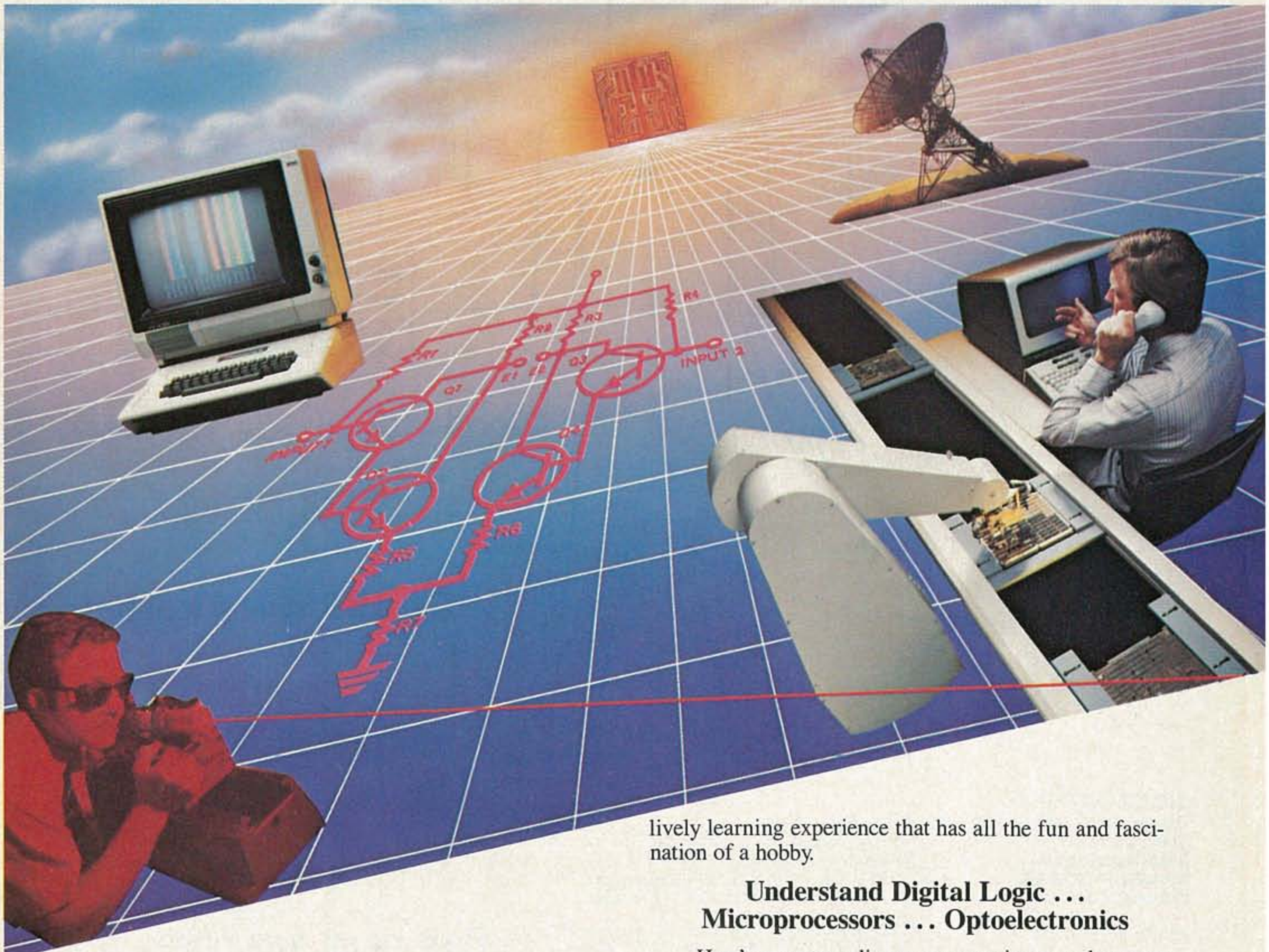

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Electronics Series

transformers, and active components such as transistors and integrated circuits.

Each Concept Module goes right to the heart of the matter. You waste no time on extraneous material or outdated history. It's a fast, efficient, and lively learning experience, a nontraditional approach to the most modern of subject matter.

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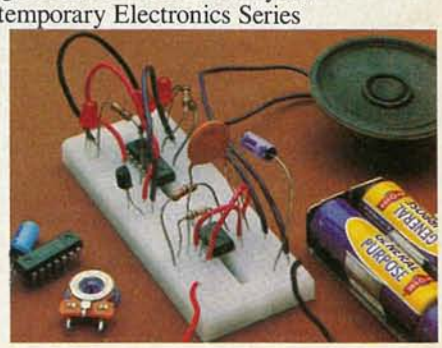

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LETTERS

Address your comments to: Letters, **Radio-Electronics,** 200 Park Avenue South, New York, NY 10003

ABOUT "HOBBY CORNER"

As a reader for the past six years, I have noted the appropriate trends in your publication toward topics of current interest. That is, you have changed your emphasis in keeping with the direction of the electronics field and the interests of your readers. However, I am concerned enough about the future of a particular department so that I am compelled to write to you for the first time.

The department in question is Earl "Doc" Savage's "Hobby Corner." Somehow, I get the feeling that Doc may be in danger of being edged out of the picture, and I feel that that would be a great loss. I am a physician who reads *BYTE, Scientific American, Popular Computing, Audio Amateur,* and half a dozen professional journals cover to cover each month, and one of my favorite columns is Doc's in **Radio-Electronics.** He covers an area that is very important to me, and I like his style. Though I have built many of the feature projects in your and other publications, I have learned more about electronics on the basic level from Doc than from anyone else.

If you have no intention of discontinuing his column, great. If you are considering substituting yet another software review or video-information column, or whatever, please don't do it.

JOHN H. HOLTKAMP, M.D.
New York, NY

Rest assured, we have no intention of discontinuing "Hobby Corner."—Editor

MAIL-ORDER COMPONENTS

"Buying Mail-Order Components" in the September and November 1982 **Radio-Electronics** should be on everyone's "must read" list. Where it didn't add to my knowledge, it verified points that I'd learned the hard way.

Only one important point was missing: the junkboxes should be obtained *before* the parts arrive. Then, when the parts arrive, they should *immediately* be categorized and stored in identifying compartments. Frequently, those parts are identified by the supplier according to *his* number, rather than the generic identity. If a few days or months go by, and the flyer, catalog, etc., has been discarded or misplaced, then the identity is gone with it. That is especially true of items frequently not marked, such as diodes. I've had to scrap several great deals, because I had not yet learned that lesson and couldn't take a chance with mismatched components.

Another point, which is a bit more obvious but perhaps still worth mentioning, is comparative shopping. Price and/or quality of a particular item might be outstanding in one catalog, but that same supplier might be undersold by someone else for other items. In fact, sometimes local suppliers can undersell the wheeler-dealers.

JOHN L. ANDERSON
Danbury, CT

EDUCATIONAL PROGRAMS

We regret that in your article "Software in the Home," (**Radio-Electronics,** October 1982) you did not mention our 1100 titles of half-hour educational programs, 300 of which have been or are being sold by Atari and Tandy, and nearly all of which are available from us here in Norman, Oklahoma.

We have full-chapter-length programs, 16 to the course, 68 courses, in reading at all levels, math from kindergarten to college, science, social studies, technical and vocational skills, and liberal arts. Reviewers have told us that we may have more tutorial programs than all the other firms combined, but we don't have games, tests, drills, and simulations.

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Goldsby Airport,
Box 1226, Norman, OK 73070
Loyd G. Dorsett, President

COPYING PC FOIL PATTERNS

I read the letter from Mr. Constan in the October 1982 issue of **Radio-Electronics** and can understand his frustrations.

I found a print shop in my local area which is set up with a large copy camera. The cost of copying the PC foil pattern is about $6.00, whether it is one small pattern or many which have been scotch-taped to two sheets of paper—taped together to make an 11 × 17-inch sheet.

One lesson I've learned is to wait at least three issues before putting together a project. That allows time for corrections to be printed.

I enjoy **Radio-Electronics** very much, buying nearly every issue. I've particularly enjoyed the current "Picture Phone" series.

Question: Can the Picture Phone be modified to copy 120 lpm FAX signals, such as weather maps, Chinese and Japanese press, etc? Those services generally use two tones separated for 800 Hz for black and white.

JIM HILL
Vancouver, WA

Unfortunately, the Picture Phone cannot be modified to handle such signals.—Editor

OOOOOOPS

Let me start by saying thank you for the kind mention of our OMNITERM intelligent terminal program in the "Computer Buyer's Guide" in your October 1982 issue. Unfortunately, you forgot to include our address in your listing of terminal software suppliers.

In addition to the OMNITERM terminal program for the *TRS-80 Model I* and *Model III* mentioned, we also have versions of the OMNITERM for the *TRS-80 Model II/Model 16* and *IBM Personal Computer*. The *TRS-80 Model I/III* version is $95.00; the *Model II/Model 16* version is $175.00, and the IBM PC version is $195.00. If any of your readers are interested in any of those programs, they can obtain a free information package from us at the address below:

Lindbergh Systems, 41 Fairhill Road, Holden, MA 01520. Telephone: (607) 852-0233; Source: TCA818; CompuServe: 70310,267.

DAVID J. LINDBERGH,
President, Lindbergh Systems

COMMERCIAL EDITOR

Several errors seem to have crept into my "Automatic Commercial Editor" in the December 1982 issue of **Radio-Electronics**.

In Fig. 2, the REMOTE jack, J1, should be shown connected to the emitter and collecter leads of transistor Q1. Also, capacitor C6 should be shown as having a value of *150* pF, not 130 pF (it's correct in the Parts List).

Finally, in Fig. 6, J1 should be connected to the large pads just below Q1. Those pads can be seen clearly in Fig. 5.

GARY McCLELLAN

TESTING POTENTIOMETERS

In his article "The Ins and Outs of Buying Mailorder Components" (**Radio-Electronics,** November, 1982), Karl T. Thurber describes the use of a multimeter to evaluate surplus or suspect potentiometers. But that testing method can damage or destroy the pot under test by exceeding the power rating of a portion of the pot element, or by exceeding the maximum allowable wiper current. Only a DVM is suitable for performing such measurements, due to its low-voltage resistance-mesurement capability. Further, if a potentiometer is to be operated or tested as a variable resistor, the wiper should be "tied" to the unused side of the pot element.

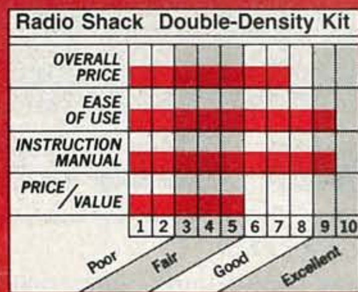
Speaking from experience, I've had them "smoking" on the bench by ignoring the above considerations. If you must measure potentiometer resistance parameters, use a DVM and *be careful.*

ALAN CAMPBELL
East Ridge, TN

That one is new to us, but if any of our other readers have had similar experiences would like to hear about them—Editor **R-E**

EQUIPMENT REPORTS

Radio Shack TRS-80 Model I Double-Density Disk Kit

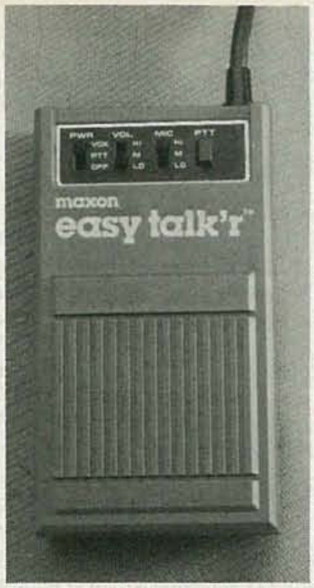


CIRCLE 103 ON FREE INFORMATION CARD

RADIO SHACK'S (ONE TANDY CENTER, FT. Worth, TX 76102) *TRS-80* Double-Density Disk Kit (catalog number 26-1143) is a retrofit for their *Model I* computer that expands the storage per disk by 80% to 100%. A double-density DOS (*D*isk *O*perating *S*ystem) provided with the kit features new commands that allow the *Model I* to function almost as if it were a *Model III* computer, and includes enhancements that were not formerly available on that earlier model.

The kit, which is priced at $149.95, consists of a somewhat complex printed-circuit board assembly, a disk with the new DOS, and documentation—called an "owner's manual"—for the double-density disk system.

Though sold directly to the user through Radio Shack stores, the circuit must be installed by a Radio Shack technician; the service charge for that is $17.50. The user can either leave the computer in the store for free forwarding to, and return from, the service center, or he can take the kit and the computer directly to the center. Either way, the service charge is the same.



Think Speak

On the job, on the field, or on the road. Now you can talk and listen hands free at a new breakthrough price.

SWAT teams use them. So do quarterbacks and firemen. Now you too can talk and listen to people near and far totally hands free while you are jogging, riding a bike, or hiking.

Both at work and at home this unique communications system with a range up to 1/2 mile will let you keep in touch.

You'll keep in close contact with your hunting partners when you hunt, and you'll communicate for ease and safety on construction sites.

Plus, you can effortlessly perform tasks like fine tuning your TV antenna when you need to communicate with someone on the ground or out of sight.

NOT A WALKIE TALKIE

This is no toy. The Think Speak is totally automated. When you speak, a special voice activated circuit (VOX) automatically engages the transmitter so you are broadcasting. When you stop speaking, it automatically returns to 'stand by' to await a reply.

It is virtually noise free because it uses a quartz crystal locked dual conversion superheterodyne communication circuit that operates on an FM band.

So, your communication won't sound like a CB or an AM radio. You'll speak and hear with the full power and clarity you'd expect from an FM radio station.

HERE'S WHAT IT IS

You wear the Think Speak just like a personal stereo. There is an adjustable headphone that you wear on either your right or left ear. The other ear is clear to hear the outside world for safety.

A flexible boom microphone lets you speak normally while you transmit. The entire shaft of the boom mike is adjustable and will retain any position you set.

All of the electronics are contained in a small 6½ oz. case that easily clips to your belt or with its removable clip fits into your pocket. And, what controls.

The voice activation circuit has a 3 level sensitivity switch. If you're riding a motorcycle or breathing hard while you jog, you can set the sensitivity to low so that you won't transmit in error.

If you are hunting or fishing and you can't talk much over a whisper, you can set the sensitivity to high. Plus the headphone has a 3 level volume control too.

In addition to the VOX voice operated circuit, you have 'PTT' which means Push to Talk. When you want to talk, you just push the PTT button.

This is a really great feature when you want to whisper very quietly below the threshold of even the high sensitivity setting of the Voice Operated Circuit. You may be into surveillance or photographing wildlife. When you can only whisper, you'll especially appreciate the super quiet FM reception of this system.

SOME SPECIFICS

You can expect long battery life from a standard 9V battery (not included). In the 'stand by' mode, the Think Speak only consumes 13.5 milliamps of power while it's ready to transmit or receive.

The antenna is conveniently clipped to the headband for normal use. For full range use, the antenna pops up.

The system operates on the 49 mhz band using FM so you shouldn't be bothered by any other radio transmissions as you are with CBs and Walkie Talkies.

There are 5 channels (A-E) allotted to the Think Speak to further prevent interference. We will ship all units ordered on each order with the same channel.

The transmisssion output is a full RF of 10,000uV/m @ 3 meters max. No FCC license is required. And, the FM hum and noise is almost good enough for a high fidelity system at 40db min. The case is 4-9/16" x 2¼" x 15/16".

PERSONAL OR GROUP

You can talk to 1 or even 10 people with Think Speaks. So, if you're the head of a Search and Rescue team you can talk to everyone at once and get responses from one at a time.

The Think Speak is great if you're skiing with a friend, using two boats on a lake or at sea, hiking in the mountains or just jogging around the block.

If you're a pitcher you can talk to your catcher or the coach. If you're on a loading dock, you can talk to the man in the truck or on the forklift. If you're a security guard, you'll never be alone.

The Think Speak is manufactured and backed by a limited warranty from Maxcon Electronics, the two way specialists.

TRY A THINK SPEAK RISK FREE

Walk around the block. Take a bike ride and really test the range of this breakthrough in personal communication. If you aren't 100% satisfied with the incredible sound quality or the range, return it in its original box within 30 days for a courteous refund.

To order your Think Speak risk free with your credit card, call the DAK toll free hotline or send your check for the incredible breakthrough price of only **$49.95** each (minimum of 2 required). Plus **$2.50** each for postage and handling. Order Number 9415. CA res. please add 6% sales tax.

When you think out loud, people will listen. Try a Think Speak risk free today.

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If busy, after hours, on weekends or in CA
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10845 Vanowen St., N. Hollywood CA 91605

Though Radio Shack does not support their double-density kit in any way, with it installed, the computer will still be able to use the Radio Shack single-density DOS. That means that most Radio Shack software, as well as any software written in a BASIC that used the Radio Shack DOS and was recorded on a single-density disk, can still be run.

If the system is booted with the new double-density DOS disk, the computer goes into the double-density mode with the new expanded operating system. When operating in the double-density mode, only the DIR and COPY commands are supported for single-density disks; that is, you can read the directory of a single-density disk, or copy a single-density file to a double-density disk; there are some problems here, however, and we'll get to those in a short while.

In the double-density mode, the user can format disks for either 35- or 40-track operation—depending on the capability of the disk drives. The Radio Shack disk drives manufactured by Shuggart (and also supplied by some aftermarket computer-equipment dealers) are limited to 35 tracks. If the disk drive has a "-1" after the serial number, it was manufactured by Tandon or Texas Peripherals and can be configured for 40-track operation. A 35-track double-density disk has a capacity of 152K; a 40-track double-density disk has a capacity of 184K.

As for enhancements, just about every important feature of the new *Model III* computer becomes available on the *Model I* if the kit is installed. For example: there is a DUAL command for a simultaneous screen and line printer display. A disk space map is provided by the FREE command. Then there's a DO command with an auto start-up created through a BUILD file (in some systems that is called "job control"). Finally, what is already an excellent single-density BASIC is enhanced when the kit is installed.

Essentially, the double-density kit gives a *Model I* many of the advanced features offered by the *Model III*, and with no fuss at all, because it takes only one disk to boot up into double-density. The documentation is superb. It is clear, easily understood even by the novice or newcomer to personal computing, and is well organized—which is a lot more than we can say for most documentation supplied with personal-computer equipment. (However, there is a minor but important error. Do not follow the instructions and attempt a BACKUP command with a write-protect tab in place. You must remove the write-protect tab on the disk being backed up.)

For those who use only Radio Shack software or programs written in BASIC there will be no problems other than slower response with the double-density DOS. For example, a communications-terminal program that takes 8.5 seconds to load using the single-density DOS, requires 30 seconds using the double-density DOS, but that is one of the more severe cases. Also, Radio Shack does not provide any double-density software, but you can generally run single-density software in a single-density mode without modifications if it won't copy as a usable double-density disk.

Unfortunately, the same cannot be said of some of the most popular non-Radio Shack software. Once the double-density kit is installed you no longer can use your *Newdos 80 Version 1* disk at all; it won't boot. *Newdos 80 Version 2* disks will boot, but won't run in double-density. If you are a registered owner of *Newdos 80* software you can write Apparat for the patches (software corrections), and by all means do it. In particular, *Newdos 80 Version 2* is dynamite with Radio Shack's double-density kit.

Worse yet, neither *Superscript* with the Epson *MX-80* printer driver nor the Hexagon Systems spelling checker—two of the best pieces of software ever written for the *Model I*—will run in the double-density mode. In fact, it's as if most of the good software has been deliberately trapped out of double-density operation (which is not the case with non-Radio Shack double-density adapters for the *Model I*). The only non-Radio Shack software that appears to work consistently in

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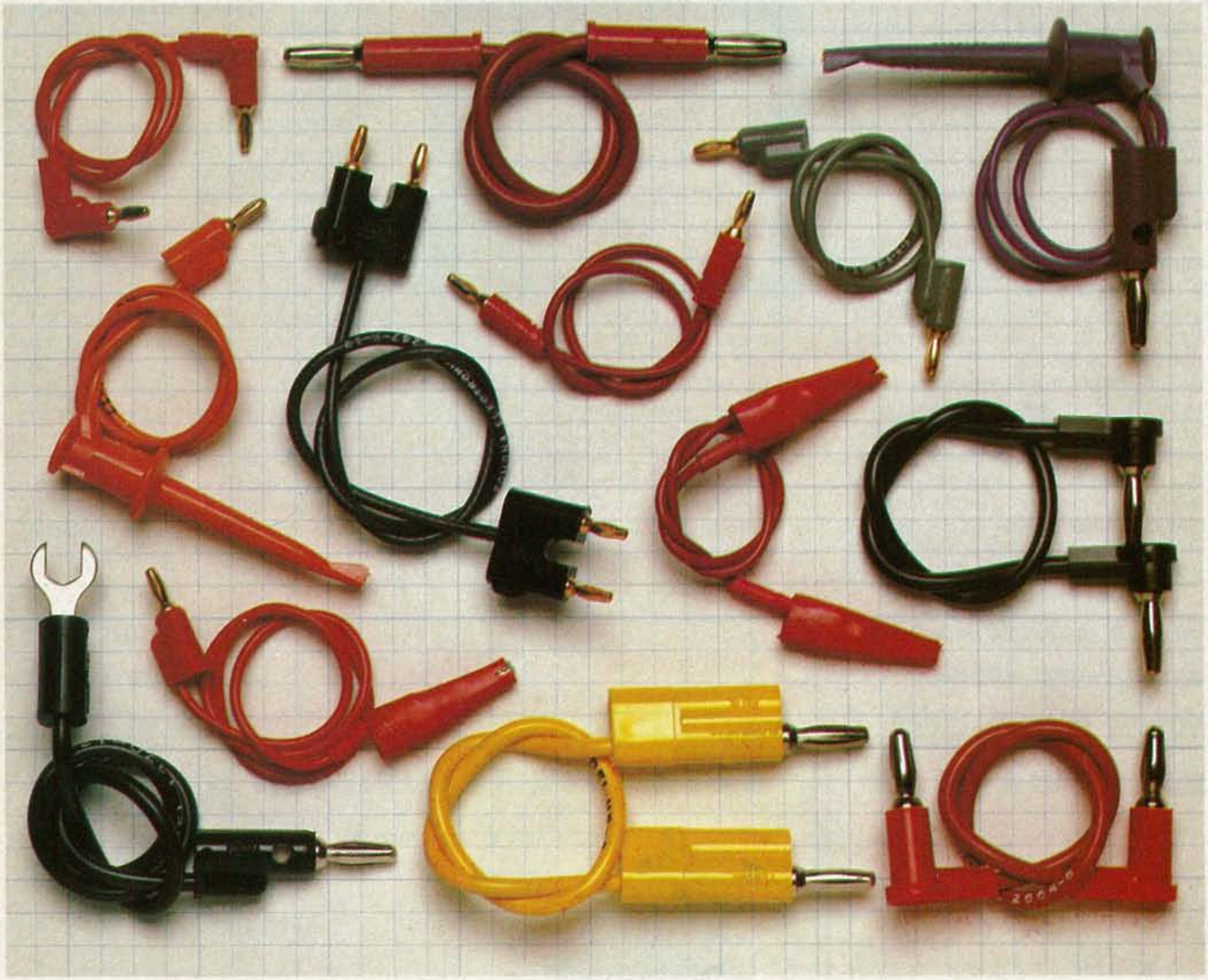

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the double-density mode are some game-type programs.

Essentially then, the double-density kit is mostly valuable if you use Radio Shack software, or programs you write yourself. However, if you want to run most of the top quality non-Radio Shack software, and/or have the full power of double-density, you must use the *LDOS* disk-operating system, Version 5.1. That is what Radio Shack should have supplied to begin with, and what they now sell as an accessory for $129. You can run *Superscript* and Hexagon's upgraded version of *Hexspell* under *LDOS*; in fact, you can even convert *Model III* software to run on a double-density *Model I* (only *LDOS* does this). *LDOS* is so extensive it's a bit of a pain to learn and use, but it's the only way to use *Model III* disks on a *Model I*.

If you use a *Model I* primarily to write your own programs, the double-density kit is an unquestioned value. But if you have substantial sophisticated non-Radio Shack software and operating systems, think twice about the kit because the software might not run in either single- or double-density modes unless you use a different DOS, and even then there are no guarantees. If you have a substantial investment in software you simply cannot afford to give up, try to locate someone using the double-density kit and try your software on their computer. **R-E**

Video Control ATOC III Video Controller

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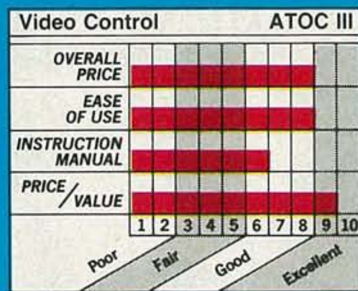

THE ONGOING VIDEO REVOLUTION HAS changed not only the way we watch TV, but also how we evaluate what we watch. By the last we don't only mean the content of the programming, but instead its video and audio quality. It's not surprising then that in addition to VCR's and videotape, the video revolution has given birth to another type of equipment. We're speaking about video accessories.

Video accessories is a term used to describe a wide variety of devices used to improve the audio and video quality of what you watch, as well those used to improve the flexibility of your setup. Those devices range from switch boxes and RF modulators to sophisticated broadcast-quality video processors.

The latest entry in the field is the *ATOC III* from Video Control (3314 H St., Vancouver, WA 98663). Rather than one accessory, however, that unit combines four of the most wanted and useful accessories into a single device. Let's now look at what it can do

Video enhancer

One of the chief problems with home videotaping is the cost of the tape itself. That's one reason why VCR's are now capable of cramming 5, 6, and even 8 hours of recording onto a single tape. But to do that, slower recording speeds must be used, which results in reduced picture quality. What's more, for a variety of reasons, picture detail and clarity can suffer when making recordings even if top-quality tape and top recording-speeds are used. That's where a video enhancer comes in handy. It amplifies the high-frequency video information, which in turn increases the apparent resolution of the video image.

The video enhancer section in *ATOC III* is easy to use. It is turned on by placing the B + W/COLOR/BYPASS switch in the

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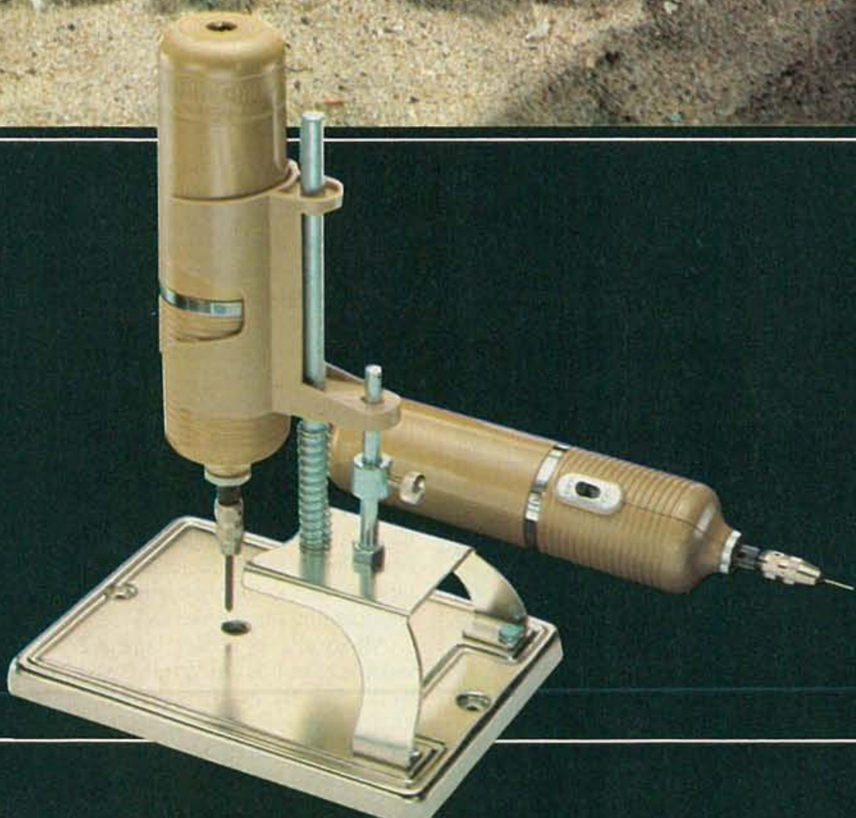

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appropriate position. The SHARPNESS control is then simply rotated to provide the degree of enhancement you prefer. One problem here, however, is that enhancing the high-frequency video information will also increase the high-frequency noise. That noise shows up in the picture as snow. That's the purpose of the FILTER control—when adjusted properly, it will get rid of the majority of that snow leaving you with the best possible picture.

To a great degree, the overall effect of the enhancer is determined by the system (TV, VCR, tape, etc.) that it is used with. In any event, however, the picture quality will be better than it would be without the device. The enhancer can also be used for recording. According to the manufacturer, if that is done, and if the SHARPNESS and FILTER controls are set fully clockwise, the enhancer will boost video signals about 10 dB at 2 MHz.

Stabilizer

Another effect of the rise of interest in home video is the corresponding rise in video piracy. That's not too surprising considering the high cost of pre-recorded tapes. What's also not too surprising is that tape distributors took strong steps to minimize that piracy as soon as they realized what was going on.

As a result, many schemes that alter the sync pulse-train came about. What those schemes do is make a tape copied from the original almost unwatchable, as the video will roll and/or jitter. The original, however, can still be viewed on a standard TV receiver.

At least that's what's supposed to happen. As it turns out, however, even the original can be unwatchable if it's viewed on a TV-set with a limited range vertical hold, or on some pre-1977 models. That's the where the stabilizer on the video control comes in. It eliminates the roll and jitter associated with tapes recorded using such anti-copy systems. It's use is again very easy—just turn it on using the ON/BYPASS switch, and rotate the LOCK control until the picture "locks in."

RF modulator/distribution amplifier

The video controller also features a full-range RF modulator, as well as a distribution amplifier capable of driving up to three VCR's. The modulator has seperate LEVEL and CONTRAST controls, and its output is front-panel switchable between Channel 3 and Channel 4. The LEVEL control varies the amount of signal coming from the unit, while the CONTRAST control sets the picture's contrast.

The inclusion of the distribution amplifier allows copying videotapes (even up to three copies at a time) while minimizing the losses usually associated with that procedure.

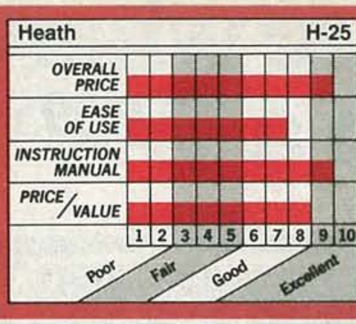
The *ATOC III* is housed in a single, compact, brushed-aluminum cabinet. Input and output connections are done using a series of rear-panel phono plugs. One minor problem here is that a lot of pieces of video equipment use "F"-connectors rather than phone plugs. But, all that means is that, if your cables are already terminated with "F"-connectors you'll need to purchase a couple of inexpensive adaptors.

The unit requires 12-volts DC for power. Because of that, it can be used for field or remote applications as it can be powered from a portable VCR's batteries. A 12-volt DC wall-plug-type power supply is provided for home use.

The manual provides simple step-by-step instructions to get the unit up and running in a matter of minutes. It also gives a very brief discussion of the various functions and illustrates four sample applications. But, unfortunately, that is about all that's included. It would have been nice to see some technical information, as well as more on some of the other applications for the device.

All-in-all, however, the *ATOC III* video control is an attractive unit that works exactly as claimed. And another nice feature is its price. If you were to buy separate units to do all of the things that this one does, you could easily spend over \$400.00, and wind up with a rat's nest of wiring. On the other hand, the suggested list price of the *ATOC III* is just \$279.95, and it's well worth it. **R-E**

Heath Model H-25 Printer



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MOST READERS OF **RADIO-ELECTRONICS** have assembled at least one Heathkit, and are familiar with their "goof-proof" instructions, large illustrations, and easy-to-comprehend steps. Up until very recently, the emphasis was towards electronic devices ranging from simple test equipment to full-function, digital computers—with a host of things in between. The *H-25* Dot Matrix Printer is not your usual step-by-step, solder R13 to J4 on P9 type of manual or kit; instead, it is primarily a mechanical assembly with, to say the least, very little electronics assembly involved.

If you have ever examined the inside of a printer, be it a daisy-wheel or dot matrix, you were immediately aware of the fact that, regardless of the manufacturer, the printer was heavily oriented towards mechanical assemblies, and perhaps compressed the electrical/electronics section to a small printed-circuit board.

Essentially, we have just described the "generic" printer, but there is nothing "garden-variety" or plain about the *H-25*. It is specified as a high-speed dot-matrix printer capable of speeds of up to 150 chracters-per-second and handles paper from label size to the oversized forms we are used to seeing in commercial computer installations. What sets this printer apart from the standard Heathkit line is the fact that the *H-25* kit, like other printers currently available, is primarily mechanically intensive in design and assembly.

The kit comes in two boxes, one small and one large. The smaller box, by the way is the heavier of the two. The large box contains the molded cabinet, chassis, and power transformer. The smaller box contains the internal workings and parts that make up the final printer. Of particular interest is the method in which those boxes are packed and the parts identified. There is a chart that you will find as soon as you open the box with a "map" of sorts telling you precisely where each pack of parts is located and its identification number. That permits you to unpack only those components you will be working with, and allows the kit-builder the option of using any convenient work surface—even the kitchen table—to build the printer on.

Assembly is broken into small-easy-to-handle stages with the first being the assembly of the Circuit Control Board. That small printed-circuit board contains the control panel that allows you to select: on/off line; forms alignment; top of form; buffer clear, and reset. The board is probably the most electronic-intensive portion of the entire kit, and requires less than an hour to complete. There really isn't all that much to it as it consists of a few LED's, an IC, and some switches, together with a flat cable assembly.

The electronics assembly is now essentially over. The first phase of the mechanical assembly centers around the assembly of the carriage, with the bearings and other components that form the mechanics of the carriage and stepper-motor for the print-head assembly. Those were no surprises and the mechanical assembly was well-supported by an almost lavish use of illustrations.

Moving right along, the assembly steps

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to the printer chassis where, besides mechanical construction, you do have some opportunity to use a soldering iron, although only to make up some interconnecting plugs. Here the soldering will involve spring clips that will be inserted into connectors. It would be wise to have some sort of a protective covering on your work surface to prevent scratching both the painted chassis and the surface you are working on. A ruler becomes quite useful and some caution as to insuring that you have selected the correct factory-assembly cable is in order. You also get a chance to use a ruler and pliers, while aligning shafts, installing pulleys, belts, and a number of other purely mechanical components.

The last phase of the purely mechanical assembly involves the Paper Drive Unit. That unit has a unique sensor that uses a mechanical disk rotating between an LED and a photo-transistor that forms an audible alarm to alert you to either a paper jam or "out-of-paper" condition. The sensor-disk is a plastic casting and according to the instructions could have burrs. We strongly recommend that you follow the cautions and suggestions as to inspection and deburring to insure that the disk will rotate freely. If you fail to follow those steps, there is a possibility that the sensor system will fail to operate.

The assembly stage is completed with the installation and alignment of the tractor bars and rather sturdy (yet plastic-molded) sprockets. Following that alignment procedure, the previously assembled stages are integrated into a hinged printer configuration that allows the assemblies to tilt-out for maintenance as well as paper loading.

The electronics section is now wired, if you can call making a few connections to a bridge rectifier and terminating cable assemblies wiring. The three factory-wired-and-tested printed-circuit boards containing the logic, driver and printer-motor controls are installed and interconnecting cables are terminated. At that point, there are two different levels of tests you can make. One relies on the LED indicators on the circuit boards; the other assumes that you own a VOM, and consists of a series of voltage and resistance tests.

With the mechanical and electronic/electrical assembly out of the way, your attention is directed to the cabinet, where you will assemble the two halves into a very functional and attractive cabinet. Despite the fact that the cabinet is molded plastic, an interesting construction technique is used, whereby you gently heat threaded brass inserts with a soldering iron. Those heated inserts work their way into pre-drilled holes in the cabinet halves and form the threaded "bases" for the final assembly.

Perhaps the best part of the *H-25* Printer, is not the printer itself, but rather the detailed and complete documentation. The two manuals cover assembly, test trouble shooting, an excellent section on configuring the printer, as well as your operating system. The printer operates with virtually any computer with an RS-232C interface and it also offers a TTY-type 20-mA current-loop interface as a standard feature.

A built-in self test allows you to test and adjust the printer whenever the need arises, and a variety of type sizes, are available under either software or hardware-control (a series of DIP switches located on the rear panel allow custom-applications programming). There is an empty IC socket that will soon be used to hold a special character ROM to further enhance the already impressive characteristics. The printer is capable of printing the full ASCII character and the *H-19* graphic set.

Considering the complexities involved in printer design and manufacture, it is quite novel to see and experience first-hand the first and probably only commercial grade dot-matrix printer available anywhere in kit form, which was obviously designed in such a manner that the printer could literally and actually be assembled on a kitchen table. There isn't another printer selling for under $1000.00 that can make that statement. The model *H-25* printer sells for $899.00 in kit form. **R-E**


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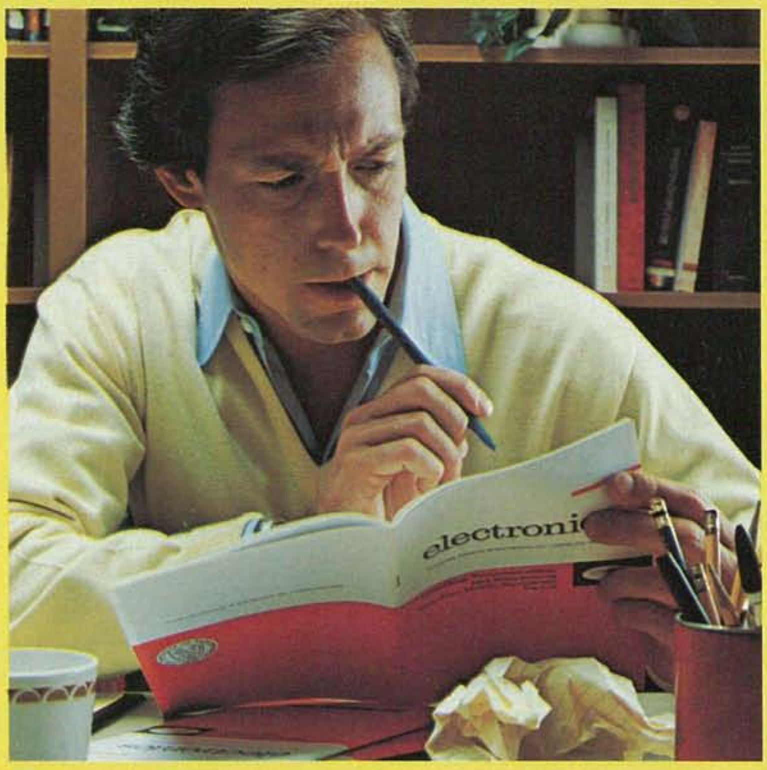

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CIRCLE 73 ON FREE INFORMATION CARD

INSIDE A 757–767 COCKPIT

State-of-the-art technology, in the form of an Automatic Flight Control system, has been incorporated into the Boeing 757/767 aircraft. Here's a look at the new system and what happens behind closed cockpit doors when you fly the new plane.

MARC STERN

"THIS IS YOUR CAPTAIN SPEAKING! WELCOME ABOARD AUTO AIRLINES Flight 203. This aircraft is entirely computer controlled, so relax and enjoy the flight. This system has been engineered so that nothing can go wrong, go wrong, go wrong...."

Everyone has probably heard a version of this rib-tickler, after all it's been around in one form or another since the early days of the computer revolution. And, just as likely, most people have probably chuckled at it and put it out of their minds. If it was thought of, it was probably dismissed as science fiction.

But, today it has become science fact with the introduction to regular service of the Boeing 757/767 series of wide-bodied airliners. Microcomputers can fly this plane from takeoff to destination.

The electronic componentry that the 757/767 sports makes those airliners not only the easiest to fly, but also the most fuel-efficient, sophisticated, and safest in the air.

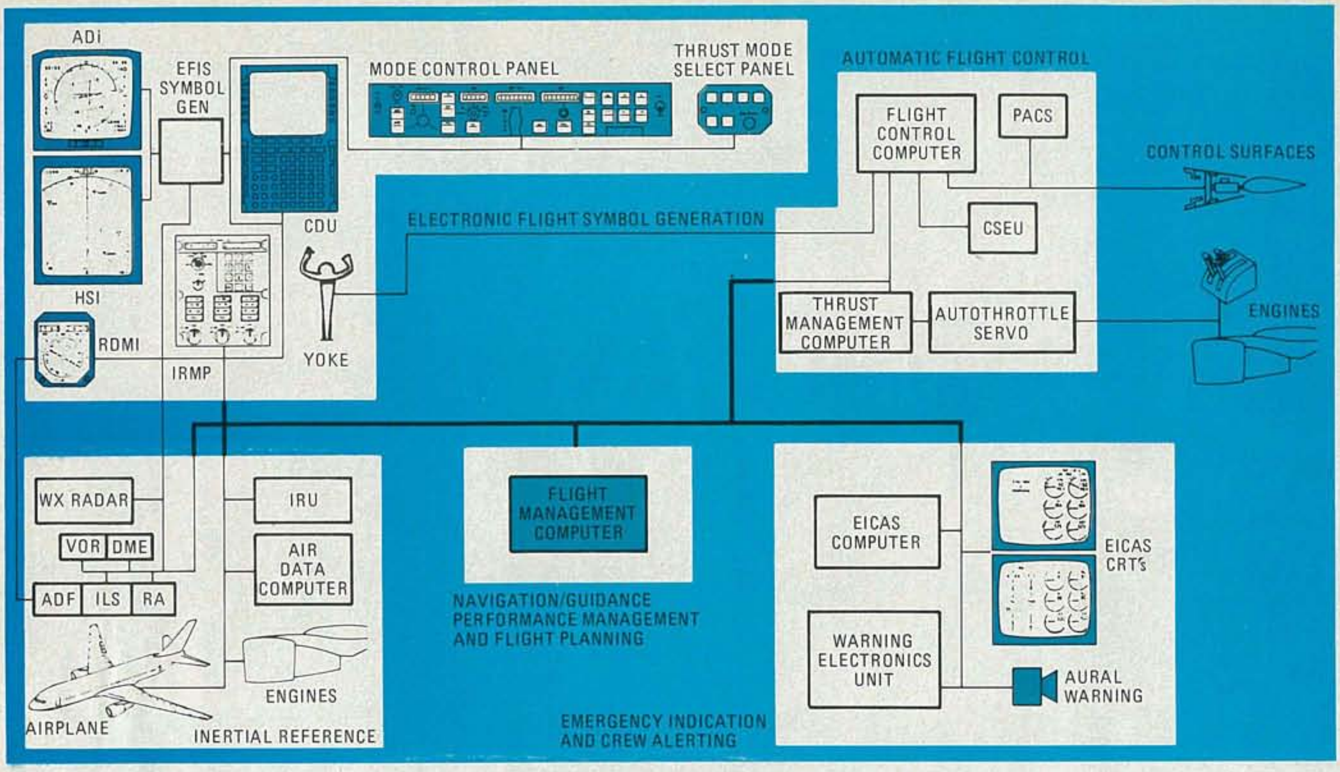


FIG. 1—THE MAJOR SYSTEMS and subsystems of the Automatic Flight Control System on the Boeing 757/767 aircraft.

In the beginning

Impetus for this concept came with the first oil embargo 10 years ago. The airline industry found itself with a fleet of fuel-hungry jetliners and it had to find some way to make its aircraft more efficient. Thus the research for the new aircraft began.

Luckily, the time was right for the airline industry. The digital microprocessor revolution was exploding. Earlier digital computers had been both too large and costly for installation aboard the average airliner. Almost immediately, researchers saw the possibilities of the new computers and began working with them.

Some of the groundwork was already laid with the digital avionics package slated for the SST (*S*uper*S*onic *T*ransport) that was later scrubbed. It was continued during the NASA/FAA Advanced Avionics Program that aimed at developing advanced displays and flight-management systems. A Boeing 737 was configured into a test vehicle.

Work on the research 737 incorporated digital flight controls, a digital navigation and guidance computer, and digital instrument displays. The program also gave the first practical demonstration of four-dimensional navigation, in which an airliner's flight in all spatial planes, as well as speed, were controlled. That allowed the time of arrival at specific locations to be calculated precisely.

Military work on the YC-14 Advanced Medium STOL prototype and the B-1 bomber further advanced the computerized flight deck. It provided experience with an advanced attitude direction indicator that had many of the features now built into the 757/767 system. It further aided the integration of all the systems, including software.

Early problems

According to Boeing, the most troublesome problem in the early development was the lack of an acceptable interface for the major subsystems. Thus, much research focused on finding a standard through which all the control systems could be interfaced.

That task was given to Aeronautical Radio Inc., an airline industry-sponsored think-tank, which in its earliest days was responsible for standardizing avionic communications. ARINC began its work and eventually developed the necessary standard.

Called ARINC Standard 429, it is a serial communications bus designed for the requirements of commercial airliners. That standard operates at 12.5 and 100 kHz over 122 twisted, shielded-pair interconnections.

It carries information to and from the system components asynchronously. Data is sent one bit after another, with the appropriate start and stop bit ahead and behind each digital instruction.

That network ties together all the pieces of the Boeing Flight Management System. Through it, data can be fed to the master component, the Flight Management Computer (FMC). The FMC "listens" to and "talks" with all the other members of the avionics management system and interprets the information fed to it.

Each major subsystem uses a separate interface bus. For instance, the Flight Management Computer and the Electronic Flight Instrument System each listen on 23 buses. Thus a unit may have anywhere between 11 and 23 transmitters and receivers incorporated within its integrated circuitry. Non-FMS digital systems, such as the anti-skid and flap control systems, also use the ARINC system.

Additionally, another ARINC standard—453—runs at a higher data rate, 1 MHz. Capable of handling more information more quickly, it is much like Standard-429 and links the weather radar receiver/transmitter with the Electronic Flight Instrument System (EFIS) Symbol Generators. EFIS generates the display data on each pilot's high-level, color graphics CRT display unit. Those displays replace many of the traditional readouts associated with an airliner's instrument panel.

The data flowing back and forth on those buses constantly update not only the FMC, but also each linked subsystem as needed. Each electronics package "hears" only data intended for it on the party-line system. The network has been engineered so that each byte of data is encoded with special start and stop bits. Only those segments of the system that are capable of decoding those bits are affected by a particular command.

Thus, if a data byte is supposed to be used only by the Automatic Flight Control System, the other major subsystems will ignore it.

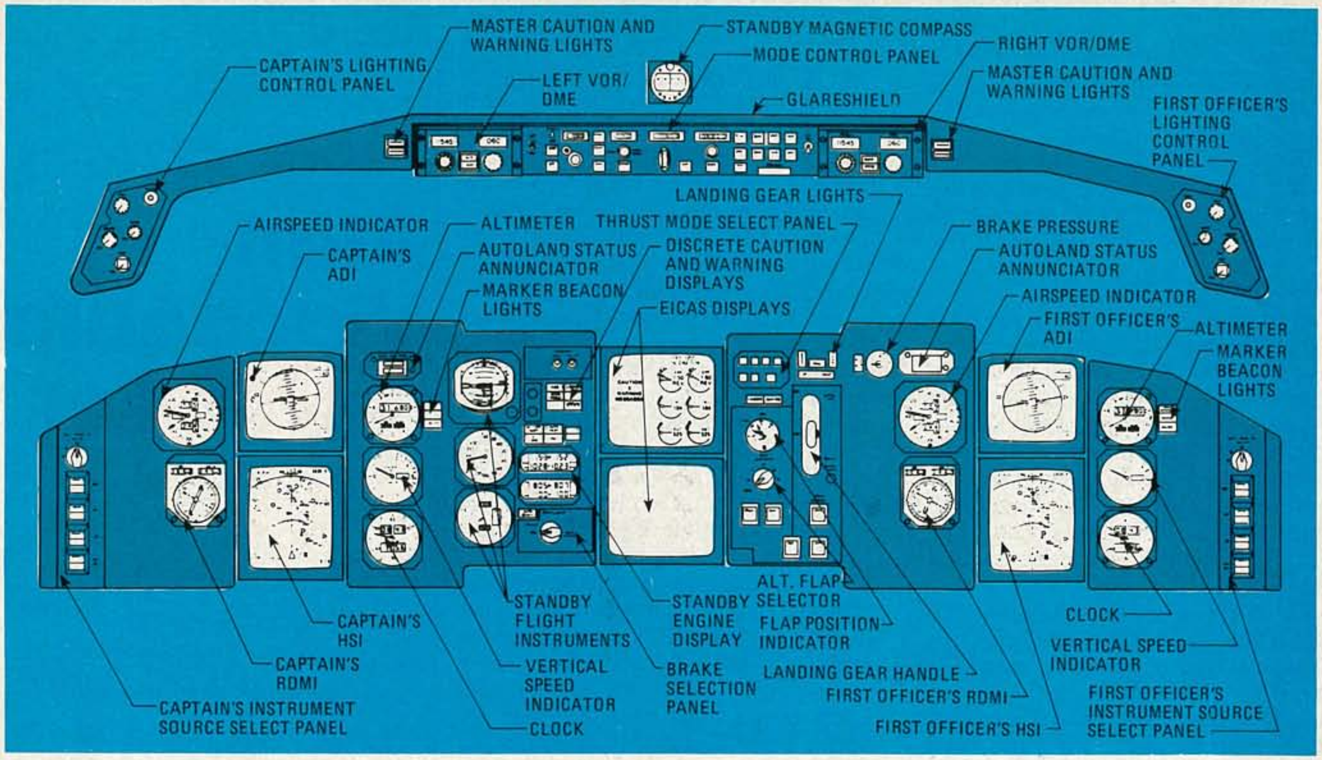


FIG. 2—THE INSTRUMENT PANEL inside the cockpit of the 757/767 aircraft.

The major subsystems

The entire Flight Management System is made up of four major subsystems, as shown in Fig. 1. These four major subsytems are the Automatic Flight Control System, the Inertial Reference System (navigation), the Emergency Indication and Crew Alerting System, and the Electronic Flight Symbol Generation System. Each major subsystem, in turn, has its own microprocessor-controlled subsystems.

Each of the major subsystems is able not only to communicate with the FMC, but it is also able to communicate with other subsystems of its own system. Thus, you can appreciate the complexity of the total package.

Not only is the total Flight Management System characterized by state-of-the-art subsystems; it is also characterized, as noted, by high-level graphic displays. No longer is there a multiplicity of dials and gauges staring at the pilots. Instead, there are no less than five major CRT displays facing the pilots. (The primary responsibility of the Electronic Flight Control System is to generate the complex graphics for the CRT displays.)

One CRT display—the Control Display Unit (CDU)—details the information from the Flight Management Computer. That includes information about the status of the flight in progress, including such things as climb and cruise modes, radio tuning, NAVAID tuning, and departure and arrival times. A second display—the Horizontal Situation Indicator (HSI)—displays a roadmap of the airliner's flight path. It can also overlay such functions as the weather radar display. Together, both displays allow the flight crew to make the fullest use of the Flight Management Computer's ability to determine the best and most economical paths for climbing, cruising, and descending.

A third CRT display, the Attitude Direction Indicator (ADI), is very much like the common non-electronic unit in that it displays the plane's pitch, yaw, and roll. The ADI display is located directly above the HSI, and both are located directly in front of the pilot. Duplicate ADI and HSI displays are located in front of the co-pilot. Figure 2 shows the location of all the displays on the instrument panel. Both CDU displays (one each for the co-pilot and pilot) are located on the center console between the pilot and co-pilot and are not shown in Fig. 2.

The fourth and fifth CRT displays are for the Engine Indicator and Crew Alerting System and those are located on the instrument panel between the pilot and co-pilot. Those display the engine indicators and such things as the gear not down, forward cargo fire, aft cargo fire, etc.

Of particular note is the level of interaction possible between the computer and the pilot. The CDU not only features fixed-functon command keys, but also another alphanumeric keyboard with which the pilot or co-pilot can input data.

Once that data has been input, it is digested by the 16-bit (Texas Instruments TMS9900) microprocessor-driven FMC and the changes are displayed on the HSI.

At that point, the changes to a flight plan are not cast in stone. The pilot can then reconfigure the flight plan and look at the new parameters. If he likes them, he hits the EXECUTE key and the new parameters are used to fly the aircraft.

Interestingly, the captain or first officer can address the CDU with terms similar to those used in Air Traffic Control, so there is no great amount of language relearning necessary, making the system user-friendly.

To handle those chores, the basic Flight Management Computer incorporates a 4-million bit non-volatile memory that stores the performance and navigation databases and operating programs.

The navigation database is capable of storing an aircraft's flight path, including both the current one and any planned revision, together with airport terminal-area procedures. Growth capability has also been incorporated for future advances without the necessity of changing hardware. For real-time updates, the FMC also contains a read-write disk memory.

Another of the primary interfaces between the pilot and computer is the Mode Control Panel, located on the pilots' glare-shield. That provides a centralized panel for all autopilot control functions. Heading, altitude, vertical speed selection, and hold modes are available, as well as the backup pushbutton selectors necessary if the system should fail entirely. It also allows automatic tracking of the flight plan in lateral and or vertical dimensions.

One of the most notable features of the computerized flight deck is its level of redundancy. For instance, not only is there one FMC for the pilot, but there is another for the co-pilot. The plane can fly with either FMC or manually.

If a major failure should occur, then backup liquid-crystal-display gauges and dials take over and provide critical readouts in place of the FMC.

Other subsystems

While the linchpin of the system is the FMC, there are other subsystems that are also important. Take the Flight Control Computer, for example. It receives inputs from the Inertial Reference System (IRU), the Flight Management Computer, the Thrust Management Computer, the Air Data Computer, the Radio Altimeter (RA), the Instrument Landing System (ILS), and the Control Wheel force transducers.

The Flight Control Computer commands the airliner's control surfaces (flaps, etc.) and engines, and responds to changing conditions by automatically altering their settings. Thus, if it appears that it would be more economical to fly over a storm than through it, the Flight Control Computer causes the plane to climb and bank in response to the new inputs.

While that is taking place, another segment of the system—the Thrust Management Computer—is computing and displaying autothrottle functions. It integrates signals from the engines, Air Data Computer, Thrust Mode Selector Panel, Flight Management Computer, and the throttle to provide autothrottle functions for all flight conditions.

For instance, with the throttles at full forward, the Thrust Management Computer provides maximum allowable engine power without exceeding operating limits. Further, performance management functions are performed in concert with the FMC, Autopilot Flight Director System, and other systems. Throttle changes during command operations, such as flight level changes, are performed automatically. And, in the event of a missed approach, the Thrust Management Computer provides the maximum allowable thrust when go-around is commanded by the flight crew.

Of even more interest from a technical standpoint is the new Inertial Reference Unit (IRU). While many people are somewhat familiar with the typical gyrocompass, the IRU uses a laser-controlled gyro for positioning. Unlike the traditional gimballed gyrocompass, there is only one moving part.

Called a Ring Laser Gyro, it uses a split laser-beam travelling in opposite directions around a closed triangular path. When angular motion is introduced, a frequency difference is detected and measured by photodiodes. That is converted to a digital output for use in the IRU computer. Three laser gyros are required for each IRU system, one for each axis.

In the align mode, the IRU is able to align itself to the local vertical, true north and an estimated latitude by gyrocompassing. No heading reference is required, because the IRU analyzes the spin vector generated by the earth's rotation to compute true north. Initial positioning must be entered through the Inertial Reference Mode Panel (IRMP). However, the last position of the previous flight can also be used to allow the IRU to compute a magnetic heading. The IRU also provides similar functions for navigation and attitude.

From all of that you can appreciate the level of sophistication needed not only in the hardware, but also the software. The programming for the Flight Management Computer alone took more than 100 man-years to create, test, and debug. It was then sent through exhaustive testing not only by the Boeing Co., but also by the Federal Aviation Administration.

It is a highly structured program, says Larry Bowe, head of engineering for Sperry Flight Systems, developer of the FMC. It's also a very capable one. It's possible for a pilot to program route and destination into the FMC and then let the computer fly the plane from takeoff to touchdown. Further, it will also alert the crew via the Engine Indication and Crew Alerting System that something is amiss in time for the pilot to take over.

The beauty of the total package is that it frees the pilot from many of the chores that he used to do manually. No longer does he have to compute the weight, temperature, weather, wind, and other parameters for a takeoff. With a few button pushes, the system does it for him. Long, in-flight computations are also eliminated. Thus, the pilot can now become a flight manager.

Pilot reaction

Pilots are ecstatic about the results. They like the displays and the possibility of using less fuel. They also like the Boeing "quiet, dark cockpit" concept, in which indications of system operations are reserved for conditions that require actions by the flight crew. There are very few distracting lights that signify normal operation on the flight deck.

In addition, the major functions of operation, status, and maintenance have been separated so they may be brought to the attention of the flight and ground crews selectively as they are needed.

So, what began as an attempt to save fuel by the airline industry has now turned into possibly the best aircraft in the air. In fact, if you fly on it, you'll never know whether the computer or the captain is doing the work.

Next month we'll present a detailed description of the displays and major subsystems of this system. **R-E**

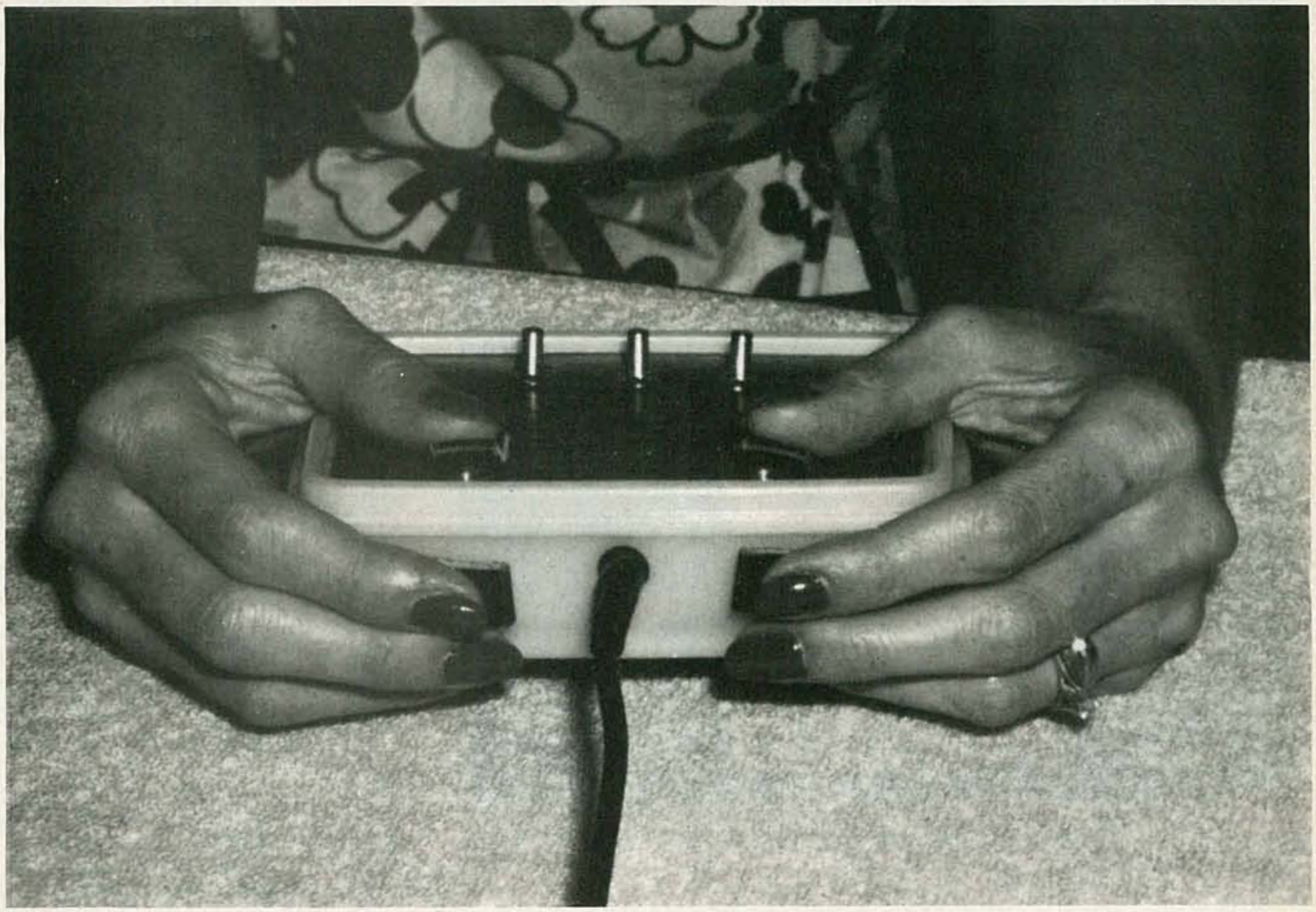
BUILD

Atari Videogame Controller

Add excitement and high scores to your home videogame. This easy-to-build joystick replacement for your Atari VCS gives you improved control plus a rapid-fire option and a tilt-activated fire switch.

DAVID J. SWEENEY

IF YOU ARE THE PROUD OWNER OF AN Atari *VCS* home videogame, you've probably spent more than a few evenings at home nursing a pair of rather sore hands. The reason why is that the Atari joysticks, which despite their shortcomings are still considered to be among the best available, are built to endure the excitement and pressure generated while shooting down those Space Invaders, or what have you, but your hands most certainly are not. Partially because of that, and partially because videogame players are always on the lookout for anything that might help improve their score, a whole industry (although, granted, a small one) devoted to supplying aftermarket game controllers has sprung up. Most of those, however, are simply better (we hope!) joysticks. What about a different approach? The joystick replacement described here, which, incidently, does not resemble a joystick in any way, will add a new dimension to your home videogame action. Among its advantages are that it is easily built, comfortable to use, and adds a couple of features not found in the standard Atari units—those are repeat-fire action and a tilt-controlled switch. What's more, the project is very economical to build and operate.



A SANDWICH BOX covered with wood-grained paper makes an inexpensive case.

Comparing the controllers.

The controller that is supplied with the Atari videogame system (see Fig. 1-a) uses five compression switches to control the game action. Four of those switches are operated by the joystick; the fifth is controlled by the red FIRE button; for simplicity's sake, we'll call those five switches UP, DOWN, LEFT, RIGHT, and FIRE (see Fig. 1-b). All of the switches are momentary, normally open, SPST types. Game software is designed so that the action on the screen is controlled by the opening and closing of those switches, which, in turn, is controlled by the movement of the joystick. In other words, if you move the joystick to the left, it will close the LEFT compression switch (more on that shortly), and the software will move the appropriate object (gun, ship, Pac-Man, etc.) to the left; moving the joystick up will move the object on the screen up, etc. Moving the joystick diagonally closes two switches at once, moving the object diagonally.

Any joystick substitute must also provide an arrangement of five switches. This device uses four pushbutton momentary SPST switches and one internal tilt-controlled mercury switch. Figure 1-c shows the location and function of those

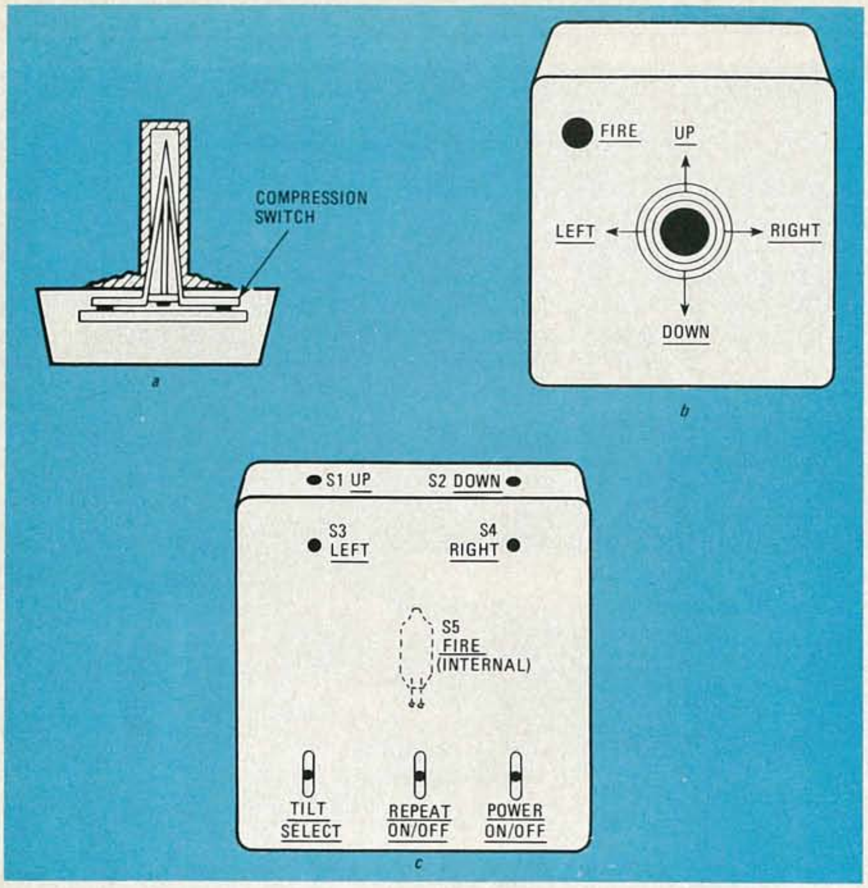


FIG. 1—ONCE YOU GET USED to the switch positions on the controller you're likely to throw your original joysticks away!

TABLE 1

	Switch	Location/Function	Joystick equivalent
Game switches	S1	Left forefinger	Up or Fire*
	S2	Right forefinger	Down
	S3	Right thumb	Left
	S4	Left thumb	Right
	S5	Internal	Up or Fire*
Setup switches	S6	Power on/off	—
	S7	Repeat on/off	—
	S8	Tilt select	—

*Selected by S8

switches, as well as the unit's three others—POWER ON/OFF, TILT SELECT, and REPEAT ON/OFF. Note that the Atari joystick's UP, DOWN, LEFT, RIGHT, and FIRE switches are replaced in our new controller by S1, S2, S3, S4, and S5 respectively. However, the function of two of those switches (S1 and S5) can be interchanged by using the TILT SELECT switch. That lets you choose whether you want to use the tilt switch (S5) to control firing or the upward movement of the object on the screen. Needless to say, whichever function is not controlled by the tilt switch will be controlled by S1. The switch functions/locations of our substitute controller, and their corresponding joystick functions, are summarized in Table 1.

As you can see in Fig. 1-c and the photos, S1-S4 are located so that they can be easily pushed by your forefingers and thumbs when the controller box is held. You're sure to find that this setup will make playing almost any game less tiring, and more enjoyable.

The circuit

The schematic diagram of the replacement controller is shown in Fig. 2. Aside from the switches we've already discussed, the bulk of the circuitry involves the repeat mode. Switch S7 is used to select either that or the single-shot mode.

In the repeat mode, you no longer need to push a button each time you want to fire a shot. Instead, each time you press the FIRE button or tilt the controller, depending on how the TILT SELECT switch is set, shots are fired at a rate of about 10-per-second for as long as the fire switch is pressed or the unit is tilted. The circuit used to do that is relatively simple, involving mainly a 555 IC oscillator and a reed relay. Basically, the oscillator is configured to open and close the relay at a rate of 10 Hz which, is about the fastest rate that you achieve manually. There is one other thing we should point out here: some games limit the number of shots you can take at a time—in Space Invaders, for instance, you can not take a second shot until the first has completely cleared the screen. Our controller can not override the software and change that.

Construction

Building our videogame controller is almost easier than describing it; it involves little more than installing the switches and repeat-mode circuitry into a suitable case. Let's turn our attention to that case for a moment. Considering the simplicity and low cost of our controller, it would seem a waste to house it in something that would cost more than the device itself. But, on the other hand, some sort of attractive case would be desirable. We decided upon a rather nice, if unlikely, compromise. The case you see in the photographs is nothing more than a refrigerator sandwich box, the kind that you can get in any discount store or supermarket; we dressed it up a little by putting some wood-grained self-adhesive paper on the lid. In use, we found that the case is easy on the hands and that it stands up well to the stress and perspiration sure to be generated when playing any videogame. In fact, the case has withstood eight months of hard use by a variety of players with no visible bad effects.

One problem did develop concerning the switches. First of all, they are rather small and easy to miss in the heat of "battle." Also, use over extended periods of time resulted in quite a bit of wear and tear on the fingers. The solution to both those problems was rather simple—an old belt was cut into strips that were used as switch covers. The strips (which measure 1 × ½ inch) are installed simply by punching a hole in one end and screwing them down next to the pushbuttons so that they lie over them.

The repeat-mode oscillator can be built using any construction technique and parts placement is not critical. The oscillator used in the prototype was built on perforated construction board and point-to-point wiring was used. The mercury TILT SELECT switch is mounted on the oscillator circuit board using a Velcro fastener as shown in Fig. 3. That mounting technique was used to allow for easy switch replacement in the event that it ever becomes necessary. The battery holder was made from a strip of aluminum that was shaped to fit the battery and secured as shown.

PARTS LIST

All resistors ¼-watt, 5%, unless otherwise specified

R1, R2—150 ohms
R3—47,000 ohms
R4—10,000 ohms

Capacitors

C1—2.2 μF, 50 volts, electrolytic

Semiconductors

IC1—555 timer
RY1—5-volts DC relay (Radio Shack 275-240 or similar)
S1-S4—SPST normally-open pushbutton
S5—mercury switch (Radio Shack 275-027 or similar)
S6—SPST toggle
S7—SPDT toggle
S8—DPDT toggle
B1—9-volt battery

Miscellaneous: cord from Atari joystick, case, perforated construction board, hardware, strain relief, battery clip and holder, etc.

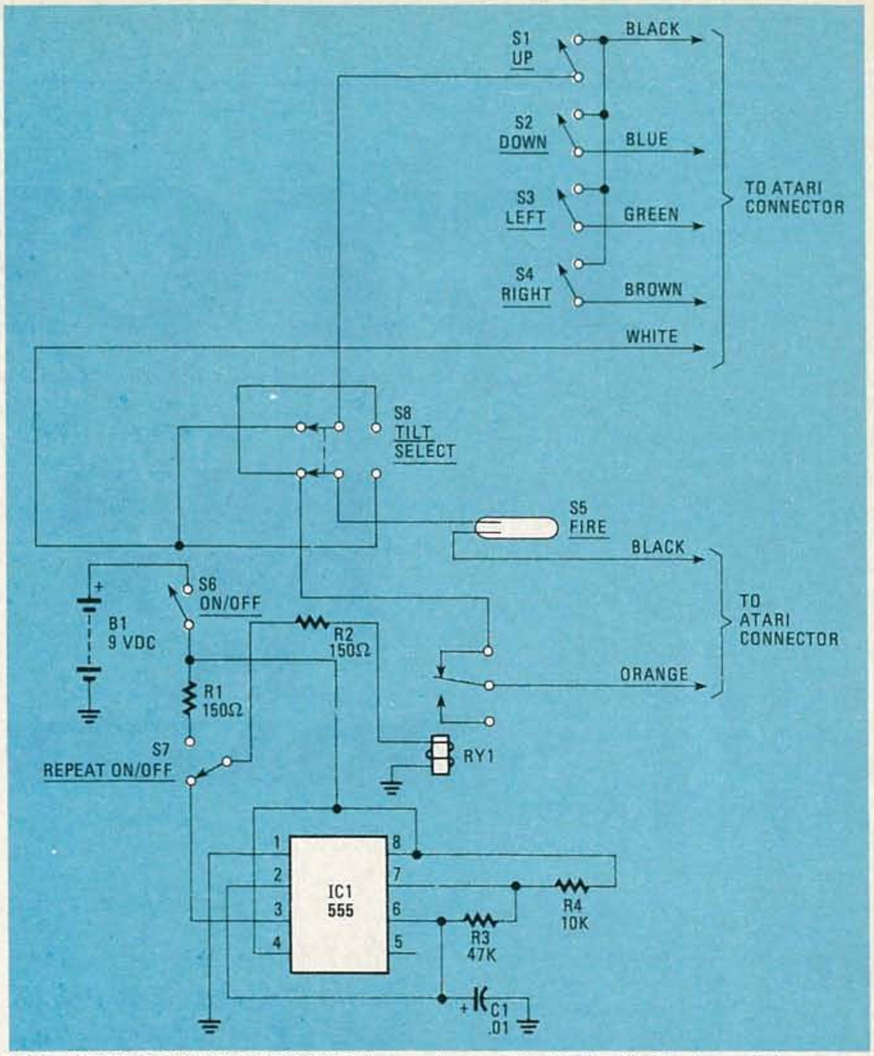


FIG. 2—HOOKUP OF THE CONTROLLER is easy because the Atari cable is color coded.

Before installing the oscillator in the case, check it for proper operation. The easiest way to do that is to apply power and check to see if the relay opens and closes at a rate of between 8 and 10 times-per-second. Also, it is very important to make sure that there are no shorts in the circuit. Keep things as neat as possible—if the nine-volts from the battery were somehow applied to the controller's outputs, costly damage to the Atari console might result.

Hooking it up

To attach the controller to the console, you can use the cable and plug from an old controller, or you can make up your own 6-conductor cable. If you would rather not cannibalize a controller and wish to make your own connector, the pinout diagram shown in Fig. 4 can be used to help you wire a standard DB-9S socket for direct connection to your Atari console. (Note that both black wires in Fig. 2 are connected to the same terminal on the DB-9S.) In either event, the multiconductor cable should be connected to a terminal strip as shown in Fig. 3, and all subsequent connections should be made from that strip. As always, be sure to provide some type of strain relief for the cable where it enters the case.

Aside from the relief the controller provides for your hands, the tilt switch and the repeat function allow you to play almost any game more aggressively. The sensitivity of the controller could pose a problem in games that require a light touch, such as Activision's *Skiing*, but should help you get higher scores when you play most other Atari-compatable games. You'll need a bit of practice to master the different motions required by the controller, but once you do, and once you see the kind of scores you'll be running up, you'll probably never go back to the standard Atari joysticks. **R-E**

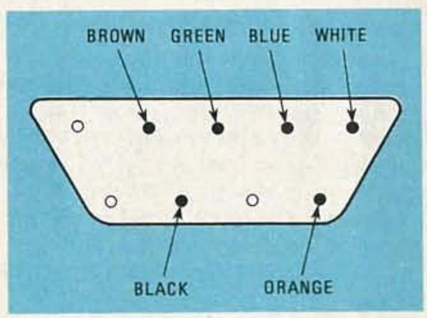


FIG. 4—THIS PINOUT of the socket on the Atari joystick cable can help you to wire your own DB-9S socket.

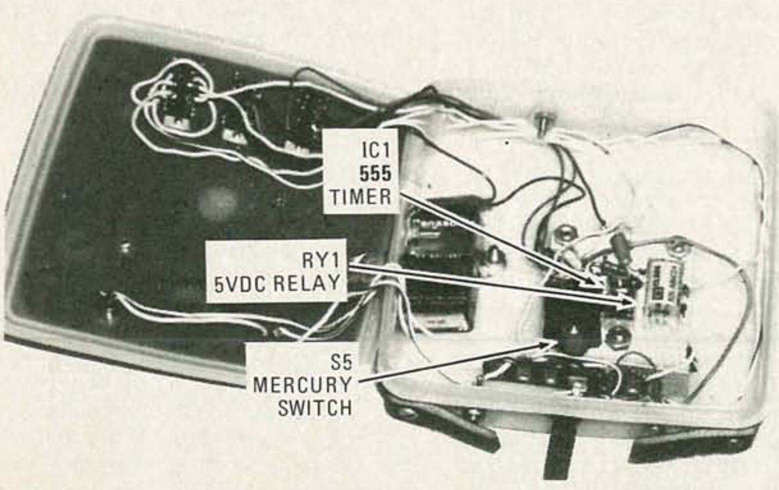


FIG. 3—TILT-SWITCH SENSITIVITY can be made adjustable by mounting the Velcro fastener on the wall of the case instead of on the circuit board.

ETCH YOUR OWN PC BOARDS

Don't let the fear of making PC boards stop your project cold. Let us show you the easy way to make even complicated boards.

ROBERT GROSSBLATT

Part 3 WE HAVE ALREADY shown you how to design a PC board layout and how to make a photo mask. Now we are ready to make the foil mask—the first step in transferring the pattern onto the PC board.

Making the foil mask

One of the things you'll need to make the foil mask—the film that's used to produce the PC board—is a contact frame. You have two options here. You can either spend a lot of money and get one in a camera shop or you can buy a cheap picture frame—the kind into which you slide a photograph; once the photograph is in place, it's held tight against the glass.

Working under the safelight, cut a piece of black paper to fit the inside of the frame and put a fresh sheet of film on top of it, emulsion-side-up. Put the positive you've just made on top of it, emulsion-side-down. Sandwich the whole thing together in the frame and use the light from the slide projector to make the exposure. If you are using a picture frame, be sure that the film is pressed tightly against the positive and that the positive is pressed tightly against the glass; if needed you can use cardboard inserts to accomplish that. Keep everything as dust free as possible.

The length of the exposure should be the same as the one you used in the last step, (see Part 2 in January's **Radio-Electronics**) as long as you keep the distance to the slide projector the same. After you develop that piece of film you will have a full-size negative of your foil pattern. The only thing you need to do with it is to check the clear areas and scrape them clean.

Hold the negative over a strong light to make sure that the black areas are completely opaque and that there aren't any pinholes in them. (Pinholes are tiny clear areas that are caused by dust getting trapped between the two pieces of film when the exposure is made.) Although there are special dyes available to correct pinholes, I've found that the white correction-fluid used to fix typing errors works well for small ones (see Fig. 14). Use a very fine brush and dab on a tiny drop of the fluid to cover the holes. Once you're satisfied that the holes have been covered and the traces (the clear areas) are clean, the negative is finished. If your board is single-sided you can start preparing the circuit-board blank, but if you're making a double-sided board, you still have a bit more work to do with the film.

Put the original 35mm film of the second side of the board into the slide projector. Tape the positive (black-on-white) film of the first side of the board to the wall and project the image of the second side on to it. You'd think that if you adjusted the size the way you did for the first side the two would be the same. Well, it never works. Slight differences in measurement can wreak absolute havoc with the registration of the two negatives. The only way to be absolutely sure that the masks for the two sides of the board will be in perfect registration is to measure one against the other.

Adjust the projected image to match the film you've pinned to the wall. There are two things to check: size and alignment. You can use the IC pads to check for both purposes. Adjust the projected image so the IC-pad spacing is the same as that on the film you've taped to the wall. Once you've done that, make sure that both images are in register at the top and bottom.

If you've made registration marks on the artwork use those; otherwise use the IC pads and the feedthrough points as references for alignment. You may find that you have to tilt the projector and distort the image to make everything line up properly. Pay careful attention to that part of the process because, if the two

images aren't in register, you're going to have a lot of problems drilling holes once the board is etched. Obviously there's some leeway in all this—even when it comes to drilling the holes. As a general rule, however, if the size or alignment is off by more than about 1/32 inch you're going to have real problems.

Errors have a nasty habit of adding to each other rather than cancelling out, and that's the reason you have to measure one side of the board against the other instead of using a grid for both of them. After the exposure has been made and the film developed, tape the two positives together to make sure the registration is correct. Try to line up the holes at both edges. If they're off you're going to have to do the second side of the board again. The chances are, however, that if you've been careful all along the registration will be correct.

Once you're satisfied that everything is lined up properly, make the actual negative (white-on-black) exposure mask for the second side of the board, check it one more time, and put all of the negatives safely away.

Board and processing materials

There are different types of copper-clad PC-board material available. The differences have to do with the weight of the copper and the material the board is

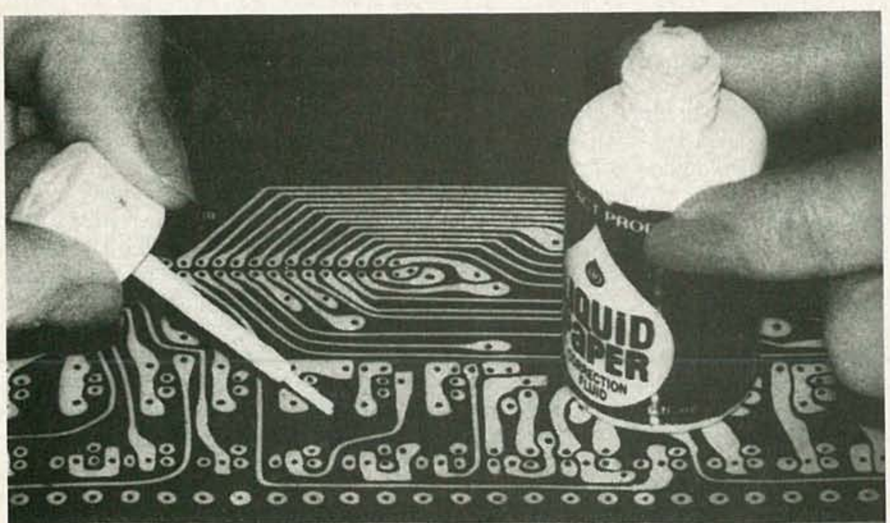


FIG. 14—TYPEWRITER CORRECTION FLUID can be used to get rid of pinholes in the finished negative.

SUPPLIES

Layout
- 20 × 24 inch sheets of 1/10-inch grid graph paper (non-repro blue)
- Non-repro blue pencils
- Fine-line black felt-tip pens
- Double-size PC-drafting aids (IC pads, doughnuts, etc.)
- Ruler and caliper
- Black layout-tape of different thicknesses
- Transfer-type lettering

Mask
- 35mm camera
- 250-watt floodlights (2)
- 35mm slide projector
- 35mm glass slide mounts
- Contact frame
- Ortho (litho) film (35mm and large enough for the actual-size mask)
- Ortho (litho) developer, stop bath, and fixer
- Red gel and safelight

Board
- PC-board blanks
- Spray-sensitizer and developer
- Glass trays
- 250-watt sunlamp or 40-watt fluorescent lamp
- Etchant

made from. The weight of the copper refers to the thickness of metal on the board and is expressed in ounces. The best all-around choice is one-ounce board. The copper is not so thick that it causes problems when you etch it, but is still thick enough to allow traces as thin as 1/32 inch. Not only that, but a 1/16-inch-thick trace of one-ounce copper can safely handle up to five amps; thicker traces can handle proportionately more.

The best board material is glass-epoxy laminate; anything else is not as good, and some types of board, such as phenolic board, are really junk. There's a difference in price, of course, but the quantities you're likely to be using are so small that the actual difference in cost is not going to be significant.

Once you've picked out your board, the next step is to sensitize it; the chemicals for that are available from a wide variety of sources. While it's possible to buy presensitized board, it's much cheaper to do it yourself. (Besides, if anything goes wrong and you have to redo the board, you'll have to resensitize it anyway.)

There are two types of sensitizers, and each has its own type of developer. Sensitizers are either "negative" or "positive." Negative sensitizers leave resist wherever they are struck by light, while positive sensitizers leave resist where they are protected from light.

I recommend using the negative process for several reasons. First, the additional mask-making step allows you to make corrections more easily to both foil and etched areas. You can make corrections on the white-on-black film with both an *X-ACTO* knife and dye or correction fluid, and corrections on the black-on-white one with the knife.

Second, if, for some reason, the mask does not make perfect contact with the sensitized board when you expose it (see below), light may "leak" under the edges of the opaque areas of the film and cause copper that you need to be etched away. If you were using the positive process, you might lose some of your thin traces. With the negative process, however, you would be more likely just to increase slightly the amount of copper that would not be etched; you might have to remove a little copper from traces that ran close together, but removing copper from a PC board is a lot easier than trying to put it back.

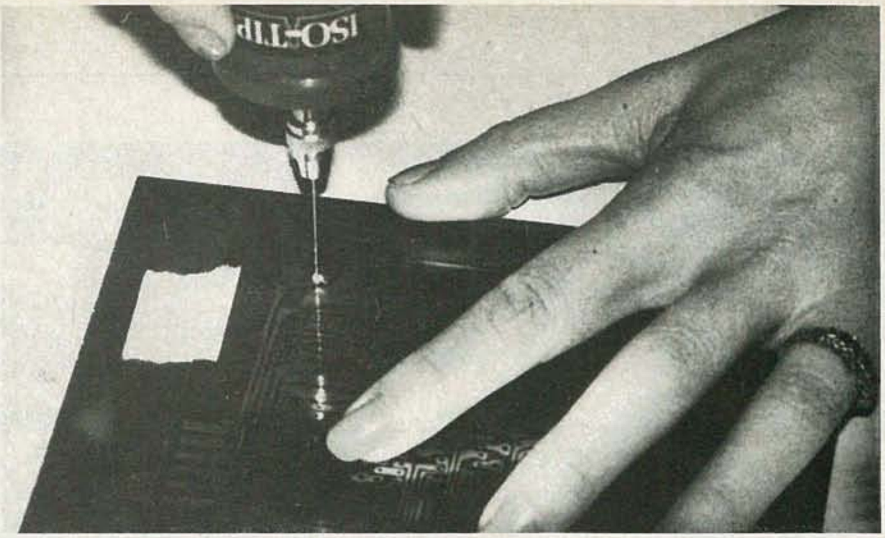


FIG. 15—IF THE BOARD IS DOUBLE SIDED, tape one of the negatives to the board and drill out four of the feedthrough holes. Those holes will be used later to make sure that the two sides of the board are in register.

Making the board

Cut the copper-clad board large enough to allow at least a one-inch border around the negative. If you're making a double-sided board, tape one of your negatives to the board, emulsion-side-down; make sure that the negative is well centered. Pick four feedthroughs—one near each edge of the board—and drill holes through the negative and the board as shown in Fig. 15. Mark the corner of the board by scratching the copper so you'll be able to tell which is the top.

Turn the board over and line up the other negative with the holes you just drilled; they should line up perfectly. Drill holes in this negative for the four feedthroughs. Mark this side of the board as well, and make sure you'll be able to tell which negative goes with which side.

Clean the copper-clad board by scrubbing it with a piece of fine steel-wool and household cleanser—a soap pad is perfect. The copper probably has some oxidation on it and you want to make sure you get it all off. To test whether the board is clean enough, run water over it—if it's good and clean, the water will bead, and not spread out over the copper. (You can see the same effect on a freshly waxed car.) Dry the board with paper towels and **be sure to keep your hands off it.** The sensitizer won't adhere well to any areas of the board contaminated with skin oils.

Several companies package sensitizers, but only a few mix them with a dye. We recommend using that type as the sensitizer itself is just about colorless; the dye makes it easier to see the board during developing, which makes it easier to tell when the process is finshed.

The sensitizer comes in an aerosol can and is, of course, light sensitive. For that reason, it has to be handled like the unexposed film—under a safelight.

Be sure to spread lots of newspaper around because you can't really keep the spray from going beyond the immediate area of the board. Then, rest the board at a 45° angle and, still working under a safelight, apply the sensitizer, holding the can about 10 to 12 inches from the surface of the board. The technique here is the same used in applying spray paint. Keep the nozzle moving back and forth over the board and move from top to bottom. Don't apply too heavy a coat of sensitizer or it will run. On the other hand, too thin a coat will disappear in the developer. When you've applied the sensitizer to the entire board, lay it down flat and leave it alone for about 10 minutes to allow the sensitizer to smooth out and thicken.

You can dry the board either by letting it sit overnight, or you can force-dry it in an oven. If you use an oven, **don't let the temperature get above 110°F**. If you do, the board will get heat-fogged and be useless—the effect is similar to what happens when you expose photographic film to X-rays. Thirty minutes or so is all you need to oven-dry the board. If you're making a double-sided board you'll have to spray the other side of the board and repeat the drying procedure. If you're not sure whether the board is dry, smell it; the drying agents in the spray have a distinctive odor that will be present as long as the board is the least bit wet.

If you're making a single-sided board, all you have to do next is lay the negative emulsion-side-down on the sensitized board, put it in the contact frame, and make the exposure (see below).

A double-sided board has to be prepared differently to make sure that the two sides remain in register. Get a slab of stiff styrofoam—the white packing material used to cushion radios, etc. during shipping (you can also find it at many florists—they use it to prepare flower arrangements). Put a wire brad, point-side-up, through each of the holes that you drilled in the copper-clad board. Then lay the negative on top with the brads through its registration holes. Place the board, negative and brads on the styrofoam and take a piece of glass larger than the board and push it down over the board. The brads will be pushed into the styrofoam, and the negative will be tightly sandwiched between the glass and the copper-clad board.

The sensitizer reacts to ultraviolet light. Ordinary light-bulbs or a slide pro-

TABLE 1—TROUBLESHOOTING GUIDE

Problem	The pattern appears on the board but is washed away by the developer.
Cause	1. The sensitizer is sprayed on too thinly 2. The board wasn't completely dried 3. The board wasn't well cleaned before the sensitizer was sprayed on
Problem	No image appears when the board is developed.
Cause	1. The exposure was insufficient 2. The board was overheated in the oven when it was dried 3. The developer is exhausted
Problem	The pattern is evident but the etchant has no effect on it.
Cause	1. The etchant is exhausted 2. The developer is exhausted 3. The exposure was too long 4. The mask wasn't completely opaquex
Problem	The pattern is attacked by the etchant.
Cause	1. The sensitizer was sprayed on too thinly 2. The exposure was inadequate
Problem	The pattern blisters and flakes away in either the developer or the wash.
Cause	1. The board wasn't clean when it was sprayed 2. The board wasn't completely dried 3. The sensitizer was sprayed on too thickly

jector don't put out a whole lot of energy in that part of the spectrum, but a sun lamp does. If you don't have one, you can use a fluorescent lamp, but the exposure times will be longer. I use a mercury-vapor type home sun lamp. With that, I keep the light about three feet from the board and use an exposure of about four minutes. If you use a fluorescent lamp-fixture with two 20-watt bulbs in it, try ten minutes as a starting point and keep the distance between the bulbs and the board about ten inches. You will have to experiment a bit to find the correct exposure time.

If you are making a double-sided board, you'll need to repeat the process for the other side. Working under the safelight, remove the brads, turn the board over, position the second-side negative, and re-insert the brads; the rest of the procedure is the same as that for the first side of the board.

The next step is to develop the board; that must also be done working under a safelight. Make sure the developer you get is made for the negative-type sensitizer. Don't use a plastic tray, because the solvent action of the developer will eat right through most plastics—use a glass or metal tray to avoid winding up with a ruined board and a lap full of exotic esters and ketones. Also, to make your work easier, be sure that the tray is large enough to provide a few inches of finger room all around the board.

Fill the tray with developer to a depth of ½ inch. If you are making a single-sided board, you can simply lay it on the bottom of the tray, pattern side up. With a double-sided board, however, you'll have to hold the board **by the edges** to keep it suspended above the bottom of the tray. That's because the resist gets really soft when it's in the developer and if it rubs against anything (including your fingers) its going to smear and ruin a lot of work. Gently agitate the solution and you will see the circuit appear after about thirty seconds.

You can check to see how things are proceeding by removing the board from the solution; be sure to hold the board so that any developer that remains on the board when you remove it can drain back into the tray. If the pattern appears clearly on the board, let the developer drain off and then dunk the board repeatedly in water. Don't let running water hit the board for the first twenty seconds or so because you run the risk of smearing the resist—remember that it's very soft and easy to ruin. If you've used a sensitizer with a dye, the pattern will be easy to see. If not, you'll only be able to see the pattern by holding the board so that the light from the safe light will hit it at an angle. With the resist still swollen with developer, the pattern will be easy to see. As the developer evaporates or is washed away, however, the pattern will disappear. Just remember to keep the pattern from touching anything.

After you've washed the developer off, blow and shake the excess water off the board (**do not wipe it off**) and reimmerse it in the developer. Give it another 30 or 40 seconds of gentle agitation and then wash it again. The best time to tell if the board will etch well or not is when it's in the water but the resist is still full of developer. Every place that was covered by the mask will shine brilliantly because the copper won't be covered by any resist—it will look really clean and polished. If the pattern is mottled, or the resist won't clear from the areas of the board where it's not wanted, you'll have to scrub the board clean and go through the whole process again.

Etching the board

Once the board has been developed completely, a safelight is no longer needed. Etching the board is the easiest part of the whole process. Ferric chloride is a popular etchant, but use whichever one is most convenient for you.

The first step is to heat the etchant up to 125°, since the hotter the etchant is the faster it works. Pour the warm solution into a tray (glass or plastic, as the etchant will react with almost any metal). Then, drill a hole in one corner of the board and slip a piece of heavy-duty thread through it. Tie it and use the thread to agitate the board in the etchant.

When you first immerse the board you can get a good idea of how easily it will etch because all the unprotected areas of the board will turn black as the etchant attacks the copper. If that doesn't happen, agitate the board for a few minutes and then take it out and rinse it off in running water. The pattern should be shiny and protected under the resist, but the rest of the board should be a dull copper color because of the action of the etchant. Examine the board closely and if you spot any problem areas or unwanted blobs of resist you can scrape them away with an *X-ACTO* knife. Constant agitation should etch the average board in about fifteen minutes. Take the board out and examine it periodically. If you spot breaks in the pattern you can dry the board and cover the breaks with tape. If one side of the board etches faster than the other, don't take the chance of having the faster side being undercut by the etchant. Dry the whole board and cover the areas you want to protect with spray acrylic, electrical tape, or just about anything waterproof.

When the etching process is finished, **don't scrub off the resist**. Wash the board and dry it with paper towelling. Drill the holes for the components and then use a saw to trim the board to size.

If you're making a double-sided board, drill the first few holes somewhere on the board where there is room for error so that you'll be able to see whether the alignment is exact or not. Since you made the patterns by laying one image over the other, you can be sure that the size is correct, but sometimes the negative for one side of the board can get shifted slightly and throw the alignment slightly off. You can usually correct for that by drilling the hole at an angle, rather than straight through the board. If you make your first few holes in a place on the board where things aren't so cramped, and you drill from the foil side to the component side, you'll be able to see whether such a tactic is needed. Since the negatives were made in register, if *one* hole is off to one side, *all* the holes will be off. That, however, can usually be corrected by drilling in the proper direction and you'll never probably find any correction other than that to be necessary.

continued on page 104

HOW TO

Interface R/C Servos

R/C servos are good for more than controlling model planes and cars. Here's a description of how they work, and some ideas on how you can use them.

DAN and JEANETTE PELTON

RADIO-CONTROL (R/C) SERVOS ARE GOOD for much more than just operating model aircraft or boats. They can be used to keep a signal generator on frequency, steer a small robot, govern your lawnmower, interface a computer to run a strip-chart recorder—in fact, those miniature servos provide just about the ideal electrical-to-mechanical interface. They are simple to use and cost-effective, and the circuits needed to drive them are simple, and easy to build—you can even put them together on prototyping boards.

How servos work

Servos are slow-running electric motors that can be stopped and started almost instantaneously. As long as they receive a control signal they run; when it stops, so do they. That makes them well suited for use in proportional-control systems, such as are used in model airplanes, boats, and cars. The control signals can be sent by radio, or fed directly to the servo-control circuits.

R/C servos generally operate from TTL logic-level voltages—about five volts—which makes them very convenient to interface with computer or other TTL circuits. The devices—which may generate several pounds of thrust—draw a maximum of 400 mA to 1000 mA, depending on the particular type used. Servo-control signals are pulses whose widths vary from one to two milliseconds in length; the servos convert that pulse-width-modulated signal into a precise mechanical movement.

Inside the servo housing is an IC that provides all the functions needed to convert the width of a pulse into the signals needed to drive the servo motor so that the output shaft is correctly positioned. Figure 1 shows a block diagram of a typical servo-driver IC and its connections to the servo motor. The output shaft of the servo motor is attached to a potentiometer. As the output shaft is driven by the motor, the voltage across the potentiometer varies. The amplitude of that voltage is directly related to the position of the output shaft, and the voltage is fed back to the servo-driver IC where it controls the time duration of an internal one-shot pulse generator.

When a logic-level input pulse reaches the servo-driver IC, two things happen. First, the internal one-shot pulse generator previously mentioned is triggered. The time duration of the one-shot's output pulse is controlled by the feedback voltage from the potentiometer on the output shaft of the motor. The duration of the output pulse is compared to that of the input pulse by two NAND gates. The result of the comparison will trigger one of the two pulse stretchers; that in turn will either set or reset the directional flip-flop.

(The pulse stretchers are required because in many servo applications—model aircraft, for example—as many as eight channels can be in use at the same time with information being transmitted sequentially to as many as eight servos. Under those circumstances, as many as 25 milliseconds may pass before a particular servo receives another input pulse. The pulse stretchers keep the servo motor running for most of the time between input pulses, keeping "chatter" to a minimum and allowing greater speed and efficiency.)

The output of the flip-flop will cause the servo motor to be driven by one or the other of the motor-drive circuits; the circuit selected will determine the direction in which the motor will turn. The motor

will turn the output shaft until it reaches a position that causes the input pulse and the pulse from the one-shot to be of equal durations.

A one-millisecond input pulse will drive the output shaft of the servo motor to one extreme, and a two-millisecond pulse will drive it to the other.

A servo-control circuit

In most applications, you will need to convert the amplitude of a DC voltage into a pulse-width-modulated signal that can be used to drive the servo motor. For example, you may have a remote TV camera that you want to be able to aim from your monitoring location. Your control console could have a joystick for that purpose which, when moved, would move the shaft of a potentiometer.

The output of the potentiometer would be a DC voltage related to the position of the joystick and would have to be translated into a pulse-width-modulated signal that could be used to control the servo. That signal can be generated by a single quad op-amp (one IC containing four separate op-amps) like National Semiconductor's LM324.

An easy-to-build PWM (*P*ulse *W*idth *M*odulation) circuit using that IC is shown in Fig. 2. Two sections of the IC (IC1-a and IC1-b) function as a ramp generator whose output is a sawtooth waveform. Op-amp IC1-c is a conditioner that limits the DC level and peak-to-peak swing of the input signal. The last section of the IC (IC1-d) compares the output of the signal conditioner with the ramp (triangle) waveform. The signal conditioner is adjusted to provide a comparator output that is compatible with the servo's requirements.

The heart of the ramp generator is IC1-b. It operates as an integrating amplifier with capacitor C1 acting as the integrating- or feedback-element of the circuit. If the output of IC1-a is negative, a current will flow through R4 and try to pull the inverting input of IC1-b down. In response, the current output of IC1-b will increase so the current flow through C1 continues to equal the current flow through the input resistor R4.

That charges C1 and, if nothing else were to happen, IC1-b's output would reach its positive limit and stay at that level. However, IC1-a is configured as a Schmitt trigger that monitors the output of IC1-b, and when IC1-b's output voltage reaches a certain point, IC1-a changes state (it goes high). Current then flows through D1 and R3, and the input of IC1-b goes high and its output drops rapidly. When it drops to a certain point, IC1-a changes state again, and the whole cycle repeats. The repetitive cycle generates a sawtooth waveform with a positive going ramp.

Adjustment

After you've built the circuit, if you have an oscilloscope available, connect its probe to the output of the comparator (IC1-d). Set the OFFSET potentiometer,

Let's get

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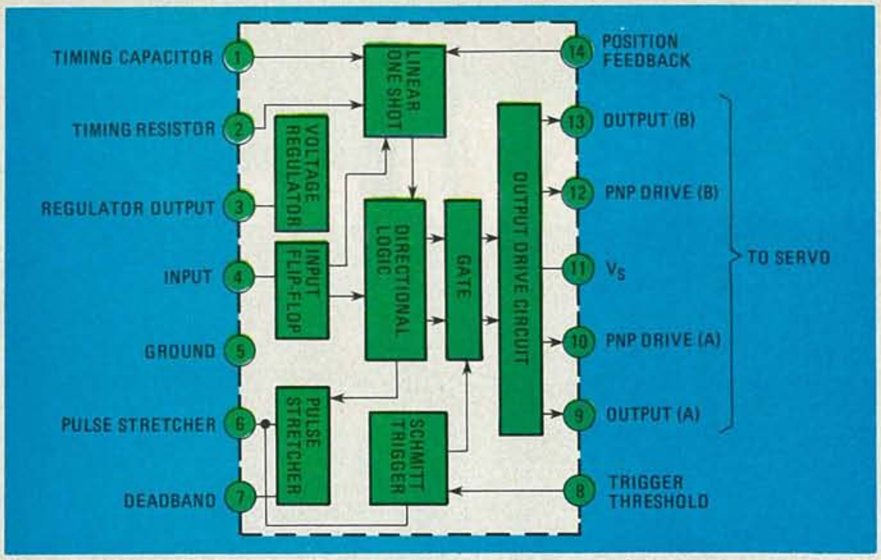


FIG. 1—SERVO-DRIVER IC DECODES input pulses and outputs signals that cause the servo motor to turn in one direction or the other.

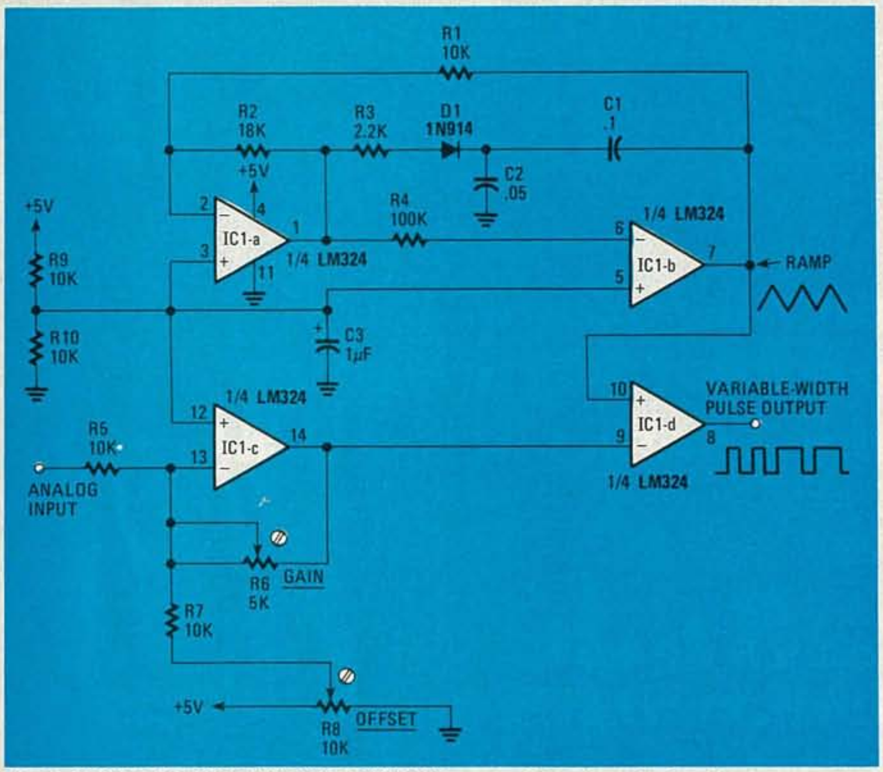


FIG. 2—ANALOG-TO-PULSE-WIDTH CONVERTER senses DC-voltage level and outputs a corresponding variable-width pulse-string to servo-driver IC.

R8, for a pulse width of about 3 ms. At the signal input (R5) apply the lowest voltage you are likely to use and observe the duration of the pulse on the scope (still connected to the output of IC1-d). Then apply the highest-level signal you expect to use and observe the pulse-width. Set R6 (GAIN) so that changing from one input-voltage extreme to the other results in a one-ms change in pulse duration. Once that is achieved, apply the lower-level signal to the input and adjust R8 for a two-ms pulse width. A high-level signal should then cause a one-ms pulse to be generated.

Connect your servo to the pulse-width output. The black or green lead of the servo is ground; red is the positive supply-voltage, and the remaining lead is for the pulse signal.

Apply the control signals from your generator and be sure the servo doesn't jam. A jamming condition is best determined by measuring the current drawn by the servo. If the current draw exceeds the midrange idle-current at either extreme of the servo's travel, adjust R8 slightly. (Midrange idle-current can be measured when the servo is at any position other than an extreme.) If the servo jams at both travel extremes, adjust R6 to eliminate the problem. If your servo requires negative-going pulses, they can be obtained by adjusting R8.

PARTS LIST

All resistors ¼-watt, 5%, unless otherwise specified
R1, R5, R7, R9, R10—10,000 ohms
R2–18,000 ohms
R3—2200 ohms
R4—100,000 ohms
R6—5000 ohms, trimmer potentiometer
R8—10,000 ohms, trimmer potentiometer
Capacitors
C1—0.1µF
C2—0.05µF
C3—1µF, tantalum
IC1—LM324
D1—1N914
Miscellaneous: perforated construction board, wire, 5-volt power supply, IC socket, cable and connector for computer's parallel port, servos and linkages, etc.

Servos can be purchased at most "hobby shops" that sell R/C equipment. Check your local Yellow Pages under "Hobby & Model Construction Supplies." They are also available mail order; check the ads in modelling magazines.

Computer control

To control a servo with a home computer, all you need is one line of a parallel port and a program with a timing loop that will provide pulse signals of one to two ms in length that repeat every 20 milliseconds. The pulses will have to be repeated enough times to ensure that the servo has reached the desired position—usually half a second is enough to go from one extreme to the other. Servos are apt to cause power supply noise, so it might be a good idea to add a 0.01-µF capacitor across the servo's power-supply terminals.

Applications

The output wheel on the servo's shaft can be attached directly to a pen or pointer for use in a strip-chart recorder. It can be directly hooked to a robot arm using model-aircraft linkages. For steerable devices, borrow the front-end parts from model-aircraft nosegear. To govern the speed of a lawnmower, hook an arm from the servo shaft directly to the lawnmower engine's throttle plate; that should give you nearly instant control.

R/C servos have dozens of uses, whether or not you use a computer to control them. Give them a try in your next project. **R-E**

"I'd tape toy commercials and play them for Mom and Dad just before my birthday."

BUILD THIS

AUTOMATIC COMMERCIAL EDITOR FOR YOUR VCR

With this handy accessory you can make commercial-free tapes of your favorite black-and-white movie classics and TV programs.

GARY McCLELLAN

Part 2 NOW THAT YOUR COMMERCIAL editor is almost complete, you can begin the final adjustments and assembly.

Adjustments

Before making the final adjustments use an alignment tool to preset the L1 and L2 coil-slugs to mid-position; that's close to the correct adjustment for them.

There are two ways you can make your adjustments. One method is to use an RF signal-generator with an output at 3.579 MHz along with an analog voltmeter. The other method, which is just as good, is to use a low-cost calibration tool designed specifically for this application together with the analog voltmeter. That tool, a simple single-frequency RF signal generator, will be described in the section on "Options."

Do not attempt to use an off-the-air video signal to make the adjustments—the signal level varies too much for accurate results. With that precaution in mind, let us proceed.

Both methods use the same easy-to-perform procedure. Start by plugging T1 into a nearby AC outlet; then turn on S1. The relay should click if all is well. Connect your analog voltmeter across R4 and set it to the 1-VOLT DC range. The meter must read zero with no signal applied. Then connect either your RF signal generator or the calibration tool to P1 (VIDEO IN). Set the RF signal generator for 3.579 MHz. The calibration tool requires no adjustment, but you'll need a nine-volt battery to power it.

Adjust the RF-level control on either signal source for about 0.1- to 0.3-volt-DC on the meter; then slowly adjust L1 for maximum output. Be sure to use a nonmetallic alignment tool for this; metal causes detuning, which can lead to misadjustment. As necessary, reduce the RF level so that the output stays at or below 0.3 volt. You should be able to get a sharp peak.

Next, carefully adjust L2 for maximum output, again reducing the RF level as necessary to keep the meter reading at or below 0.3 volt. That adjustment should also peak-up nicely. If you have any problems making the adjustments, send a self-addressed, stamped envelope to the supplier indicated in the Parts List. You'll receive a free troubleshooting guide, which should solve your problems. Finish by carefully touching up L1, and then L2. When you are satisfied that both coils are peaked, you are finished. Remove the analog voltmeter and the signal source.

Final assembly

If you like, you can now install the completed unit in a suitable case. A small plastic clock-cabinet works well. We do not recommend that you attempt to install the editor inside your recorder, because most machines don't have enough room for it.

Options

There are two simple accessories you can build for use with your commercial editor. The first is a 3.58-MHz signal generator to help in adjusting the unit and the other is an adaptor that allows you to use the editor with a VCR that has a pushbutton PAUSE control (the device was designed for VCR's with slide-switch controls).

The schematic of the signal generator is shown in Fig. 7. It's a very simple device; the only critical part is the crystal, which should be cut for 3.579545 MHz $\pm 0.01\%$, parallel-resonant (20 pF). A crystal in an HC6/U case will fit nicely on the PC board shown in Fig. 8. Parts placement for the signal generator is shown in Fig. 9; the editor's input-cable plugs into J1.

If your VCR has a pushbutton remote control, you'll need the adaptor shown in Fig. 10. In use, photocell PC1 is placed over the PAUSE LED on the VCR. When relay RY1 closes—indicating that a commercial is being broadcast—pin 2 of EXCLUSIVE-OR gate IC1-a goes high (pin 1 is low at that point) and the output of that section of the IC also goes high. That

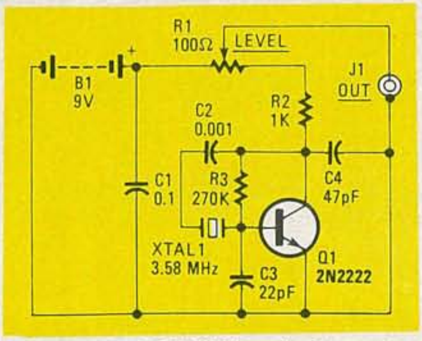


FIG. 7—IF YOU DON'T HAVE a signal generator, you can build this one to align the editor.

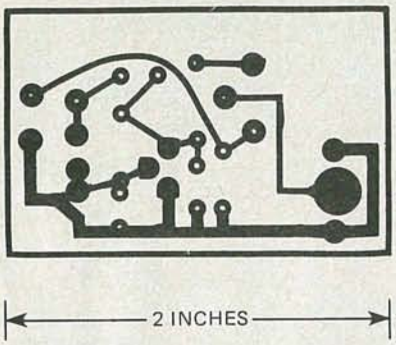


FIG. 8—FULL-SIZE foil pattern for signal generator.

PARTS LIST—PUSHBUTTON PAUSE-CONTROL

All resistors ¼-watt, 5% unless otherwise specified
R1, R2—27,000 ohms
R3—1 megohm
R4—10 megohms
R5—1000 ohms
R_x—see text
Capacitors
C1—0.1 µF, ceramic disc
C2—0.1 µF, Mylar
Semiconductors
IC1—4070 CMOS quad EXCLUSIVE-OR gate
Q1, Q2—VN10KM FET (Radio Shack 276-2070 or equivalent)
LED1—jumbo LED
D1—1N4148
PC1—photoresistor (Radio Shack 276-116 or equivalent)
Miscellaneous: perforated construction board, 9-volt battery, plug (PL1) and jack to fit recorder and editor, etc.

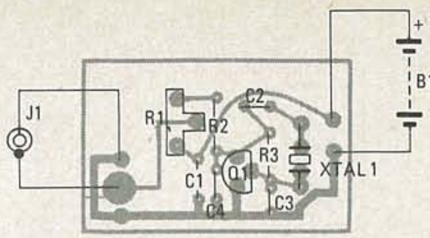


FIG. 9—OUTPUT JACK, J1, can be mounted on PC board by drilling out large foil pad *completely* and running resistor lead to trace leading to it.

PARTS LIST—SIGNAL GENERATOR

All resistors ¼-watt, 5% unless otherwise specified
R1—100 ohms
R2—1000 ohms
R3—270,000 ohms
Capacitors
C1—0.1 µF, ceramic disc
C2—0.001 µF, ceramic disc
C3—22 pF, ceramic disc
C4—47 pF, ceramic disc
Semiconductors
Q1—2N2222
XTAL1—3.579545-MHz, parallel-resonant (20pF), HC6/U case
J1—PC-mount RCA phono jack
Miscellaneous: PC board, 9-volt battery, solder, etc.

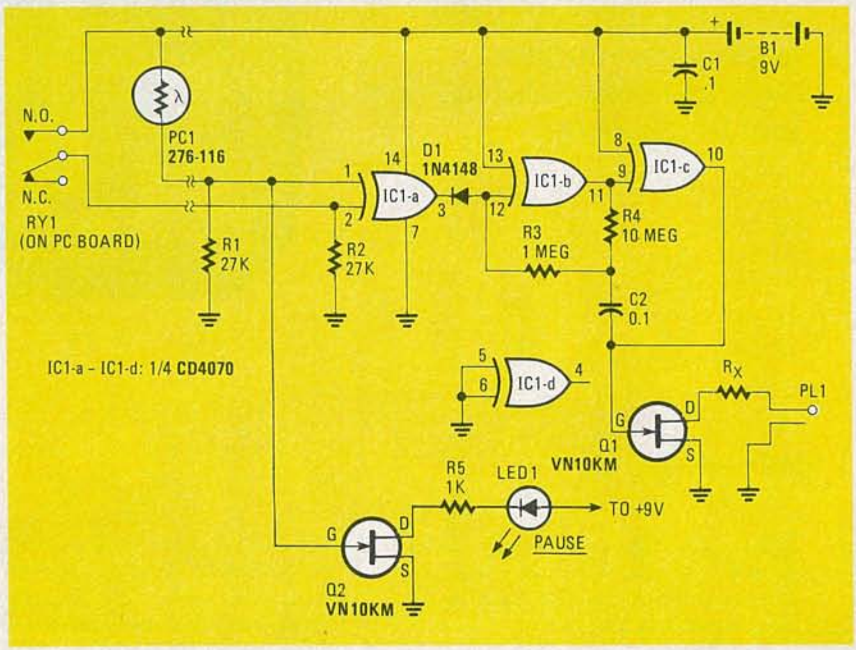


FIG. 10—BUILD THIS PAUSE-CONTROL converter if your VCR uses pushbutton-type controls.

The following are available from Technico Services, 1920 W. Commonwealth Ave., Box 20HC, Fullerton, CA 92633: kit of all parts, *less case*, (CK-2), $54.00 plus $3.50 postage & handling (nonrefundable); PC board only (CK-1), $10.00, postpaid; assembled and tested calibration tool (3.58-MHz signal generator) (CAL-3), $10.00, postpaid. California residents please add 6% tax.

triggers the 2-Hz oscillator formed by IC1-b and IC1-c, which in turn, causes switching transistor Q1 to output a pulse to the VCR's PAUSE jack.

That pulse is interpreted by the VCR's microprocessor as a signal to stop the machine and to light the PAUSE LED. The illuminated LED causes 9 volts to flow through PC1, taking pin 1 of IC1-a high, and stopping the pulse generator. When the relay opens after the commercial(s), pin 3 of IC1-a goes high again (pin 1 is high and pin 2 is low) and another pulse is generated that causes the recorder to start up. Transistor Q2 and LED1 are optional—they substitute for the covered-up LED on the VCR to indicate when the machine is in a pause state.

Resistor R_x is required by many systems. To find out whether you need to include it, measure the resistance across the plug of your remote control with its PAUSE button depressed. If you get a reading, use a 5% resistor of that value (or close to it) for R_x. (Note: some VCR's, such as the Sony *SL-5000* will not need that resistor.)

The adaptor can easily be built on a 1½-inch square piece of perforated construction board. Use a length of 2-conductor speaker wire to connect PC1 to the board and use jacks and plugs of the appropriate size for connection to the editor and the VCR. Attach PC1 to the VCR by placing a piece of double-sided tape over the photocell. A hole should be cut out of the middle of the tape over the photocell and the assembly stuck over the VCR's LED PAUSE indicator.

Use

Operation of the editor is simplicity itself. Plug P1 into the VIDEO OUT jack on your recorder; then plug P2 into the PAUSE jack on the machine. If you have a remote pause-control, and wish to use it, plug it into J2 on the editor. If you are using the pushbutton-control option, follow the instructions in the "Options" section.

To record a black-and-white movie without commercials, perform the following steps in the order given. First turn on the editor using S1. That is done because the relay momentarily closes upon power-up, and that can stop the recorder unnecessarily . Then turn the recorder on, tune to the channel you want, and push the RECORD lever or button. The VCR will now automatically stop during color commercials, and then restart when the movie resumes. That is all there is to it.

To tape commercial-free programs while you're away, simply leave the editor on and set the recorder's timer and channel-selector, and put the recorder in-

continued on page 104

Digital IC Tester

An IC tester like the Programma III can make work a lot easier for you. Here in Part 2 we'll continue with the construction of the device

GARY McCLELLAN

Part 2 IN THE FIRST PART OF this article we finished one side of the display-board portion of the IC tester. Let's now start on the other side.

Display board: other side

Turn the display board over, position it as shown in Fig. 6 and install the 7805 voltage regulator, IC5, at the bottom right corner. Note that the tab faces left. Once it is in place, turn the board over and solder the leads; then clip off any excess. Note that although there are two large pads by the voltage regulator, nothing will be mounted on them.

The next step is to install the resistors. Start with R4 through R19. They're the 100K units around SO1, and you'll need 16 of them. Install the R12–R19 units first, then solder the leads on the other side of the board and clip off the excess. Turn the board back over so the resistors are visible and solder them to the foil in four places at the edge of the board (the pads can be seen in Fig. 5, (see January 1983 issue of **Radio-Electronics**) at the bottom of the board). That step is important because it connects the ground foils on both sides of the board together, so don't forget to do it.

After that, install R4–R11 in the same way. Move to the foil side of the CD4011, and solder two 10K resistors, R1 and R2, across the IC pins. Connect R1 between pin 8 and pin 1, then connect R2 between pin 8 and pin 7. Move to the bottom, and install a 68 ohm, *1-watt* resistor at R36. Note that it mounts vertically. Solder the lead closer to the middle of the board, and to both the top and bottom sides of the board; that gets the power to the IC's. Moving on, install a 1K resistor at R40. Then move left and install an 8.2K resistor at R37. Finish up the resistors by installing a 3.3K unit at R38, and a 2.2K unit at R39. Check your work carefully. If you had any problem installing a resistor, chances are it is in the wrong place! Check to be sure. When you are sure all the resistors are installed properly, you can continue.

Next, SO1 and the jumpers can be installed. Do not omit the socket; it's the connector for the wiring from the panel board. Install SO1 as shown, and turn the board over to solder it in. Turn the board back over and install a jumper between the two points to the left of the socket and resistors. A leftover resistor lead will work fine. After the jumper is soldered in, position it away from the copper foil nearby to prevent shorts.

The capacitors finish up this phase of the wiring. Turn to the voltage regulator, and install 0.1 μF ceramic discs above and below it at C6 and C7. Clip off the excess leads and you are done. Figures 7 and 8 show how the completed component- and foil-sides of the display board should appear.

Next, position the display board so that the IC's are facing up and, referring to Fig. 9, install the six jumpers from SO2 to the IC's. Use short lengths of insulated hookup wire.

The next step is to install connector SO1. Refer to Fig. 10 for details. Note that the wires are all inserted from the "foil" side of the board. First, cut eleven pieces of hookup wire, each about four inches long. Prepare one end of each wire, and insert a wire into each of the holes indicated in the illustration. Then route the wires for pins 1, 10, and 11 of

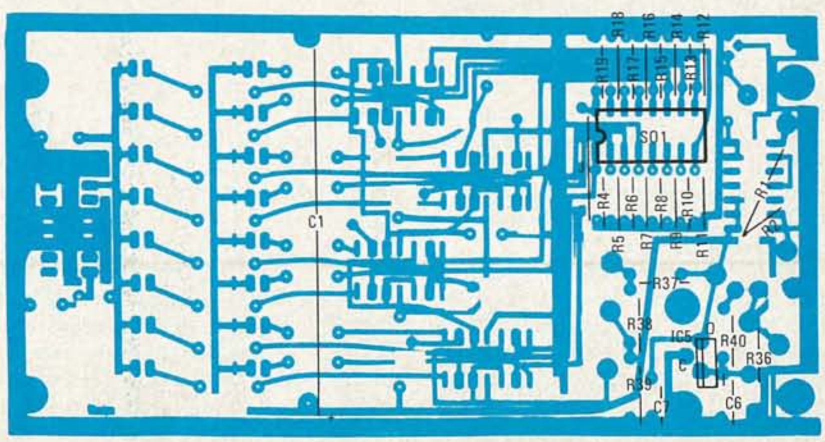


FIG. 6—PARTS PLACEMENT on "foil-side" of display board. Resistor R2 (at right) is soldered to pads on opposite sides of board.

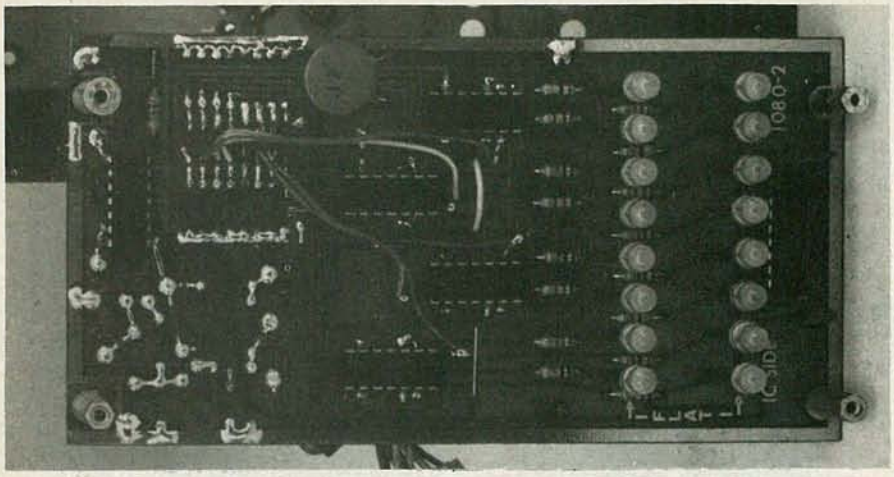


FIG. 7—"COMPONENT-SIDE" of display board. Mounting of LED's will be described in next part of article—don't install them without reading it.

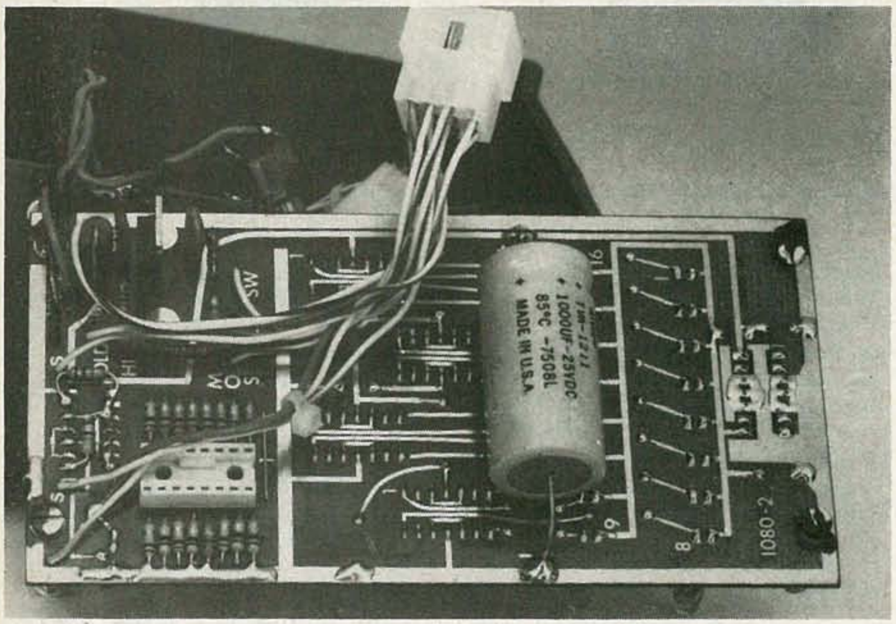


FIG. 8—"FOIL-SIDE" of display board. Multi-wire assembly connects to components on panel board.

the connector over the voltage regulator and group them with the others. That will make a neat cable.

Trim the ends of the wires so that the total cable is about three inches long. Then prepare each wire end, and install the connector. Note the pin identifications in the illustration. I used a Molex 12-pin nylon connector for P102, but almost anything with the correct number of pins will work. After the wires are connected to the pins, check your work for errors and correct any you may find. If you like, lace the wires together to give a professional appearance.

Now for the power cable. Prepare two 1-foot lengths of hookup wire. If possible, use one red, and one black, wire. Connect the wires to the board as shown in Fig. 10. The red wire should go to the hole indicated by a "+," and the black one to the one indicated by a "−." Twist the wires together.

The final step (with the exception of installing the LED's) is to install capacitor C1. Be sure that it's oriented properly. Push the leads through the foil, and solder. Be sure to solder the negative terminal on *both* sides of the board.

LED installation

If you didn't buy the double-sided panel board, you'll want to make one up using the foil patterns shown in Figs. 11 and 12. You can then install the LED's on the display board (however, you need the panel board to do that) and be done with it.

Place the panel board in front of you so that you can read the lettering on it. Notice the sixteen positions below the label "LOGIC LEVEL INDICATORS." They are for the LED's and will have to be drilled and/or filed to a diameter of 0.200 (2/10)-inch. You may want to use several increasingly larger drill-bit sizes to do that. Stop and check the hole size from time to time using one of your LED's until the fit is snug. Make another hole the same size at the position above the "OVERLOAD" label using the same procedure.

At the edges of the board there are seven large positions marked, and, slightly inboard of them, four smaller ones (those four are for mounting the display board). All eleven should be drilled to 1/8-inch for 4-40 hardware. Then, turn the panel board over and install a 3/4-inch threaded spacer at each of the four "inboard" holes. (If you can't find the spacers, you can make a substitute for them with 4-40 × 1 bolts and nuts. First, install a bolt and secure it to the panel with a nut. Then, add another nut, but screw it down only until the distance between the panel and the side of the nut away from the panel is 3/4 inch.) Now you're ready to install the LED's.

Refer back to Fig. 5 (in Part 1), and note the positioning of the LED's. The flat spot on the package (or the shorter lead) indicates the cathode, and should point to the left. Insert the top row of LED's, LED9–LED16, in the display board, but don't solder the leads. Place the panel board on the top of the spacers on the display board, and temporarily secure it in place with the 4-40 hardware. Push each LED forward so that it seats in the appropriate hole on the panel board. After all the LED's are in place, solder their leads to the foil, and clip off the excess. Separate the display board and the panel board, and install the bottom row of LED's, LED1–LED8. Again, temporarily install the display board on the panel board and push the LED's through the holes. Solder the leads in place and clip off the excess lengths. That completes the LED installation, so remove the display board.

Panel board

The rest of the work on the panel board consists mainly of installing jacks and wiring two cables. The schematic in Fig. 13 will help you understand what has to be done. It's routine work, but you'll get the best results if you take your time.

The first thing is to drill more holes. Position the board so you can read the legend "PROGRAMMA III." First, drill all the "HI," "PULSE," and "LO" holes to a diameter of 0.230-inch (a little less than 1/4 inch). A few tips on drilling PC-board material: To avoid tearing the foil, use at least three smaller drill sizes before you get to 0.230-inch. Better yet, start small and use a file or reamer to enlarge the holes. Use one of the jacks that will be installed to check hole size periodically. Carefully enlarge each hole until a jack fits snugly in it. Then deburr the holes, working from both sides of the board; use a sharp knife like an X-ACTO knife.

Next come the holes for the two switches. They, of course, are between the "TTL" and "MOS" legends, and just below the word "PULSE." Using the same technique as you did for the jack holes, enlarge the switch holes to 0.250-inch.

Now, the small parts can be mounted on the panel board. They include the IC test socket (SO101), the switches, and the OVERLOAD LED. The jacks will be installed later. Install the test socket first, from the front side of the board (the side with the lettering). After that, install a SPDT toggle switch at the TTL/MOS hole. Then install an SPDT pushbutton switch in the PULSE hole. Finish up this phase of construction by installing an LED in the OVERLOAD hole, from the rear of the board. Use quick-setting epoxy on the rear side of the board to secure the LED in place. Allow the epoxy to dry before you continue.

Now for the jacks. Refer to Fig. 14 for details, and note how the lugs on the jack bodies are oriented on the rear side of the board. For easiest installation, start at the top of the board with the "HI" row. Install the jacks, one by one, positioning the bodies as shown and then tightening the hardware. After that row is completed, continue with the "PULSE" row just below it. After that, move down to the "LO" row, and repeat the whole process. When you've finished the three rows, check for loose hardware and tighten things up as required. Then install the other three rows of jacks in the same fashion.

Panel board wiring

The jack wiring comes next. Note that only one lug of each jack will be used; the ground connections have already been made by attaching the jacks mechanically to the foil on the board. Again, refer to Fig. 14 for the wiring. Start with the pin-16 series of jacks (HI, PULSE, and LO), and tie the three terminals together with a

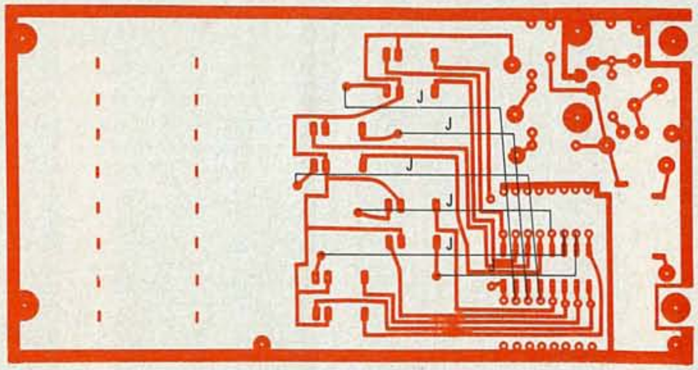


FIG. 9—RUN SIX JUMPERS between the zero-insertion-force test socket and the approriate pads on the component-side of the board.

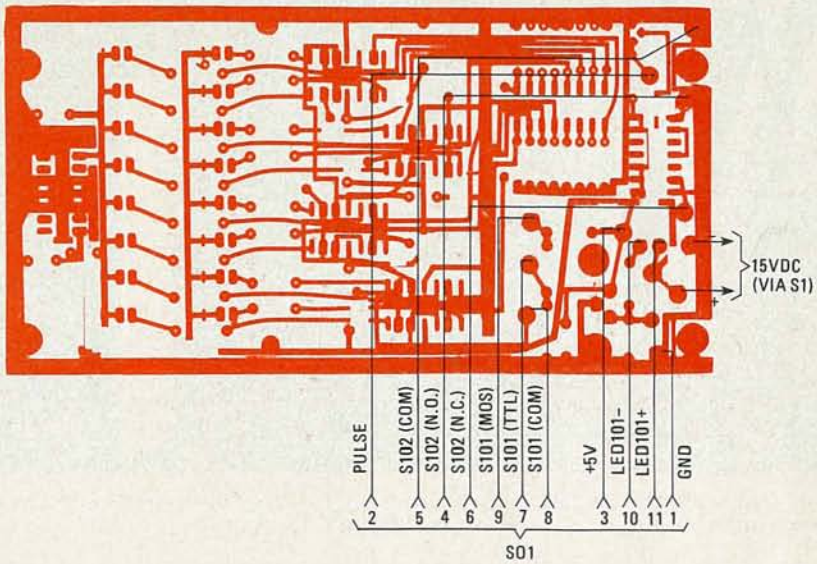


FIG. 10—MAKE UP AN 11-WIRE cable to connect SO1 to the circuit board at the points shown.

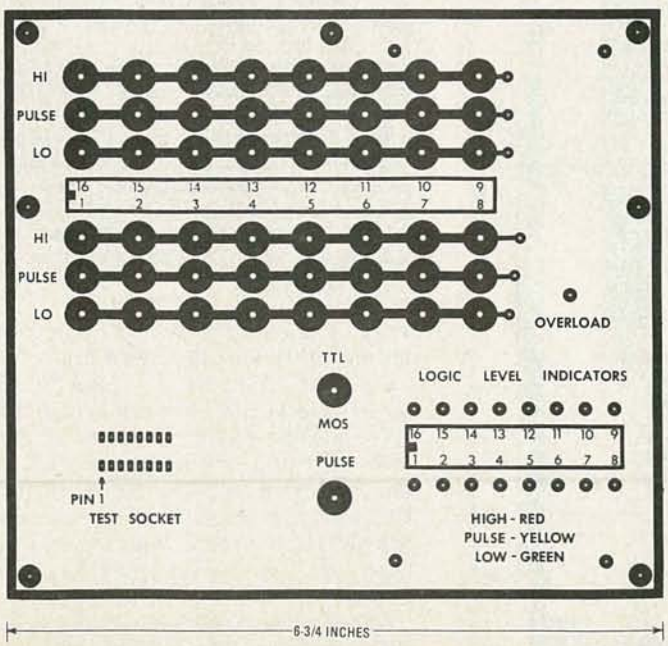


FIG. 11—TOP OF PANEL BOARD. Drill out holes at large foil pads as described in text.

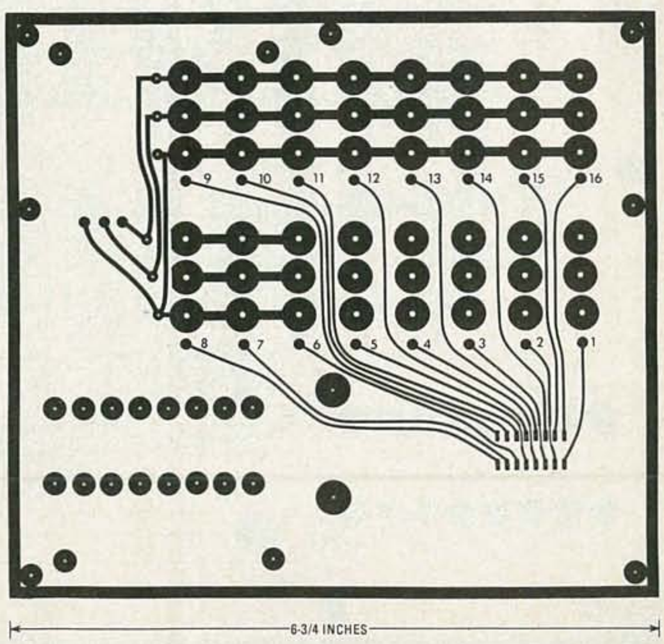


FIG. 12—FOIL SIDE OF panel board. Holes for 16 LED's are at lower left.

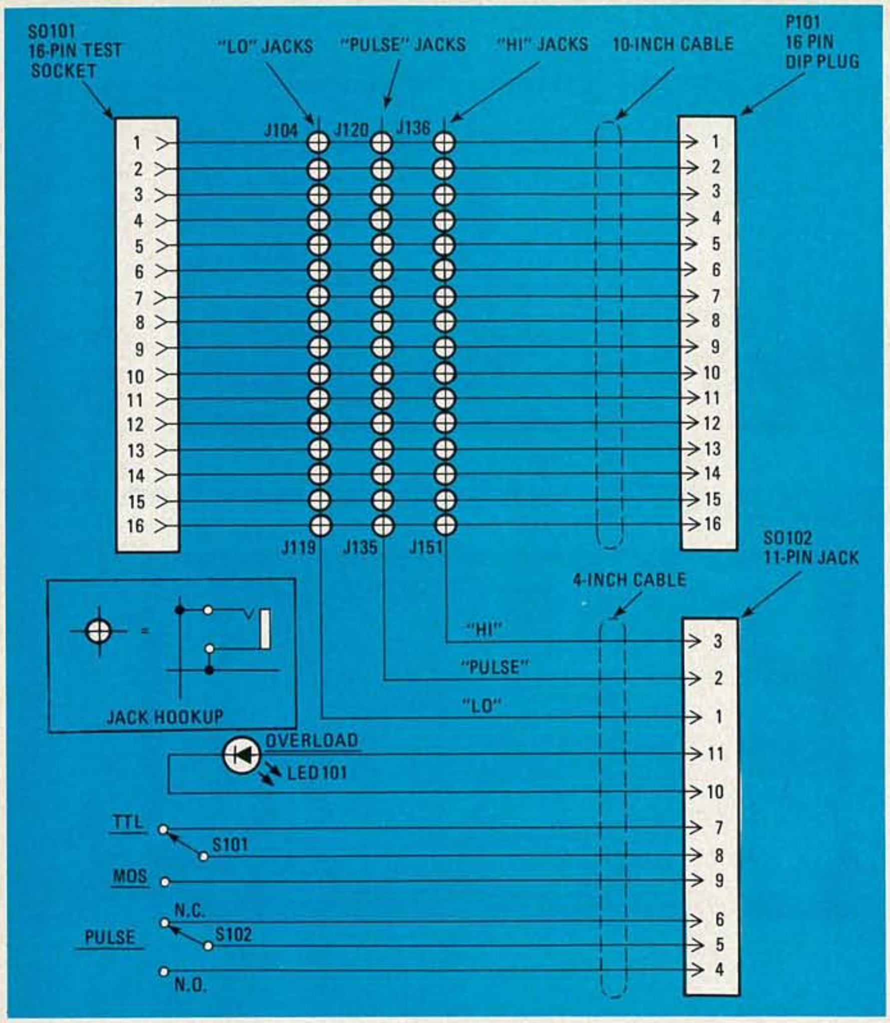


FIG. 13—PANEL BOARD SCHEMATIC shows jack array J104–J151. Inset shows how jacks are connected. Note that switch S102 is actually an SPDT pushbutton type.

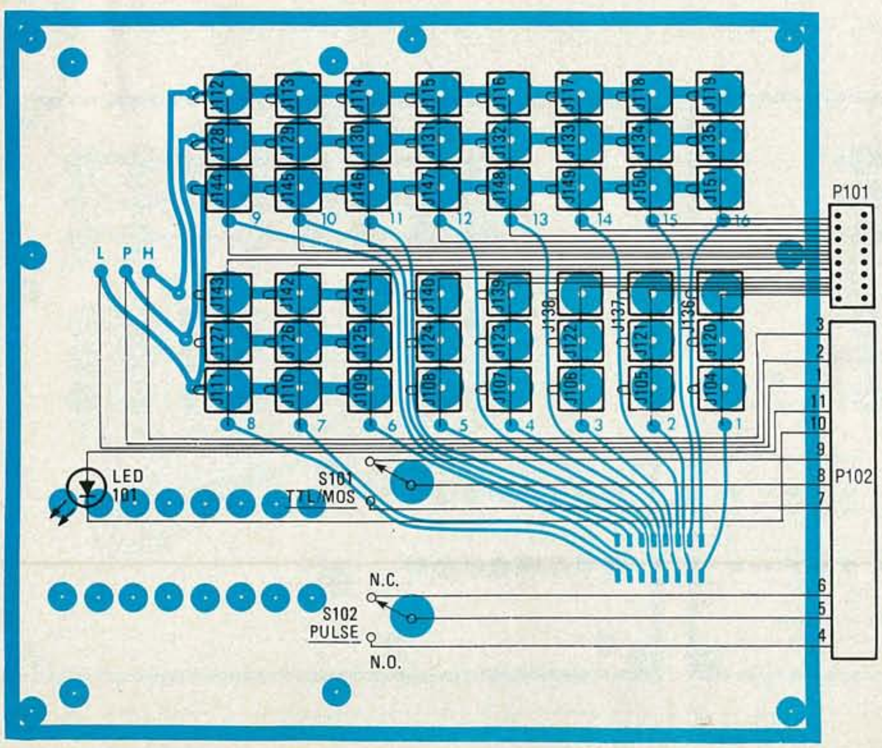
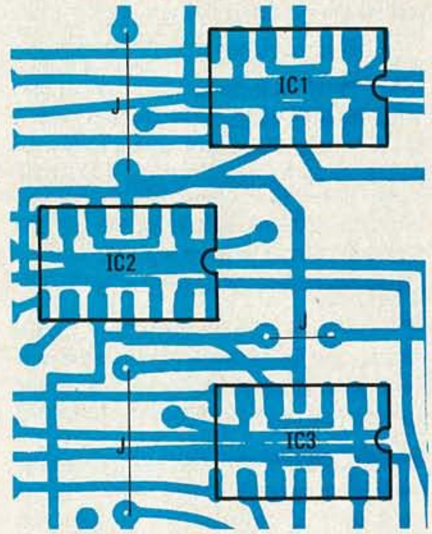


FIG. 14—CENTER PINS of the HI, LO, and PULSE jacks for each IC pin are bused together. No wires are connected to ground lugs.

OOOOOOOPS

The center jumper in Fig. 5 of Part 1 was shown incorrectly. The correct portion of that parts-placement diagram is shown below.



PARTS LIST—PANEL BOARD

Semiconductors

LED101-jumbo red LED lamp
P101—16-pin DIP header with 10-inch (minimum) cable
P102—12 pin Molex nylon connector
S0101—16 pin ZIF (*Z*ero *I*nsertion *F*orce) socket (Welcon ZIF—16 or similar)
SO102—12-pin socket to mate with P102 from display board
J104–J151—miniature phone jack
J201—two-conductor polarized jack (a phone jack is OK)
S101—SPDT mini toggle switch
S102—SPDT mini pushbutton switch (push-on/push off)
S201—SPST toggle switch
Miscellaneous: cabinet, hookup wire, 4-40 hardware, ¾-inch threaded spacers, phone plugs, etc.

The following is available from Technico Services, PO Box 20HC, Orangehurst, Fullerton, CA 92633: set of two etched & drilled PC boards (IC-1), $30.00. Available from ABC Electronics, 2033 W. La Habra Boulevard, La Habra, CA 90631 is a set of all parts, *excluding PC boards* (IC-1P), $85.00. CA residents please add sales tax; foreign orders please add $3.00 for postage & handling.

piece of uninsulated bus wire. Connect the end of the wire to the pad below the "LO" jack. Then move to the pin-15 series of jacks, and connect them in the same manner. Keep going until all the jacks are tied together and connected to the appropriate pads on the PC board. Check your work carefully. It's very easy to make a mistake here. Watch for shorts, especially, and correct any errors you find.

When we continued this article, we'll finish up the panel-board wiring and complete the assembly. Then we'll make sure the tester operates properly. **R-E**

ALL ABOUT

VLF Active Antennas

Because of poor antenna performance, the low frequencies are, as a rule,neglected by shortwave listeners. This series of articles will show you how you can overcome those problems and hear what you've been missing.The principles we'll discuss can even be used for reception up to 30 MHz.

R.W. BURHANS

GENERAL-COVERAGE COMMUNICATIONS receivers that are capable of continuously tuning from 10 kHz to 30 MHz are becoming ever more popular. However, users are often disappointed with their performance at the extreme low end of the spectrum—but it's not always the receiver that's to blame. Often, poor VLF (*V*ery *L*ow *F*requency) performance is due to the use of an untuned, random-length antenna. Such antennas are often used because of the difficulty of building a full-size VLF antenna. As, we'll soon see, however, full size antennas, aren't always necessary for good reception at low frequencies.

This series of articles will introduce you to practical active-antenna systems that are physically very short. For example, Fig. 1 shows some experimental wide-band active antennas using whips that are just one-meter long. The casual SWL or VLF-LF listener with an appropriate receiver will get good results using those—provided that appropriate attention is paid to such things as antenna location, interference considerations, circuit construction, and ground systems.

Active antenna basics

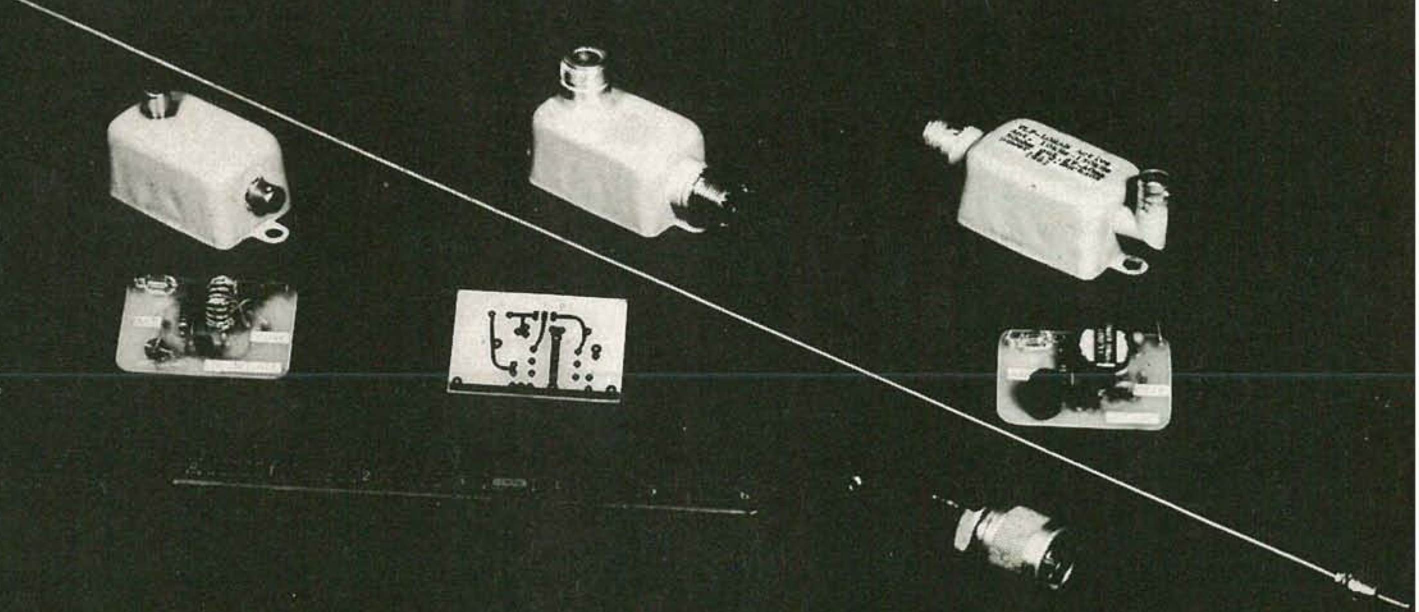
In this discussion, we will restrict ourselves to active systems using vertical whips. Loop antennas are very useful but tuning, coil changing, and an entirely different type of circuitry are needed for that type of active antenna system. Short whips are usually easier to make and operate, but have the disadvantage of being more sensitive to local noise (power-line noise, for example). Loop antennas are directional—they have to be oriented with respect to the signal for best sensitivity. On the other hand, vertical whips are omni-directional—sensitivity is not affected by the antenna's orientation.

Typical active antenna preamplifiers operate primarily as impedance converters or current amplifiers—they convert a small input-signal voltage at a high-impedance input to nearly the same voltage at a low-impedance output. A coaxial cable is connected from the output to the receiver's low-impedance antenna input (typically 50 to 500 ohms). As is common in many TV antenna-mounted preamplifiers, the power for operating the active preamplifier uses that same coaxial cable. There are, however, basic differences between the VLF-HF systems and the TV-type active preamps. For example, the VLF-HF active antenna must have a higher input impedance and more attention must be paid to the details of the amplifier's dynamic range and distortion. Another difference is that the frequency range covered by the VLF-HF preamplifier is a couple of orders of magnitude greater than that covered by the TV-FM units.

Active antenna preamplifiers mounted at the base of a short whip antenna are most often used at low frequencies (10 kHz to 100 kHz). There, the antenna length is much less than .001 wavelength. The general rule in airborne or marine VLF communications, or Omega and Loran-C navigation systems is to use a short active-antenna system .

Antenna sensitivity

Let's now introduce the concept of *effective length* (l_e). (In low-frequency usage, that is sometimes referred to as effective height). The effective length of an antenna is equal to the ratio of the voltage at the antenna output terminals to the field strength of the input signal (measured in volts/meter). In equation



form that is stated as:

$$\frac{V_{OUT}}{E_i} = l_e$$

The ratio of the effective length to the physical length (l) is a measure of the antenna efficiency. For example, an antenna with a physical length of 100 cm could have an effective length of 20 cm. The resulting output signal strength E_o would then be only one fifth that of the input.

The effective-length-per-unit-length of an active antenna can be estimated by determining the input capacitance of the system. That input capacitance includes the antenna-mount capacitance, C_m; the input-wiring capacitance, C_g, and the antenna-whip capacitance, C_a. (See Fig. 2-b.) The relationship is:

$$\frac{l_e}{l} = \frac{C_a}{C_a + C_m + C_g} \quad (1)$$

A typical one-meter long whip antenna might have a measured C_a of about 10 pF over a flat ground plane. Also, an antenna mount might have a fixed capacitance of C_m = 5 pF and the input wiring and active circuit capacitance might be C_g = 8 pf. The efficiency for a system with those values would be:

$$\frac{10}{10 + 5 + 8} K = \frac{10}{23} K = 0.434 \text{ K} \quad (2)$$

The factor K (which was assumed to be equal to 1 in equation 1) is a measure of the nearby shielding or coupling effect of the local ground plane (trees, structures, buildings, etc.). In practice, K is always less than one. A value of 0.75 might be obtained with a top-hat capacitive-loaded vertical antenna mounted on a pole or structure such that the local ground plane slopes away from the antenna on all sides. Values of K as low as 0.1 might be possible for a low horizontal wire with trees or buildings close to and higher than it. For example, let's presume that the K of equation 2 was equal to 0.5. The effective length would then be 0.434 × 0.5 = 0.217 meters. That is typical of what is actually observed with a medium-quality active antenna with a length of 1 meter. Another way of thinking about that antenna is to say that its efficiency, in terms of converting the input field strength to a corresponding level at the output terminal, is about 21.7%.

Because of the coupling factor, an active antenna mounted up in the clear will generally outperform an antenna mounted near obstructions. At VLF frequencies, a hill or mountain 0.5 km away from the antenna can reduce the antenna's sensitivity. Precision measurements of the phase and amplitude of 100-kHz Loran-C signals, made while flying over hilly terrain at low altitudes, can yield information about the variations of ground conductivity and terrain contours, which are related to K.

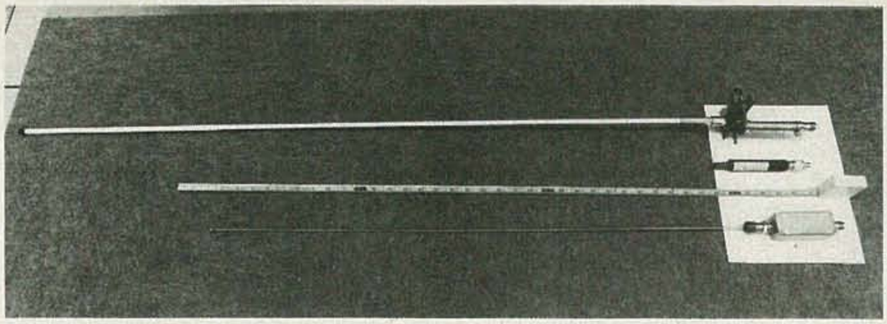


FIG. 1—EXPERIMENTAL WIDE-BAND ACTIVE ANTENNAS. The ones shown here are approximately one meter (39.47 inches) long. The tape measure is pulled out to 41 inches.

Input impedance

Active antenna receiving preamplifiers at frequencies of about 10 kHz have a high input impedance (greater than 1 megohm). That is because of the low antenna capacitance (C_a). Thus, the whip antenna can be considered to be a voltage source with a high internal impedance when coupled to the preamplifier input terminal (see Fig. 2). That internal impedance becomes lower as the frequency of operation is raised—reaching a value around 10,000 ohms at the AM broadcast band (1-MHz region).

If a short whip were connected directly to a 500-ohm receiver input terminal, a LF signal would be greatly attenuated as a result of the mismatch. For example, let's look at what would happen to a 10 kHz signal. The reactance of C_a for a 1-meter whip would be about 1.6 megohms at 10 kHz. Without an active preamplifier, the attenuation would be about 500/ $(1.6 \times 10^6 + 500)$ ohms, or roughly −72 dB! If, on the other hand, an active preamplifier were used, the same 1-meter whip would provide ample signal at 10 kHz, as the source would be much more closely matched to the load.

The effective capacitance of a wire antenna is approximately 10 pF/meter. Thus, at 10 kHz, a 30-meter wire antenna directly connected to a 500-ohm receiver-input terminal is a 50,000-ohm reactance. Another way of looking at that is to say that the antenna efficiency is 500/50,000 = .01, or 1%. At 10 kHz, our 21.7%, 1-meter active antenna looks much better than that 30-meter wire.

As we go higher in frequency, up to the 30-MHz region, the impedance of the 1-meter whip decreases to the point where it could be connected directly to a low-impedance receiver input. Hence, active, high-input-impedance antenna systems are most useful at the VLF-LF range (usually below 500 kHz); at those frequencies they can perform as well as a very-long-wire antenna that is connected directly to the receiver's low-impedance input.

Antenna noise levels

In airborne applications, for aerodynamic considerations and to minimize interference, it is desirable to use as small an antenna as possible in the VLF range. A recent FAA report suggests a minimum effective length of about 20 cm when operating at 100 kHz (Loran-C). An active antenna with a 20 cm l_e will provide an output signal level of 20 μV across a 50-ohm receiver input terminal when it is immersed in a 100 μV/meter electric field.

The antenna noise level found in a receiver is a function of the receiver bandwidth. A typical Loran-C reciever might have a noise level of perhaps 1000 μV/m. Thus, a weak Loran-C signal may be buried in noise to the 100 μV/1000 μV, or −20dB S/N level at the antenna input,

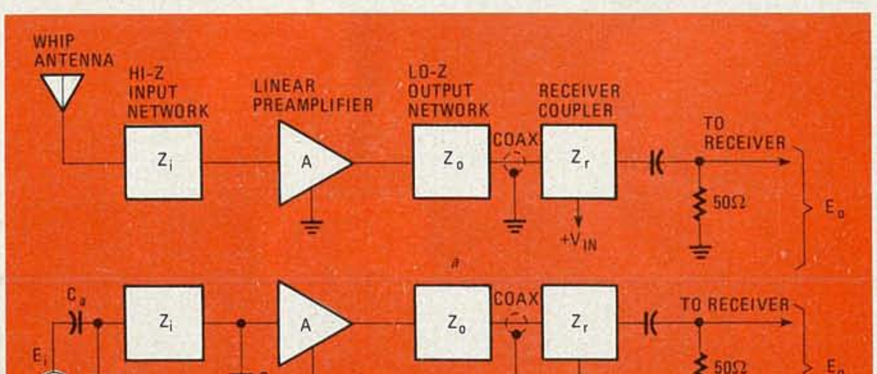


FIG. 2—BLOCK DIAGRAM OF AN ACTIVE ANTENNA is shown in *a*. The whip antenna is replaced by its equivalent circuit in *b*.

even though the total signal and noise level (S + N) is quite high at the preamp output. That is a general characteristic of most VLF-LF receiver systems. The antenna noise is much larger than the receiver-circuit noise levels by at least an order of magnitude.

Figure 3 is a chart that shows the magnitude of the atmospheric noise level (in the midwestern United States at 170 kHz) as a function of the receiver bandwidth. Summer afternoons are dominated by the noise of thundershower spherics. They produce a typical noise level of 100 μV/m (40 dB above 1 μV/m) in a receiver with a 400-Hz bandwidth. In the morning, summer noise levels are lower. Lower still are the winter noise levels, which are usually less than 1μV/m. However, in the winter, the antenna becomes less sensitive despite the reduced noise level. That is due to the lower conductivity of ice and frozen ground. For example, propagation of VLF signals is very poor over a large ice mass like the Greenland ice cap. The action is similar to that of a carbon wedge inserted into a microwave waveguide.

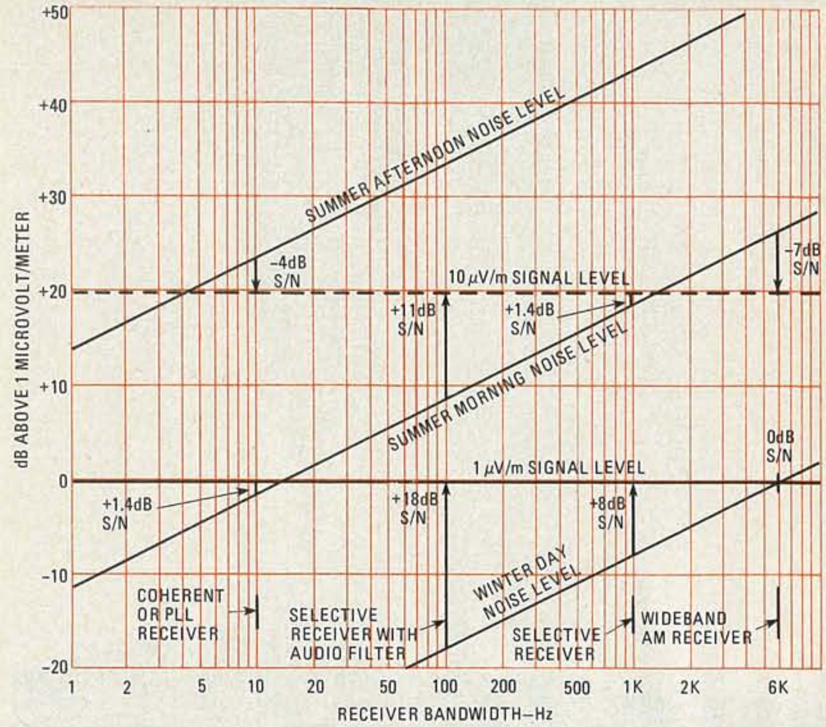


FIG. 3—ANTENNA NOISE LEVELS are a function of the receiver's bandwidth and differ from season to season as well as with the time of day.

Intermodulation distortion

We want an active-antenna system that will ensure that the signal heard on the receiver is not some spurious response of the preamplifier or the receiver itself. That may be rather difficult in some urban areas, where the general RF-"pollution" level is high over the entire VLF through HF spectrum. We do not want our antenna system to amplify strong signals that are in the passband of the active antenna but *not* on the frequency we are interested in receiving.

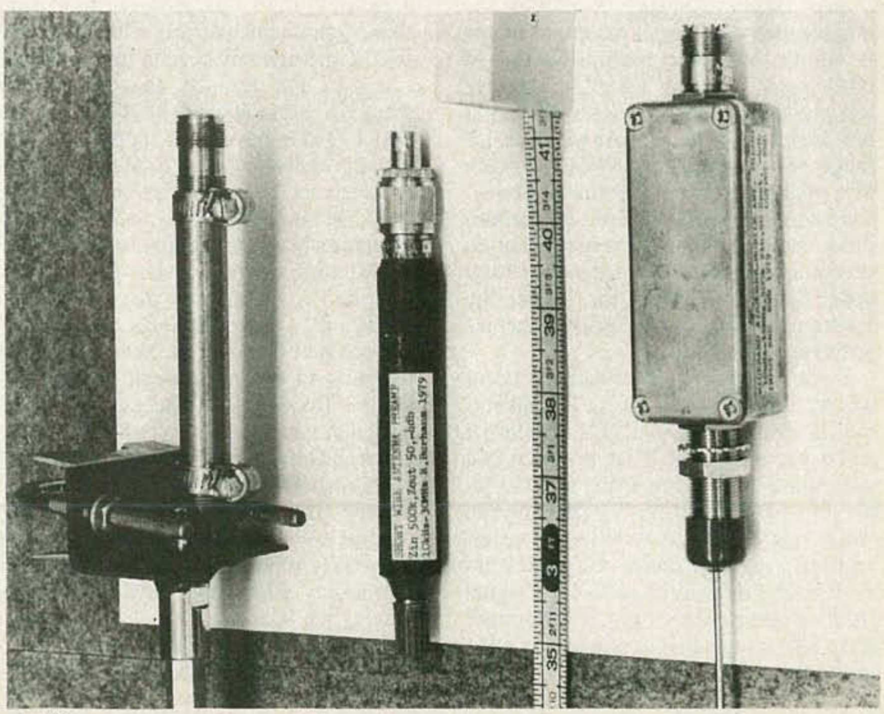
Achieving those goals is difficult in practical wide-range semiconductor preamplifier circuits. That's because they suffer from problems caused by second- and third-order intermodulation distortion products that are created by small non-linearities in the active preamp.

Second order distortion

Suppose we have an active-antenna system connected to a receiver tuned to 370 kHz in the LF beacon band. Let's also suppose that there are local broadcast-band transmitters on 1340 kHz and 970 kHz that produce a difference frequency of 1340 − 970 = 370 kHz. If the active-antenna preamplifier is not perfectly linear—and it never is in practice—then at some high signal level, a mixture of the two broadcast-band AM signals will be superimposed on the desired 370-kHz beacon signals. If the listener is located close to the AM transmitters, the interference signal level might be quite high. It increases by 20 dB every time that the strength of the signals causing the interference increases by 10 dB. The problem can be reduced by using semiconductor circuitry that is more linear, or by using high-impedance traps and low-pass filters connected directly to the active-antenna input circuitry.

Third order distortion

Third order distortion can be a more severe problem. It occurs when a strong local AM broadcast-band signal mixes or multiplies with a weaker signal producing interference frequencies of $2f_1 - f_2$ or $2f_2 - f_1$. Suppose f_1 is a weaker signal on 700 kHz and f_2 is a strong local signal on 1340 kHz. Then $2f_1 - f_2 = 60$ kHz and $2f_2 - f_1 = 1980$ kHz. If we tune our receiver to each of those frequencies, signals will be heard faintly in the receiver. The one at 60 kHz is particularly troublesome, since it is right on top of a normal VLF time signal from WWVB and produces annoying fading that coincides with the signal variations from the broadcast stations.



ACTIVE ANTENNA PREAMPLIFIERS can be made very small.

An active-antenna system presents few mounting-problems.

TABLE 1 Harmonic number	Frequency—kHz
1	15.734
2	31.468
3	47.203
4	62.937
5	78.671
6	94.406
7	110.140
8	125.874
9	141.608
10	157.343
11	173.077
12	188.811
13	204.545
14	220.279
15	236.014
16	251.748
17	267.482
18	283.217
19	298.951
20	314.685
21	330.419
22	346.154
23	361.888
24	377.622
25	393.357
26	409.091

That type of two-tone interference increases by 30 dB for every 10 dB increase in the level of the two interference signals. The large number of broadcast-band stations, and the thousands of LF beacons in the continental United States (as well as the world), means that there are many potential interference sources that could cause problems for VLF-LF receiving setups.

Harmonics and overload

Another common type of interference that plagues all types of reception setups is simple harmonic multiplication. In other words, a strong signal on 250 kHz can produce weaker harmonic signals at 500 kHz, 750 kHz, etc. At the VLF-LF range, that problem is usually not as much of a concern as those mentioned above, since the interference caused by second, third, etc. harmonics is usually not as severe as that caused by second or third order distortion. Also, the higher the harmonic number, the weaker the interference signal will be.

Input preamplifier overload can occur when a locally strong station is transmitting at a frequency that falls within the antenna's passband. That problem can sometimes be cured by using traps or input low-pass filters, or by shorting the whip to ground with a remote, weatherproof, low-capacitance relay. However, it is very difficult to get rid of a signal from a nearby amateur or CB transmitter if the active antenna is designed to operate in the same frequency band.

Other interference

Most TV receivers radiate some horizontal-oscillator signal (15.734 kHz); that problem is especially severe in modern solid state and IC sets. The harmonics from that source, up through 400 kHz, can often be heard in a VLF-LF receiver. A list of the TV-oscillator harmonic frequencies up to 409.091 kHz range is shown in Table 1. If your communications receiver lacks a precision digital readout, those interference signals can be used for frequency markers in the VLF-LF range. Sometimes, however, those signals can interfere with the reception of an important beacon. In the case of Loran-C, for instance, the interference from TV harmonics at 94.406 kHz and 110.140 kHz have been reported to disturb the operation of some marine Loran-C receivers near marinas in populated areas; in such situations, audio or notch filters can be used to reduce that problem.

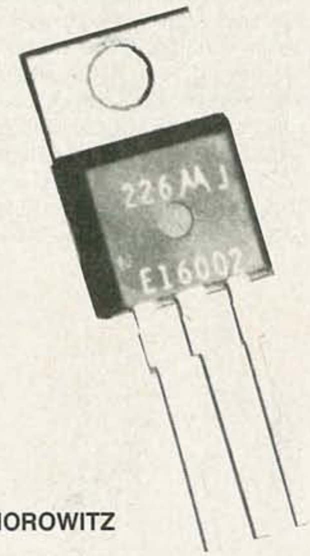
Harmonics from 60-Hz power-line-operated systems can also cause interference. For instance, the 170th harmonic of 60 Hz is 10.200-kHz, which happens to be the Omega navigation-system frequency. That, as you might imagine, can cause problems, especially when an Omega receiver is poorly located with respect to power lines or faulty power-line ground systems. Rusty marine vessels that use 60-Hz power systems have reported problems with those harmonics when operating Omega receivers while at sea.

In some cases, better grounding of house-wiring systems can help reduce interference from power systems. Active antennas work best when some ground reference is provided at the antenna base. That's because any antenna that is very much shorter than one-quarter wavelength acts like an electric field probe that measures the potential difference between itself and its ground plane. Thus, good grounds are always a necessity and they can eliminate many reception problems. As to what type of ground system to use, a cold-water copper-pipe system or deep-driven copper rods and heavy conductors will do; but a large number of copper radial-wires laid out around even a short pole-mounted whip will provide marked improvement in VLF reception.

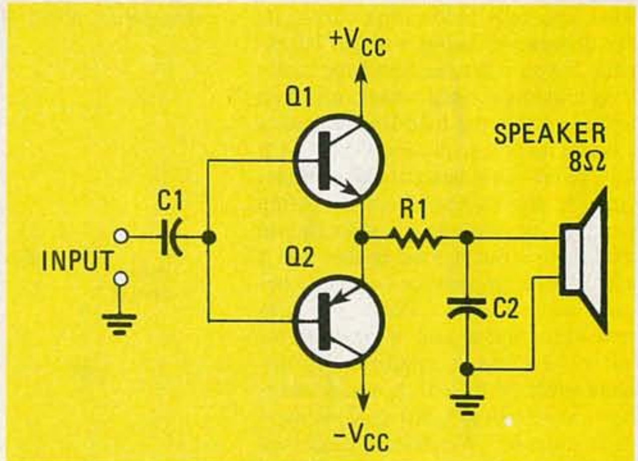
A wide variety of other types of interference are often heard throughout the VLF-HF region; their sources include garage-door openers, microwave ovens, motor controllers, personal computers, and TV-set remote tuners. The active circuitry contained in such devices often radiates signals at frequencies between 40 and 200 kHz. Many microcomputer systems radiate strong harmonic energy in the 1- to 30-MHz range. Some control systems are vibration-sensitive and can be frequency- and amplitude-modulated by room or household noises. Those signals cause interference that is independent of the type of active or passive antenna used on the receiver.

Active-antenna systems may not be the ultimate answer to a single small receiving antenna covering all frequency ranges, but they can provide very satisfactory performance with proper attention to the details that we've covered in this article. The next article in this series will present some practical circuit details of active-antenna systems for the experimenter, SWL or casual listener. **R-E**

How to Design Analog Circuits —Power Amplifiers



MANNIE HOROWITZ



The various types of power amplifiers, and some important factors to consider when designing those circuits, are the topics we'll cover in this month's article.

A TRANSISTOR DELIVERS POWER TO THE load or device connected to it. If we're looking at a DC amplifier, the power delivered is, of course, equal to the load resistance multiplied by the square of the DC current flowing through that load.

In the case of an AC amplifier, however, things get a little more complicated. Should a full cycle appear across the load, the relationship of power to current and resistance remains the same as in the DC case, but now the effective current is the peak current in the cycle divided by the square root of 2. If, on the other hand, only one-half of the cycle appears (with zero output during the other), the effective current now becomes the peak current divided by 2. When more than one-half of a cycle of current flows but there is less than a full cycle, the effective current in the resistor is somewhere between the two.

The portion of the cycle that appears across the output load is determined by the class of operation of the amplifier being used. Large signal transistor power-amplifiers operate in Class-A through -H. Most audio and RF circuits, however, are designed for Class-A,-AB, -B and -C operation. Special considerations are involved when a design calls for a circuit to operate in the Class-D through -H modes. In this discussion, therefore, we will briefly look at the latter classes, but concentrate on designs involving the four more-popular ones.

In Class-A circuits, current flows through the transistor over the complete cycle and bias is set at the center of the transistor's load line. In Class-B circuits, the current flows only during one half of a cycle and the transistor's bias current is set for $I_C = 0$. In Class-AB operation, current flows through the transistor during one half of the cycle and part of the other one. Finally, in Class-C operation, current flows through the transistor for less than one half cycle.

Class-A amplifiers

Class-A amplifiers that are designed to reproduce low-power signals are usually biased at the center of their load line. Class-A power amplifiers are also ideally biased at that point but some additional factors must be considered. For one thing, to deliver power, a transistor must dissipate power. Despite the size of the load, the product of the collector current and collector-to-emitter voltage at any point on the load line, must be less than the power dissapation rating of the transistor if the device is not to be destroyed. That condition will be met if the load line for the device is chosen so that it falls below the maximum permissible power-dissipation curve of the device.

Let's now look at how that power-dissipation curve is derived and how it is used in determining the load line. As an example, assume that the circuit we are designing uses a transistor that can dissipate 10 watts and handle a maximum collector current of 1 amp. If you were now to calculate the maximum allowable voltage for currents of from zero- to one-amp, you would wind up with the data shown in Table 1. Plotting that data as shown in Fig. 1 gives you the maximum

TABLE 1

Current (amps)	Voltage (volts)
0	∞
0.1	100
0.2	50
0.4	25
0.5	20
0.8	12.5
1	10

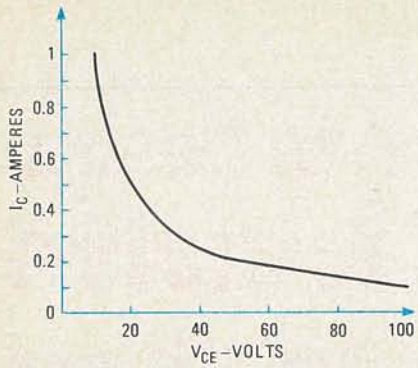


FIG. 1—THE MAXIMUM POWER dissipation curve for a transistor is plotted here using the data from Table 1.

power-dissipation curve for the device. As long as the transistor is biased so that its load line falls below that curve, its power-dissipation rating will not be exceeded. If you want the transistor to deliver its maximum rated power, it should be biased so that the load line intersects the maximum power-dissipation curve at just one point—the center of the load line.

Class-A power amplifiers are often used to provide power to a loudspeaker in a small radio. But a loudspeaker has a relatively low impedance—usually between 4 and 16 ohms. Thus, if it is to present a reasonable load to the collector circuit of a Class-A amplifier its impedance must be raised. A transformer, such as the one shown in Fig. 2, is ideal for that purpose. We briefly discussed transformer principals in the article that appeared in the December 1982 issue of **Radio-Electronics**. As stated there, the impedance of the primary is related to the impedance of the secondary by $Z_P/Z_S = (N_P/N_S)^2$. Thus, if an amplifier circuit has an output impedance of 72 ohms but you wish to use the circuit to drive an 8-ohm speaker, you'll need an impedance-matching transformer with a turns ratio equal to $\sqrt{Z_P/Z_S} = \sqrt{78/8}$, or 3:1.

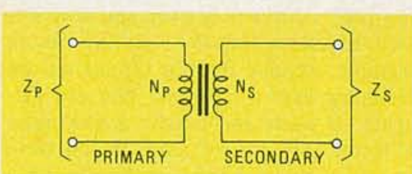


FIG. 2—A TRANSFORMER is used to alter the impedance of the load seen by the transistor.

When a transformer is used between the loudspeaker and transistor in a Class-A amplifier, the maximum efficiency of the overall circuit is 50%. That is, the maximum sinusoidal power that can be delivered to the load is equal to 50% of the power that must be supplied by the power source and dissipated by the transistor when idling. Thus, while a transistor can be biased to demand a maximum of 10 watts from a supply, only 5 watts would be delivered to the load over a cycle; the remaining power is dissipated by the transistor.

While that 50% sounds low, in reality the efficiency is even 20% to 40% lower because of the losses and limits of the circuit and transformer. As bad as that is, it could be worse. If you attempted to place the load directly in the collector circuit instead of using a transformer, DC power would be dissipated by the load as well, limiting the maximum efficiency to about 25%. That will still be reduced by the same 20% to 40% we mentioned earlier, leaving us with an efficiency of about 20%, if we are lucky.

Let's now assume that you want to design a Class-A amplifier to deliver 4 watts to an 8-ohm loudspeaker. If a transformer is used in the circuit as shown in Fig. 3-a, the transistor must be capable of dissipating about 10 watts. If you use a 25-volt power supply, your load lines will look like those shown in Fig. 3-b.

(As mentioned in the December issue of **Radio-Electronics**, when a transformer couples a load to the transistor circuit, the collector sees DC load that consists of the winding resistance of the transfomer primary along with any other resistance in the collector circuit. It also sees an AC load due to the reflection through the transformer of the load in the secondary. The quiescent operating point for the circuit is where those two load lines cross.)

Start the design by drawing the DC load line. The slope of that line equals the total DC resistance in the collector circuit. In our example, that is assumed to be close to 0 as the only element in the collector circuit is the primary of the transformer. The DC load-line is therefore a vertical line at V_{CE} equals 25 volts. Because the maximum power the transistor can dissipate is 10 watts, the maximum current that may flow through the transistor with 25 volts applied is 10/25 = 0.4 amps. Therefore, the Q or quiescent point is 25 volts, 0.4 amps. Any bias current below that level may have been chosen on the DC load line, but the delivered power would not have been less than the maximum that the transistor is capable of delivering safely.

The AC load line is determined by the impedance reflected into the primary of the transformer, but it must pass through the quiescent point established by the DC-bias conditions. Because it must vary around that point, the collector voltage may swing from 0 to double the supply voltage, or to 50 volts. Similarly, the collector current can vary through a cycle from 0 to double the quiescent current, or to 0.8 amps. Consequently, the impedance seen by the transistor in the primary winding of the transformer, is $(50 - 0)/(0.8 - 0) = 62.5$ ohms. Because the loudspeaker's impedance is 8 ohms, the turns ratio of the transformer must equal $\sqrt{62.5/8} = 2.8:1$. All points on the AC load line must, of course, be at or below the maximum permissible power dissipation curve of the transistor.

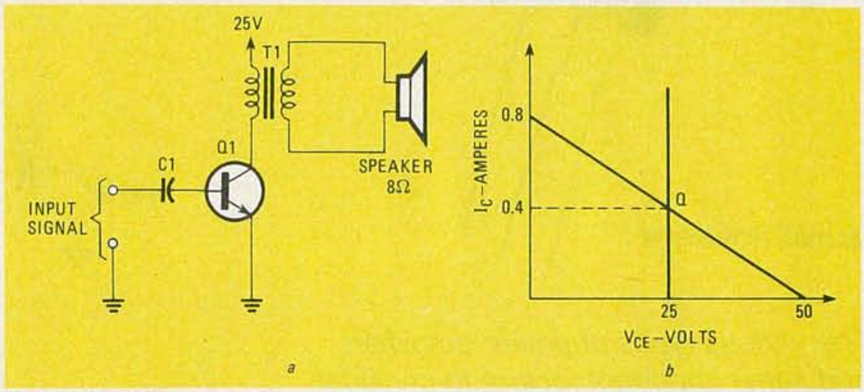


FIG. 3—A CLASS-A AMPLIFIER is shown in *a*; the load lines for the circuit are shown in *b*.

Class-B amplifiers

Since in Class-B operation a transistor is biased at the point where the quiescent or idling current is equal to zero, in that mode of operation current flows during just one-half of a cycle. Thus, assuming an NPN transistor for example, the only time current flows through the device is when the positive portion of the cycle is applied to its base. No current flows during the other half of the cycle. A simple Class-B amplifier is shown in Fig. 4.

If you want a Class-B amplifier to reproduce the entire input cycle, two transistors must be used in the circuit. One of those reproduces one half of the cycle while the other reproduces the second half of the cycle. The two halves are recom-

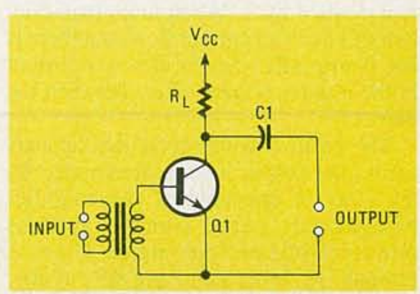


FIG. 4—IN A CLASS-B AMPLIFIER, current flows only during one half of a cycle.

bined across the load to produce an amplified version of the input waveform. Such a circuit, called a push-pull amplifier, is shown in Fig. 5. It gets its name from the fact that when one transistor conducts, the other is off. In Fig. 5, the relative phases of the applied signals are shown at the bases of the transistors; the outputs are shown along the leads from the collectors. Note that the lower device is turned on during the first half of each cycle while the upper transistor is turned on during the second half.

Considering the transformer circuit in Fig. 5 along with the loudspeaker load resistance, the impedance reflected from the secondary into the primary of the transformer is $R_L' = (N_P/N_S)^2R_L$, where R_L and R_L' are the resistance of the loudspeaker and the impedance reflected back from the secondary into the full primary winding, respectively, and Np/Ns is the ratio of the number of turns in the primary winding to the number of turns in the secondary winding. From that, it can be determined that the impedance each transistor sees, R_L'', is equal to $R_L'/4$.

The power required to operate the circuit shown in Fig. 5 over an entire cycle is equal to $I_{CMAX}V_{CC}/1.57$. The maximum power that the circuit can deliver to the load is 78.5% of the full-cycle power demanded from the supply. Power delivered to the load over the complete cycle, is double the maximum instantaneous power each transistor dissipates during the cycle, or $V_{CC}I_{CMAX}/2$.

We noted in our discussion of Class-A amplifiers that the load line of a transistor must not cross or go above the maximum-power-dissipation curve. That does not hold for Class-B operation because the transistors conduct for just one-half of each cycle and the total power dissipation is found by averaging over a complete cycle. Considering that, the load line may cross the power-dissipation curve, or a portion of it may even lie above that curve, provided that the average power dissipated by the transistor during the complete cycle does not exceed the transistor's stated maximum power-dissipation rating.

The amount of power actually dissipated by a transistor, depends upon the portion of the maximum output power that is actually delivered to the load. When the power across the load is 40% of the maximum output signal that can be supplied by the circuit, maximum power is dissipated by the transistor. If the output is more or less than 40% of the maximum, the transistor will demand less than the maximum power from the supply.

To check the temperature rise of the output transistors, set the amplifier up so that it delivers 40% of the maximum power to the load. Allow the circuit to operate that way for several hours, then check to see if the temperature of the transistor has exceeded its upper limit and whether or not the device is still working.

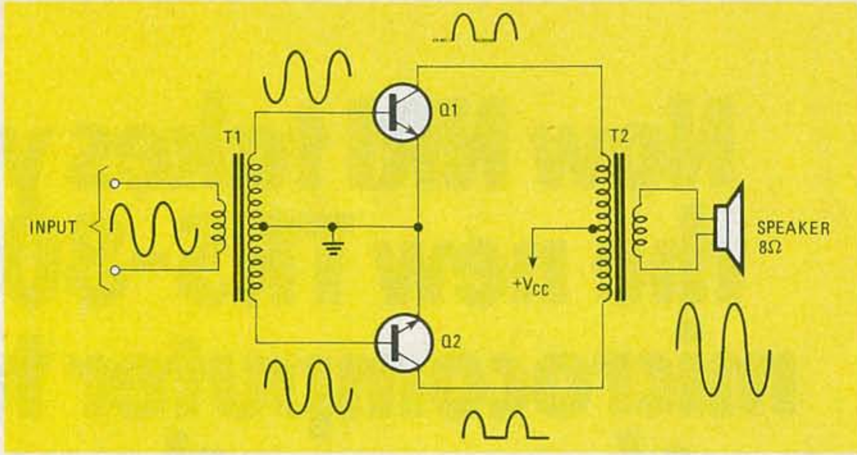


FIG. 5—IF YOU WANT a Class-B amplifier to reproduce an entire cycle, two transistors must be used in a push-pull configuration as shown here. Note that the relative phases of the signal at various points in the circuit are also shown.

Although two transistors are used in a push-pull circuit, the design revolves around one device at a time. The first step is to decide how much power, P_{RL}'', must be delivered by the overall circuit. Each device, then, must deliver one half of that power; the overall circuit is arrived at by designing the appropriate circuit for each transistor.

The first step is to select transistors that are capable of handling the amount of power that they will be called on to dissipate. If the supply voltage is V_{CC}, the load, R_L'', seen by one transistor is $V_{CC}^2/4P_{RL}''$. The maximum average power dissipated by the transistor is found from $P_{MAX} = V_{CC}^2/\pi^2R_L''$. That is, of course, the power dissipated when 40% of the maximum output is developed at the output. Select a transistor that is capable of dissipating that power.

Turning to the transformers, they are chosen as discussed in the December 1982 issue of **Radio-Electronics** (see that issue for a full discussion of the technique). Bear in mind that the impedance that must be seen across the entire primary winding of transformer T2 is $4R_L''$.) Thus, if the impedance presented by the load to the secondary winding is R_L, the transformer turns ratio should be equal to $\sqrt{4R_L''/R_L}$. Also, the primary must be center-tapped.

Class AB amplifiers

In Class-A operation, the output transistor is biased at the center of the load line, while in Class-B, it is biased at the point where no collector current flows when the transistor is in the quiescent or idling state. In Class-AB operation, the transistor is biased to operate at a point somewhere between Class-A and Class-B. In that mode, some collector current flows when the device is idling. Although that decreases the efficiency of the circuit, Class-AB operation is useful where good and reliable reproduction of the input signal is required.

As noted in our earlier discussions of diodes and transistors, no (or very little) conduction takes place through those devices unless somewhat more than a specific minimum voltage is applied to their terminals. Essentially no current flows through the base-emitter junction of a germanium transistor if less than about 0.2 or 0.3 volt is applied. Similarly, a minimum of between 0.5 and 0.7 volt must be applied to the junction of a silicon device before any current will flow.

If we rely only on a signal at the input of the circuit to turn on a transistor, it will not be turned on until that input exceeds the required minimum voltage. A sinewave at the input will therefore be distorted after being amplified by a Class-B circuit as is shown in Fig. 6. Here, there is no signal at the crossover point during the time when one transistor of the push-pull pair stops conducting and the second one begins.

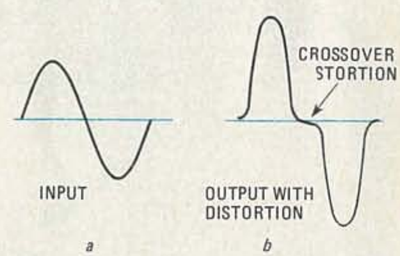


FIG. 6—CROSSOVER DISTORTION, shown in *b*, occurs because a transistor does not conduct at low input-signal levels.

Although that distortion is undesirable, it may be acceptable for some applications. But what may be even more critical in Class-B operation is that when a transistor is cut off at a rapid rate, large transient voltages develop in the circuit. As a result, the transistor may break down.

To avoid breakdown while minimizing distortion, the transistor is biased so that some collector current flows when the circuit is idling. That current is usually

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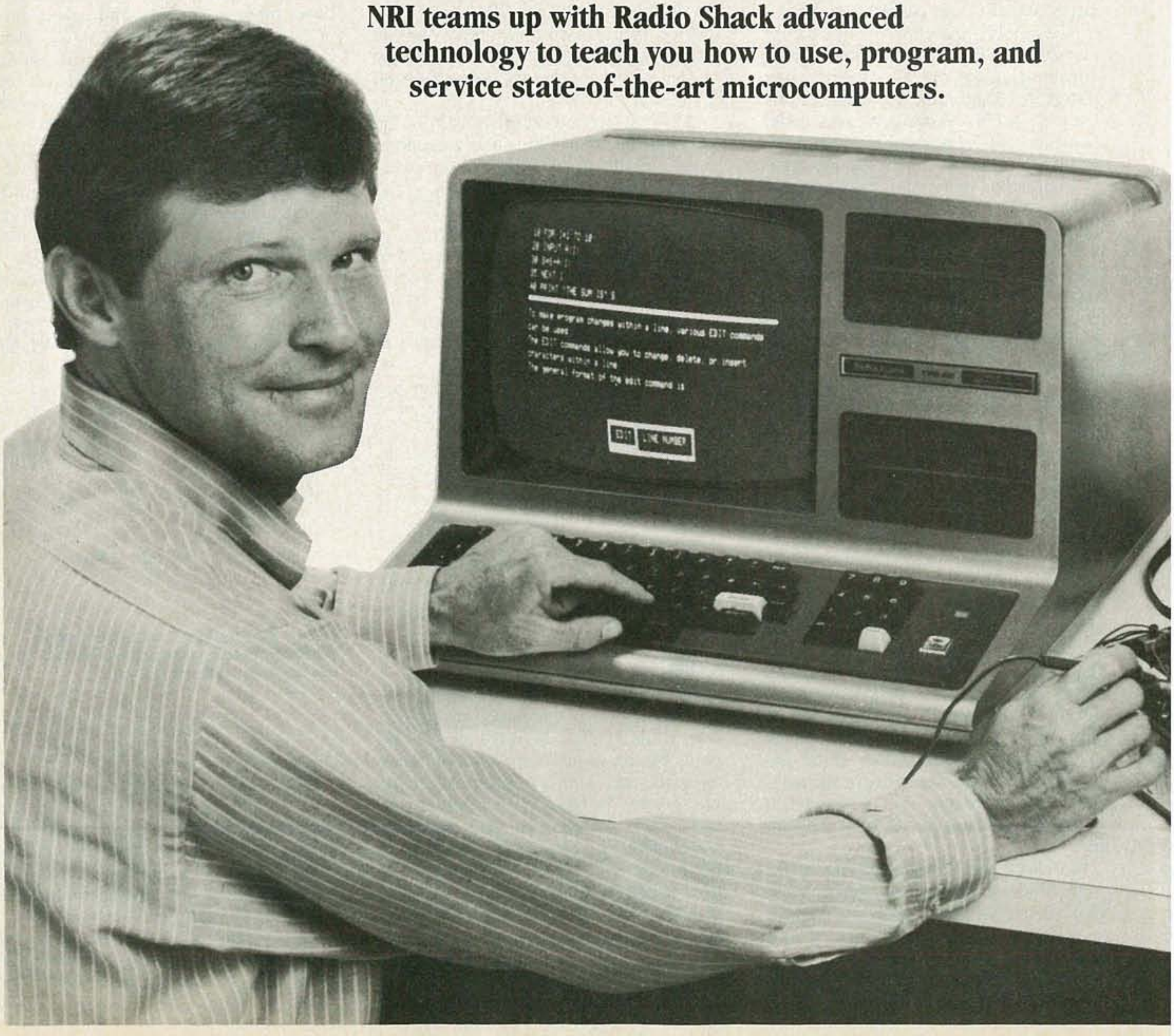

between 10 and 25 mA, although idling current as high as 300 mA can be used in high-power designs. Distortion can be reduced farther by using a diode in series with each emitter load in the transistors of the push-pull circuit. That diode rounds off the crossover point to a greater degree than is possible when only the junction of the transistor is in the circuit.

Class-C amplifiers

In the Class-C mode of operation, the transistor is biased so that it conducts for less than one-half of a cycle. To do that using an NPN device, the base is biased negative with respect to the emitter. As the output is obviously in the form of pulses, the efficiency in some cases can be as high as 85%.

Although not useful in audio applications, the Class-C amplifier is frequently used in RF circuits. A resonant L-C circuit is placed at its output. Each time a signal is applied to the amplifier's input, a full cycle is generated across the L-C circuit, provided that circuit is tuned for the freqency (or a multiple of the frequency) of the signal applied to the amplifier's input.

Class-D through Class-H amplifiers

We could devote quite a bit of space to detailing the various other classes of operation, and how to design circuits using those modes of operation. Because the usefulness of those modes is limited mainly to special circuits and applications, we will just briefly note what they are. Each class is characterized by high efficiency and some boast excellent fidelity.

Class-D amplifiers are used to convert audio signals to pulses. In some designs, up to one-half million of those pulses are produced each second. When audio is converted to pulses, the width of each pulse is related to the instantaneous amplitude of the audio signal. When reproduced through an amplifier, the pulses are fed to a push-pull circuit. The output from the circuit is connected through a resistor to a loudspeaker that is shunted by a capacitor, as shown in Fig. 7. You'll note that no transformer is used between the load and transistors; instead, the transistors feed the amplified pulse signals directly to the loudspeaker through resistor R1. Resistor R1 and capacitor C2 form an integrator circuit where the width of each pulse determines the voltage developed across C2 and hence across the loudspeaker. That converts the pulses back to audio, which is output through the speaker.

Class-E, -F, and -G amplifiers are quite similar. In each half of the push-pull circuit, two transistors are connected in series. When the input signal is low, only one of the transistors in each half of the push-pull circuit conducts current, while no voltage is applied to the remaining devices. When the input signal is high, the transistors in both halves of the push-pull circuits are turned on. Since all the transistors conduct only during the peaks in the audio input signal, efficiency is quite high.

Class-H amplifiers use logic circuits in an otherwise standard push-pull amplifier. Normal or average levels of audio are reproduced in the usual Class-AB fashion. When input signals are large, however, the logic circuit activates the power supply to provide high voltages to the push-pull transistors. Because the supply voltage and hence the power dissipation are both low during the greater part of the audio cycle, the efficiency of the circuit is high.

The various classes of operation described here, are not the only means of improving distortion and efficiency. Biamplification can be added to the list. In that arrangement, the entire audio signal is fed to a filter such as the one shown in Fig. 8. At its outputs, the audio bandwidth is split into two bands—a band of high frequencies and a band of low frequencies—and each is amplified by a different push-pull amplifier. Each amplifier is designed to reproduce a particular band most efficiently. The crossover frequency, $f1$, is usually chosen to be anywhere between 400 and 800 Hz. At $f1$, gain has decreased somewhat on the low frequency band and increased an equal amount on the high frequency band. The values of the inductors and capacitors in the circuit can be found using the formula given in the figure; R is the resistance presented to the filter by the input circuit of the amplifier.

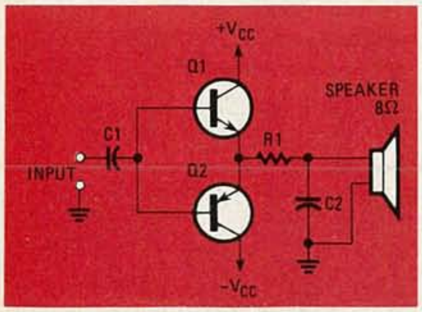

FIG. 7—IN A CLASS-D AMPLIFIER an audio input is converted to pulses and then reconverted to amplified audio.

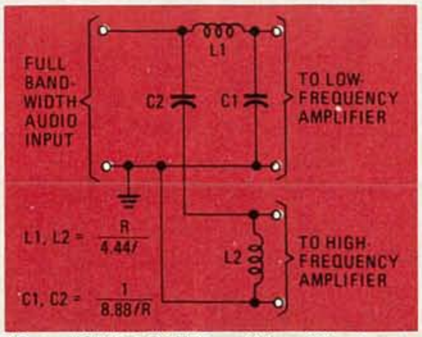

FIG. 8—USING A FILTER and biamplification, as shown here, can improve efficiency and reduce distortion.

VFET's and MOSFETS

Although bipolar power-amplifiers were considered in detail, the power FETs—the VFET and MOSFET—are now becoming popular. Those devices are used in push-pull circuits similar to those using bipolar devices. Just as the base-emitter current of the bipolar device was adjusted for a predetermined idling collector current, the gate-source voltage of the FET power amplifiers must be adjusted for a desirable idling drain-current level. Power FET circuits may be considered to operate in the Class-AB mode, but it is not unusual for the drain current to be set to a level as high as 500 mA. Distortion is low because the amplification characteristics of those devices are essentially linear.

Solutions to thermal problems

When a transistor dissipates power, it gets hot. That heat must be removed from the transistor it if is not to overheat and be destroyed. If heat is not removed from a bipolar device, its collector current builds up. If that build-up is not controlled and limited, the current level and power dissipated by the device may become excessive and exceed safe levels of operation, resulting in breakdown. Although that type of current build-up does not occur in the drain circuit of the VFET as its temperature rises, the VFET can break down if excess heat is not removed from the device at a reasonable pace. Here, we will describe methods of removing heat from the bipolar device. The disscussion, of course, also applies to FET's.

There is a thermal resistance that impedes the dissipation of heat from the junction of the transistor to the surrounding air. That resistance, called θ_{JA}, is in units of °C/watt. The temperature of the junction, T_J, depends upon the temperature of the air, T_A, around the transistor and the average power, P_{diss}, being dissipated by the device over a relatively short period of time. Those factors are related to each other by the equation:

$$P_{diss} = \frac{T_J - T_A}{\theta_{JA}} \quad (1)$$

The thermal resistance θ_{JA} consists of three thermal resistances. Those are θ_{JC}, the thermal resistance from the junction to the case, θ_{CS}, the thermal resistance from the case to a heat sink, and θ_{SA}, the thermal resistance from the heat sink to the surrounding air. Using those resistances, equation 1 becomes:

$$P_{diss} = \frac{T_J - T_A}{\theta_{JC}\ \theta_{CS} + \theta_{SA}}$$

continued on page 104

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The sensing circuit can be built to detect either steady or fluctuating air flows. The heart of the circuit (shown in Fig. 1) is a Radio Shack piezo buzzer (part number 273-060) and an LM324 quad op-amp. Note that the red wire from the piezo element should be connected to capacitor C1, and the black wire to ground.

When a current of air hits the piezo element, a small signal is generated and is fed through C1 and R1 to the inverting input (pin 2) of one section of the LM324. That causes the output (pin 1) to go high. Resistor R3 is used to adjust the sensitivity of the detector. The circuit can be made sensitive enough to detect the wave of a hand or the sensitivity can be set so low that blowing on the element as hard as you can will produce no output. Resistor R2 is used to adjust the level of the output voltage at pin 1.

The detector circuit can be used in various control applications. For example, an SCR can be used to control 117-volt AC loads as shown in Fig. 2-a. Also, an NPN transistor, such as a TIP29, can be used to control loads as shown in Fig. 2-b. I have driven such loads as incandescent lamps, solenoids, and relays with the setups shown.

The control circuits discussed above work well when there is a constant air flow. However, in situations where the air flow fluctuates—because the output will fluctuate with the wind source—a latch-type circuit may be necessary. One such circuit is shown in Fig. 3. The fluctuating output of the NPN transistor activates the 555 timer, and allows the load to be driven for a certain length of time—as detemined by the setting of potentiometer R2—without an input.

There are a great number of possible applications for the air detector circuit and it also makes a great building block for more complex circuits. For example, a solid-state weather vane could be constructed using a group of sensors—each facing a different direction—to turn on direction-indicating lights or LED's. A digital wind-speed indicator could also be built.—*Chris Mabry*

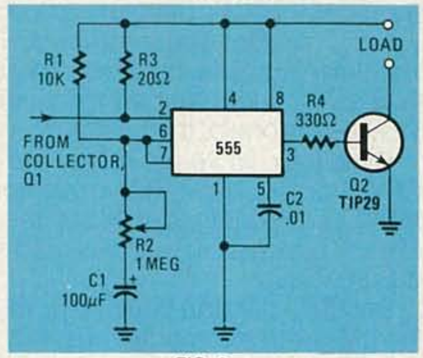

FIG. 3

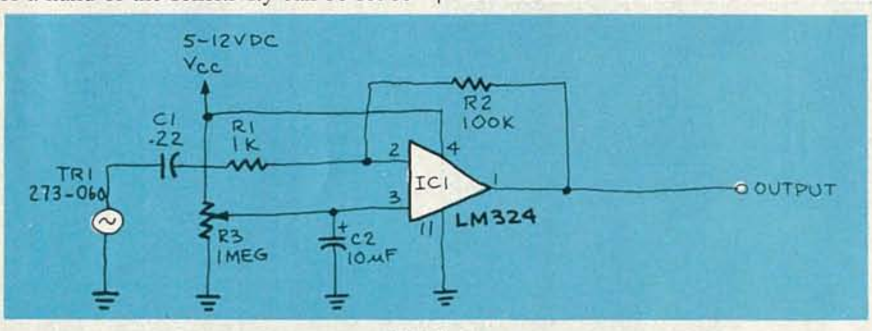

FIG. 1

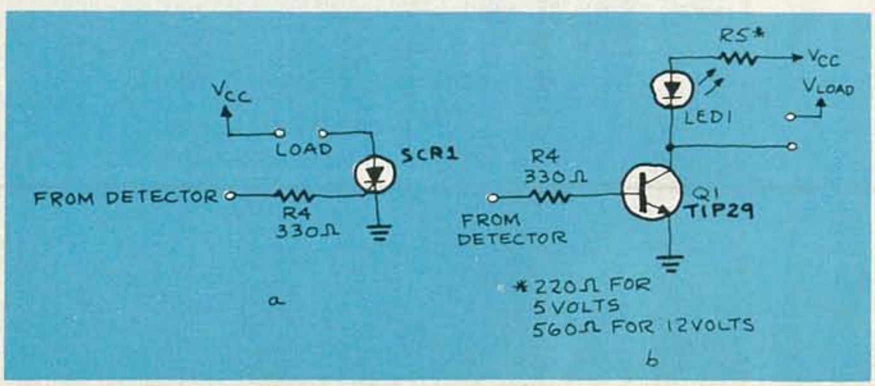

FIG. 2

HOBBY CORNER

Here's our new look

EARL "DOC" SAVAGE, K4SDS, HOBBY EDITOR

THIS IS THE FIRST "HOBBY CORNER" IN the new format that we have been promising. Don't expect the changeover to be immediate—neither Rome nor magazine columns are built in a day. Gradually, though, we'll ease into full stride.

As we begin, you should be aware of the "rules of the game." First, of course, is what we have stated before—that this column cannot provide new circuit designs for esoteric applications. There simply isn't enough time in the month. Second, keep in mind that there is only one Jack Darr—and I am not him. Unlike Jack, I am unable to troubleshoot your equipment by remote control, even on those occasions when you provide what appears to be sufficient information. At best, I may be able to offer a suggestion for an approach to solving your problem, as is the case with George Santana (see below).

Next, as many questions as possible will be answered here in the column. Those questions will be the ones which have the widest interest. Please do not expect an individual reply in the mail. Once again, there just isn't enough time.

From time to time, I will provide a reference to an article or book. You will have to dig up the material. Copyright laws prevent our selling or even giving away copies of a few pages of this or that. Possible sources are the original publishers, your local library, and friends who squirrel away magazines year after year.

I want to thank those of you who have already sent inquiries, and those who will send them. Keep them coming and remember that it may be several months before your question appears.

AN INVITATION

To better meet your needs, "Hobby Corner" will undergo a change in direction. It will be changed to a question-and-answer form in the near future. You are invited to send us questions about general electronics and its applications. We'll do what we can to come up with an answer or, at least, suggest where you might find one.

If you need a basic circuit for some purpose, or want to know how or why one works, let us know. We'll print those of greatest interest here in "Hobby Corner." Please keep in mind that we cannot become a circuit-design service for esoteric applications; circuits must be as general and as simple as possible. Please address your correspondence to:

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High-voltage generator

Twelve-year-old Eric Jackson (Ontario, Canada) sent the diagram of a battery-operated high-voltage generator and asks how to make a smaller one. Well, Eric, let's talk a bit about how and why the device works. Then you can try various components until you get what you need.

The circuit in Fig. 1 shows a basic circuit of the type you have. A transformer, as you know, is a device that increases or decreases voltage, as determined by the ratio of the number of turns of wire on each side. The one shown is connected as a *step-up* transformer—there are more turns on the output side than on the input side, and the output voltage is higher than the input voltage.

A transformer will not work on DC—it depends on the electromagnetic field

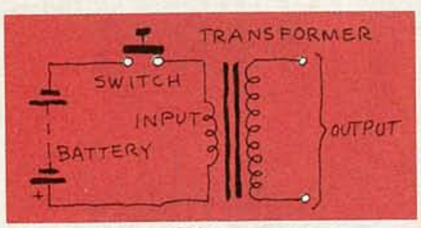

FIG. 1

changing; that's just what happens when AC is applied. The object, then, is to convert the DC from the battery to AC so the transformer can operate.

The normally-open momentary switch will convert the DC into a type of AC—but it won't be AC as we normally think of it. It will just be a current that alternates between on and off—not a nice, neat sine-wave. When you press the switch, current flows through the input side of the transformer, causing a magnetic field to build up. That *change* (from there being no field to the presence of one) induces a higher voltage on the output side.

Release the switch and the current stops. That causes the field to collapse. Because that is another change, it induces another shot of higher voltage at the output.

You can get pretty tired of pushing that switch. What you need is something to make and break the circuit for you. We'll substitute a relay for the switch, as shown

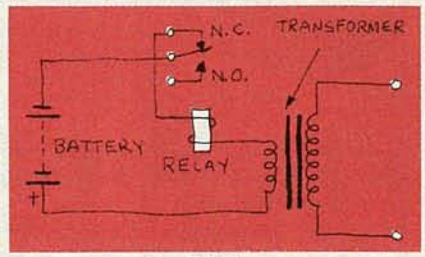

FIG. 2

in Fig. 2. When power is first applied, the relay contacts are closed and there is a current flow through the circuit—the relay coil and the input side of the transformer. The resulting magnetic field in the input winding induces a higher voltage in the output winding. At the same time, the magnetic field at the relay core pulls the armature and breaks the contact—it opens the switch and stops the current flow. That, of course, causes the magnetic field at the transformer to collapse, just as it did when you released the manual switch.

The magnetic field at the relay collapses, too, releasing the armature, which completes the circuit again. Thus, the cycle is repeated. The current starts and stops; the magnetic field builds up and collapses, and a shot of high voltage is produced at the output for each change.

The level of the output depends upon several factors. First, there is the ratio of output turns to input turns in the transformer. The higher the ratio, the higher the output voltage. Then, a higher battery voltage (and, thus, current) creates stronger fields, so the amount of change is greater and the output level increases. Finally, the faster the relay operates (within certain limits) the higher the output will be.

As far as parts selection is concerned, almost anything will do. I recall building this circuit when I was about your age, Eric. I used an audio transformer from an old radio and a door buzzer for the relay. I also remember getting shocked—but fortunately, the current was extremely low.

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CIRCLE 72 ON FREE INFORMATION CARD

So I got shocked, but wasn't hurt. Be careful, though—don't tempt fate.

High current

George Santana (NJ) wrote in to describe his troubles with a stereo receiver. Briefly, it seems that the radio started cutting off and on for periods of 15 to 20 minutes, and later it began blowing fuses.

Well, I can't give George a definitive answer on his equipment, but thinking through some of the possibilities here may be of help to him now, and to you later, should you experience similar problems. His problem sounds like one bad component causing additional troubles.

Almost all modern equipment contains a *crowbar* circuit of one sort or another. That is nothing but an automatic switch that shuts down the power supply when either too much current is drawn and/or the equipment overheats. It closes everything down before the unusual condition causes more serious problems.

The crowbar circuit may be a discrete circuit in or near the power supply or it may be built into one of the components. Many solid-state voltage regulators have built-in protective circuits. When the power supply cuts off, something's wrong and the equipment should not be used until the problem is found and corrected.

George's description of the on-again, off-again receiver surely sounds like a protective crowbar-circuit in an overcurrent/overheated condition.

Let's suppose that—unnoticed as time goes by—papers and books and whatever get stacked up around and on top of a piece of gear. That could prevent proper circulation of air around the components, and poor ventilation will produce high temperatures—sometimes high enough to trigger the crowbar.

It is more likely, however, that another component has changed value or has failed altogether. When that happens, it can cause a change in current—it may increase or decrease. The latter situation does not activate the protective circuit, but it makes its presence known by changing the way the equipment operates.

In this case, I suspect that a component change has caused an increase in current (and heat). That would cause the crowbar circuit to cut the power. Later, when things have cooled down, the crowbar circut allows the power to return. If permitted to, that cycle repeats until there is more serious component damage.

What do you do when things have reached that stage? First, I would look for a short, and then for a component that has changed appearance. Specifically, I'd examine the resistors in a power stage—they are frequent culprits. If one shows signs of having overheated (it will probably look darker than the others) you may have found the problem.

If that test fails, you can begin measuring component values and testing transistors. An alternative is to "bull" your way, and turn the equipment on to see whether you can find a part other than the crowbar device that gets too warm—or *hot*! That's called the burned-finger test. If a component is too hot to keep your finger on it, there's something wrong.

The next procedure would be to measure the voltages at various points. Those values are compared with the normal ones (information provided by the manufacturer) or, lacking that information, with what you think should be normal at those particular points. If the gear won't operate so that voltage measurements can be made, I would disconnect the various stages of the circuit and then connect them one at a time until I got to the one that triggered the crowbar circuit.

There's nothing really scientific in all that, except for the thought process. The object is to identify the faulty part. If you can't spot it right off, then narrow down the possibilities until it is located. That approach applies not only to George's receiver, but to troubleshooting any piece of gear—electronic or otherwise.

An invitation

The mailbox is waiting; What would you like to know? Send me a question and I'll see if I can find the answer. **R-E**

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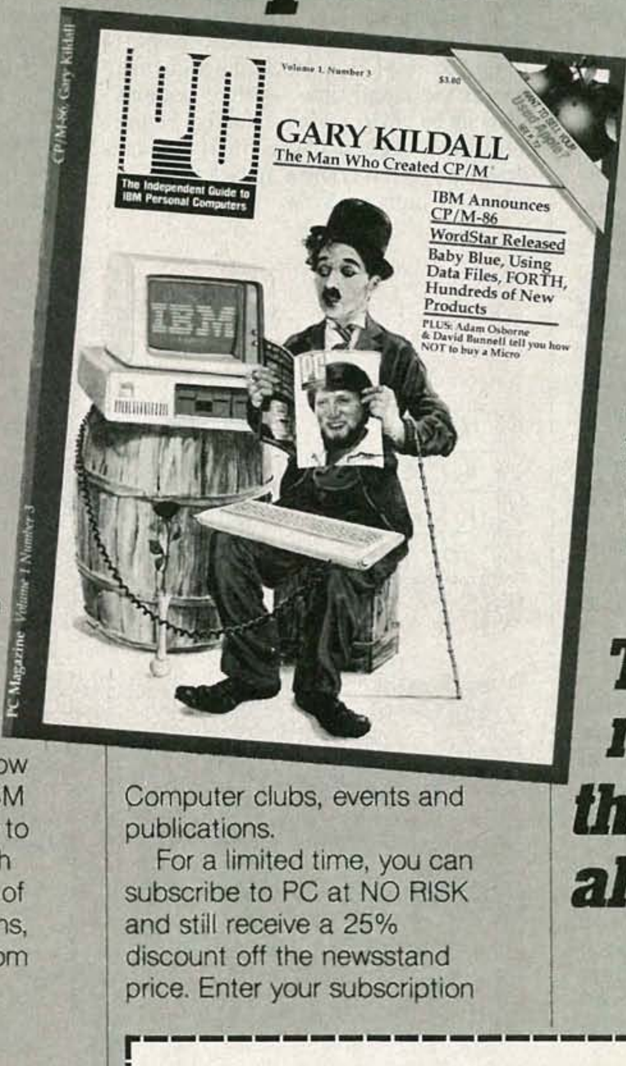

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CIRCLE 54 ON FREE INFORMATION CARD

THE DRAWING BOARD

Designing a keyboard encoder

ROBERT GROSSBLATT

BEING ABLE TO TURN A CONCEPT FROM A vague idea into a working piece of hardware is one of the greatest joys of electronics. The increased complexity of modern electronics can give people second thoughts about deciding whether to build or to buy. The same dilemma had to be faced, though, when transistors replaced vacuum tubes—and you know what happened then.

This department is dedicated to those of you who like to get your hands dirty—the same people who can't resist the temptation to take the cover off a piece of new equipment to "see what's inside." We'll be discussing original design techniques, shortcuts, pitfalls, and breakthroughs. There will be an equal balance of theory and application so you'll learn not only what to do, but why you're doing it and how to adapt the ideas presented here for your own purposes.

And, if you know a better way to do something, or catch me in a mistake, let me know. I'm as fallible as any of you.

Design criteria

Complex circuits are made up of lots of discrete sections. That seemingly trivial statement is one of the *keys* to original design. You can bet your new pair of white tennis shoes that the 12-page schematic that came with the last kit you built started life as doodlings on someone's 8½ × 11 pad of paper. The first part of any original design is a list of design criteria—in other words, what you want the circuit to do and how you want to make it do it. Let's suppose we want to design a circuit that will allow us to enter data from a keypad. Our design criteria would be something like this:

1. Up to 10 digits will be entered from a keypad.
2. Data will be placed on a Tri-state bus.
3. Any data on the bus will be displayed on LED readouts.
4. Each keypad entry will generate an audible signal.
5. The keypad will have two-key roll-over (two keys may be pressed "simultaneously," but the state of the second will not be read until the first has been released).
6. The circuit will have power-on reset.
7. The data bus will be able to be reset from the keyboard.
8. Operation will be glitch-free.
9. The entire circuit will use standard parts that are inexpensive and easily available in single-unit quantities.

Once the criteria have been set, the next thing we need is a block diagram that breaks the circuit into separate sections that can be designed individually. Figure 1 is a block diagram of the circuit that was described by our criteria. In order to meet criterion number 8, we'll use CMOS technology. Not only will its noise-immunity make the circuit as glitch free as possible, but the low power-requirements of that logic family will help a lot if you decide to run the circuit from batteries.

A keypad encoder

Since the BCD (*B*inary *C*oded *D*ecimal) encoder is obviously the heart of the

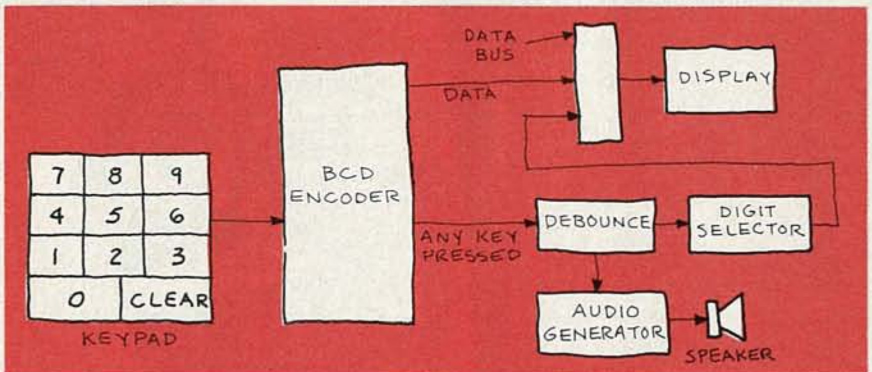


FIG. 1

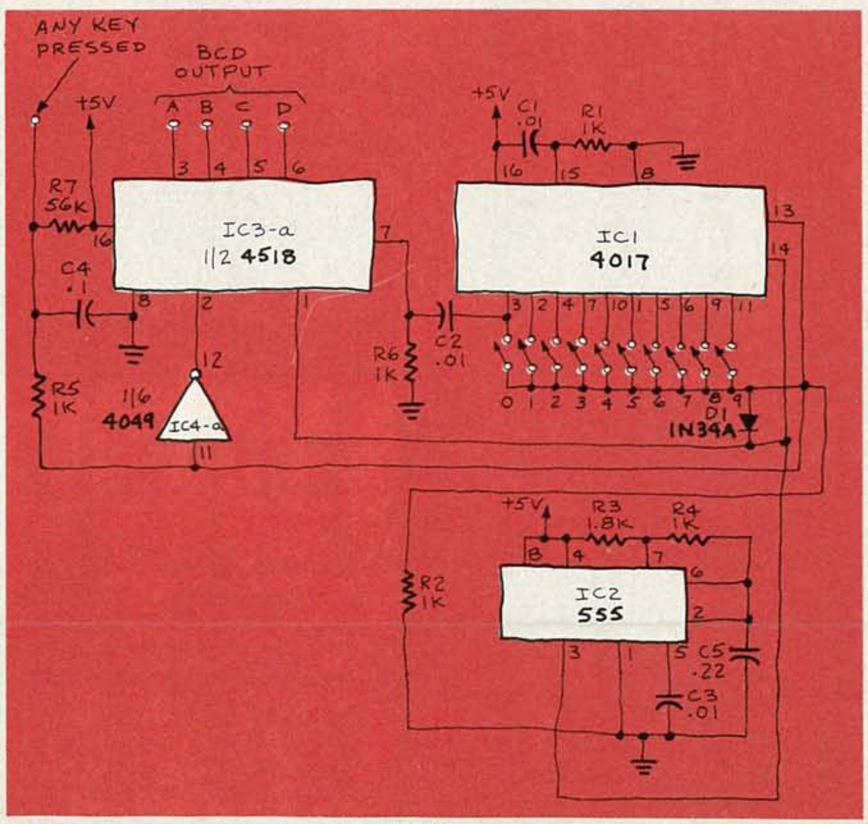
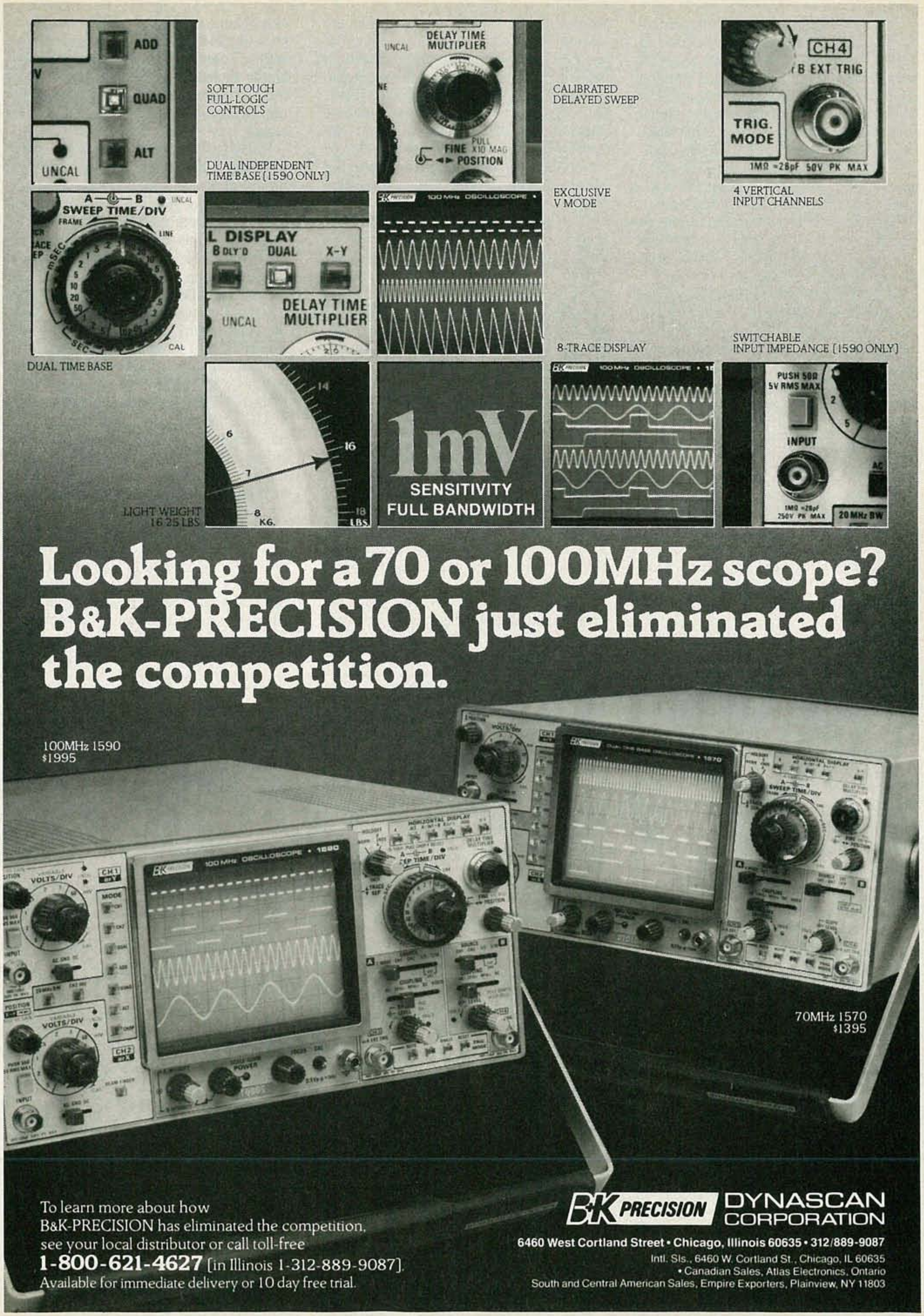


FIG. 2



CIRCLE 46 ON FREE INFORMATION CARD

circuit, we'll start with that. There are lots of different schemes that can be used to design such an encoder, but they all usually decode the output of a running counter. The approach we'll take is shown in Fig. 2. A 555 is set up as a signal source running at about 2 kHz. That clock is used to drive both a 4017 decade counter and a 4518 binary counter. The 4017 gives us decoded one-of-ten outputs at the same time that the 4518 counts up in BCD. The trick to getting the circuit to operate properly is to make sure that both IC's run in sync. We'll do that by using the reset pins on each IC.

The reset pin on the 4017 has to be held low for normal counting but we want to make sure that the count starts with zero when the circuit is first turned on. Therefore, resistor R1 holds the reset pin low so the IC can count, while C1 provides a positive pulse at power-up to reset the counter to zero. We can handle the 4518 in a similar fashion. The reset pin (pin 7) is held low by R6 and the count is started at zero by C2. When the "zero" output on the 4017 goes high it sends a positive pulse through C2 and on to the reset pin of the 4518. That does two things for us. Not only does it make sure that the two IC's are in sync at power-up, but it keeps them in sync; it does that by resetting the 4518 to zero every time the 4017's count hits zero.

Resistor R2 keeps the 4017 enabled as long as none of the keypad switches are closed. When a switch is closed, the IC is disabled and the count stops. The high signal generated by the key closure is also inverted by IC4-a and disables the 4518. At the same time, diode D1 conducts, making sure that the clock stops. The result of all that is that when you close a numbered switch on the keypad, the corresponding BCD code appears at the outputs of the 4518.

The circuit has two-key rollover because scanning starts up again at the instant that the keypad switch is released. When the second switch-closure is reached, scanning stops once again and the 4518 outputs the BCD equivalent of the second number. We also get an "any key pressed" output that is debounced by C4 and R7.

The circuit uses the 4017 as a one-of-ten decoder, and that means that all the keypad switches have one side tied together. It's just as easy to build a BCD encoder that uses switches in a row-and-column matrix, and there are even keyboard-encoder IC's such as the 74C922 that have the clock, counter, and all the rest of the circuitry on a single chip to take care of all the housekeeping chores that we performed with resistors and capacitors.

The reason for our design is given by criterion number 9. The IC's we're using are common ones that are available from almost any supplier (see the ads at the back of this magazine). They cost about a dollar apiece. Keyboard-encoder ICs aren't as readily available, and cost at least five times as much. If none of that impresses you, there's an even more basic reason.

There isn't very much you can learn by plugging a black box into the wall and turning it on so it can do whatever it was designed to do. And the more specialized an IC, the more it begins to resemble a black box. Thus, one of the best reasons I can think of for designing a circuit from the ground up is to understand how it works and to be able to correct any problems that crop up. Also, the more basic the components in the circuit, the more flexibility you have in design. Although that isn't readily apparent yet in our circuit, as we add the other sections shown in the block diagram, we'll see how really flexible the circuit is. And unless you have an understanding of how basic circuits work, it's impossible to understand more complicated ones. You can't learn to program a computer by buying game cartridges.

Now that we have our keyboard encoder operating and putting out a four-bit code, we can concentrate on the rest of the circuit. Next time we'll continue our project by adding the digit selector and display so we can encode up to ten digits sequentially. **R-E**

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SERVICE CLINIC

Super-fast capacitor checks

JACK DARR, SERVICE EDITOR

OVER THE YEARS, I'VE GOTTEN MILLIONS of letters (well, thousands, at least) asking "What's the best capacitor tester?" That's one of my favorite questions—because I know the answer! For background on what capacitors do, read the November 1982 "Service Clinic." Stated as simply as possible, capacitors are mainly used for one thing—to move signals. Mostly, they take them away from places where they aren't wanted (as with filter and bypass capacitors) or take them from one circuit to another without upsetting the DC levels (as with coupling capacitors). Figure 1 shows an example of the use of each type of capacitor.

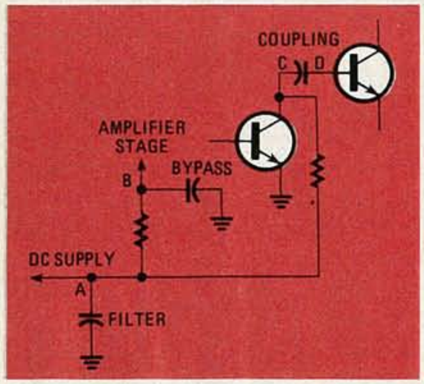

FIG. 1

What's the best way to test capacitors? Why, check to see whether they're doing their job with the signals. Those tests can be made in-circuit, during actual operation—the best test for anything. What's the only test instrument that will *show* you signals? The oscilloscope. The beauty of testing capacitors with a scope is that there is practically no "setup," or adjustments to make...although you *do* have to turn the scope on.

You don't have to set up the sweep for any given frequency—just pick up the probe and touch it to any point which is bypassed or filtered. Even if the scope's horizontal-sweep frequency is far away from the normal operating frequency of the circuit, you'll see some vertical deflection if there are any signals—and, if you do, that normally means trouble. You can adjust the vertical gain of the scope to see what the actual peak-to-peak amplitude of the signal is.

For filters in higher-voltage supplies in tube sets, the ripple (signal) should not be more than about 1.5 volts P-P at the filter output (point "A" in Fig. 1). In solid-state sets, the ripple should be much less or should not be there at all.

For cases where the complaint is distortion, poor sync, unstable color or hold, etc., start by checking all points in the circuit that have bypass capacitors (point "B" in Fig. 1). In practically all sets showing "mysterious" symptoms, and especially in those that show multiple symptoms, look for an open bypass-capacitor. In many cases, an open bypass capacitor will allow a feedback loop (or loops) to be set up, and trouble will be caused by the resulting cancelling or adding effect of the unwanted, unbypassed signal. An open bypass-capacitor on an AGC bus can cause more problems than you can shake the proverbial stick at.

The best test for any possibly-open capacitor is to bridge a good one across the suspect one. (Turn the power *off* in all solid-state sets when you do that.) If that removes the undesired signal, the fault has been pinned down. Incidentally, that test will also tell you whether or not the capacitor in the circuit is the correct value! If it's too small, it will not bypass all of the undesired signal or take out enough of the ripple. In general, the values of bypass and filter capacitors are not at all critical, as long as they're large enough! Those capacitors are used to take out undesired signals, and, as long as they do the job, you're OK. If the markings on the suspect capacitor are unreadable, and no schematic is available, "guesstimate" the value of the substitute and then check for signals at the bypassed point. If you tried a .01 μF capacitor and still had some signal, try a .02, then a .05, etc. until you get the signal out.

Coupling capacitors

Coupling capacitors are easy to test. If you see a signal on the input of a circuit but not on the output (points "C" and "D" in Fig. 1), the coupling capacitor is open. That type of test is far easier and more efficient than taking the capacitor out of the circuit, checking it on a bridge, and then replacing it. If the original capacitor is a tiny, low-voltage electrolytic, in most cases the heat of unsoldering it will heal the bad contact, and it will work when replaced! If you leave it there, you're just replacing the trouble! Save yourself a headache —replace it with a new one. A clean signal at the input with distortion at the output can be due to a *leaky* capacitor; that's common enough with low-voltage electrolytics.

More filter problems

The raster can often tell you where to look for the cause of a problem. If you see one or two horizontal bars across the raster, they are probably hum bars caused by a weak or open filter capacitor in a rectified-line DC supply. But what if you have what seems to be hum-bars, but they're *vertical*, there are five or six of them, and they're on the left side of the screen? That's easy—those are also hum bars, and are caused by insufficient filtering of a DC power supply. However, the symptoms point unmistakably to the fact that the DC power in this case is coming from the *flyback*, where a rectifier and small filter capacitor develop a low DC-voltage for one or more of the transistor stages. The multiple bars are the result of normal ringing during the flyback interval, and are due to an open filter-capacitor on the output of the rectifier.

A problem like that can show up especially when the boost voltage is used to power anything in a set, and its filter capacitor is open. The vertical hum bars are the clue here, and you can use your scope to verify your suspicions instantly by checking the DC output of the supply for ripple.

Your scope is the ideal "quick-check" instrument for capacitors, and it can save you a lot of time. If you don't know exactly what's causing the problems you're seeing, just grab the scope and start looking through the set until you find a signal where it ought not to be. It should be easy to find out why it's there. Just look for the nearest bypass or filter capacitor and bridge it. **R-E**

SERVICE QUESTIONS

HELPFUL HINTS

In the Quasar II chassis (all the ones that use the 84C70120A08 or FA front panel), if the picture repeatedly collapses and expands vertically, resistor R32 (270 ohms, ½ watt) is bad. For best results, replace it with a one or two-watter, preferably a glass-film type. I've never had a callback on sets where I've done this.

If you find the 220K resistor in the horizontal-oscillator plate circuit of an RCA CTC-53 out of tolerance, replace it, *and* the 120K resistor in the same circuit. They are both commonly responsible for failures and you can tell they're bad by the fact that they'll be discolored.

Thanks to Douglas P. Hoff of Vacaville, CA for that information.

FLAG-WAVING VDP

My uncle just bought a new Zenith videodisc player and hooked it up to his 25MC38 Zenith chassis, a 1967 model that is working well despite its age. The problem is that vertical lines wiggle, and the overall picture is not too stable. The videodisc player works fine on a later solid-state set. I'm puzzled.—R.R., Kingston, NY

That sounds like the familiar flag-waving problem often found when using VCR's and other such equipment with older sets. The "stock" cure is to speed up the time constant of the horizontal AFC by using smaller capacitors. In your set, try C65 and C67, both of which are on the bottom of the AFC-diode unit. Try a value that is about half of the original value.

(*Feedback: It was right where you said! I replaced C47, the .047-µF capacitor on the AFC grid of the 6U10 with a .001-µF capacitor. That did the trick and the set works nicely on both videodisc and TV signals. My uncle is very happy!*

SPOT OF INTERFERENCE

Here's an odd problem with a Zenith 14B38Z—a round spot of interference in the center of the screen with vertical lines from top to bottom. Looking at the chassis, an "eyeball check" showed a .01 disc capacitor that was cracked. Replacing it cured the interference. It was a coupling capacitor from the flyback to the AFC diode. It must have been radiating RFI that got into the video.

Thanks to James S. McIntyre of Pettus, WV for that information.

LOW HIGH-VOLTAGE

Ray Nielson, who didn't give his address, says that a bad fail-safe circuit led to a high voltage of only 6 KV on a Sony SCC-110B. The horizontal-oscillator control, Q951, was biased on, and it shouldn't have been. Zener diode D505 checked out good out-of-circuit, but a new one fixed the problem. It apparently was leaky under load. And here's a "no-no"—Don't turn those sets on unless everything is hooked up. When he had a board removed and applied power, he blew a regulator and SCR! **R-E**

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STATE OF SOLID STATE

A switch-mode power supply controller

ROBERT F. SCOTT, SEMICONDUCTOR EDITOR

THE GROWING POPULARITY OF THE switch-mode or switching-type power supplies has—in the last six or seven years—led to the development of more specialized component-types than any other electronic circuit since the early days of radio. It has involved the development of special types of rectifier diodes, inductors, and a wide variety of dedicated IC's.

Switching power supplies

Before taking a look at the Signetics NE5561 switch-mode power supply controller IC that we're covering this month, let's take a look at Fig. 1 and see what a switching power supply is all about. Basically, a switch-mode power supply can be thought of as a type of series voltage-regulator in which the pass (series) transistor has been replaced by a solid-state switch and a series inductor.

The switch-mode power supply controller—enclosed by dashed lines—has four major sections: a precision free-running multivibrator or clock, an electronic power-switch, a pulse-width modulator (PWM), and an error amplifier.

The *multivibrator* supplies the clock frequency and any timing signals required by the exterior circuit design or application. It drives one input gate of the PWM and, in some applications, provides the switching drive-voltage in transformer-type flybacks and DC-to-DC converters. The *electronic switch* is closed and opened (switched between saturation and cutoff) at a rate and duty cycle that keeps the supply's output constant.

The *pulse-width modulator* accepts signals from the clock multivibrator and the error amplifier. Its output is a pulse train whose duty cycle is determined by the output of the error amplifier in the feedback path between the power supply output and the PWM. The *error amplifier* compares the voltage tapped from the power supply output with a precision reference-voltage, and develops an error voltage based on the difference between the input signals.

The error voltage varies the switching-pulse duty cycle (the ratio of the on-time to the total time period) as a function of the input voltage and the output load conditions. The switch's on-time is increased if the sample voltage tapped from the supply output is low compared to the reference voltage. If the output sample is higher than the reference voltage, the error voltage narrows the switching pulse, decreasing the switch on-time.

Commutating diode D1 is also called the "catch" or "free-wheeling" diode. Its action is similar to that of a damper diode in TV-flyback power supplies. The abrupt turn-off of the switch causes the choke's magnetic field to collapse and develop a counter electromotive force (emf) that tends to keep current flowing through the choke. During that period, D1 conducts, permitting the counter-emf current to maintain the charge on C1.

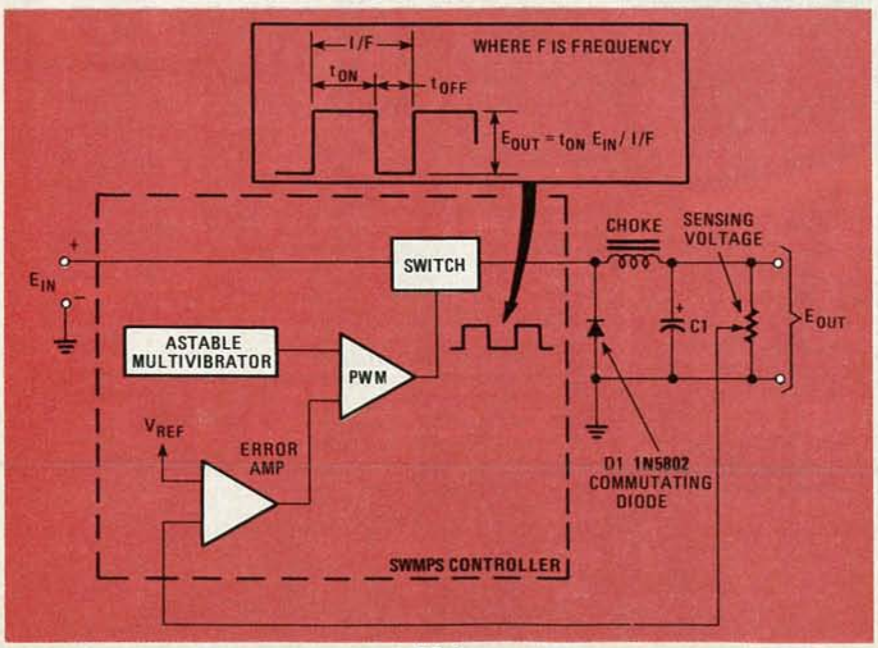

FIG. 1

The NE5561

Small DC-motors have been used for years in automotive and aircraft applications, and are finding many new uses as more and more electronic and computer controls are added.

The circuit in Fig. 2 shows how the Signetics NE5561 switch-mode power supply controller can be used in a DC motor-control application. The circuit is efficient and does not present the heat and power-dissipation problems that are inherent in linear speed-controllers.

The NE5561 provides constant motor-speed through pulse-proportional drive based on feedback from a tachometer that is driven by the motor. A switching circuit consisting of transistor Q1 and commutating diode D1 delivers the programmed pulse energy to the motor. The motor drive-current is in the form of constant-frequency, variable-width power pulses.

The heart of the NE5561 is the sawtooth generator that drives the PWM and the SET terminal of an R-S flip-flop latch. The oscillator frequency, determined by R_tC_t, is set at 20 kHz, a frequency high enough to eliminate the audio noise associated with lower-frequency switching drives. The output of the DC tachometer is proportional to the motor speed and should be 2.7 volts per 1000 rpm. The tachometer output is applied as negative feedback to the input of the error amplifier through a voltage divider that delivers 3.75-volts DC to ensure servo lock.

Duty cycle control

The motor-speed controller feeds a chain of 12-volt pulses to the motor. The duty cycle of the pulses is directly proportional to the load-torque demand. The circuit can be modified for torque-limiting by feeding a derivative of the motor return current (typical current drawn might be 0.3-amp no-load, and 0.6-amp full-load) back into the CURRENT SENSE terminal, pin 6.

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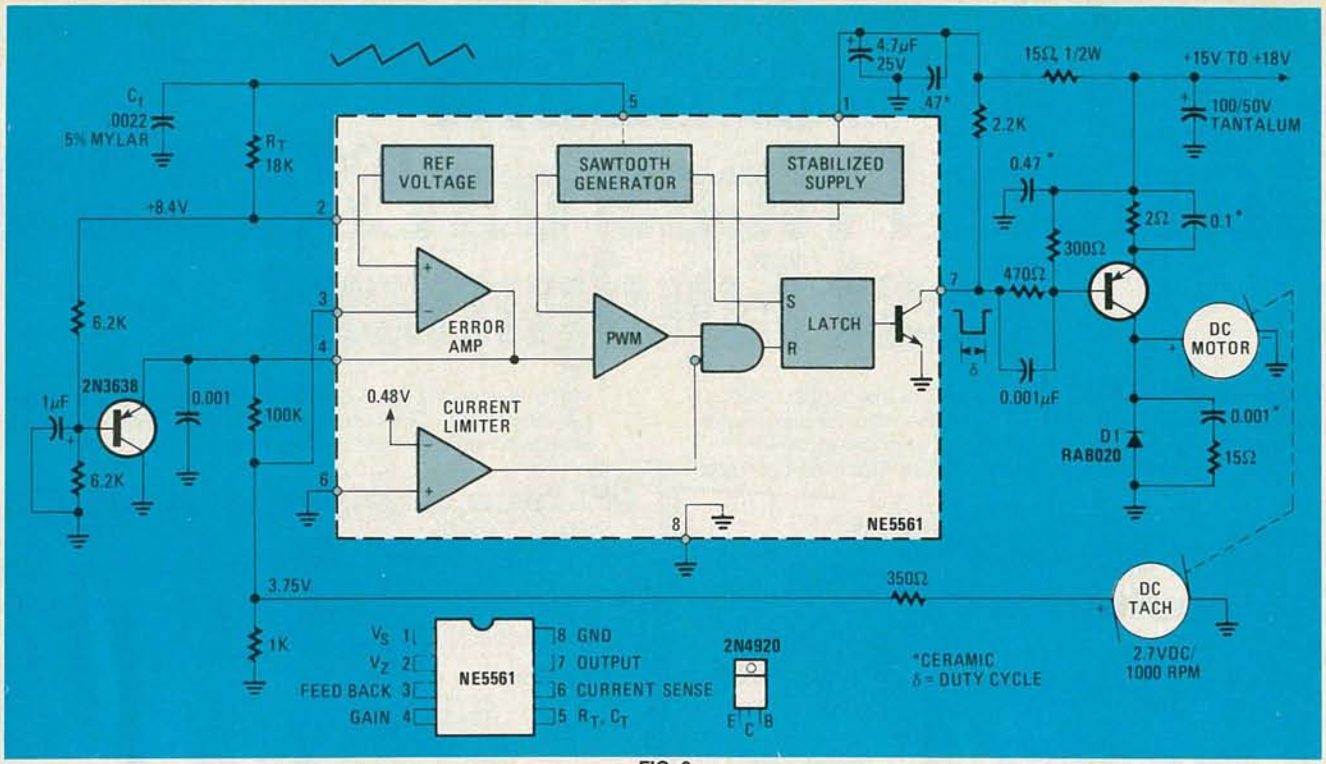

FIG. 2

duty cycle from immediately rising to its maximum is required at the initial start-up of most circuits driven by the NE5561. Without cycle-limiting, at initial turn-on, the DC feedback voltage at pin 3 of the IC is zero. That causes the error amplifier's output to go high and force the PWM to its maximum duty cycle.

This circuit was taken from the NE5561 data sheet. For additional information and some interesting power-supply circuits, refer to that data sheet and *Switch Mode Power Supply Circuits*, from Signetics Corp., PO Box 409, Sunnyvale, CA 94086. **R-E**

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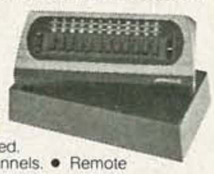

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Handheld computers

LES SPINDLE*

IN PREVIOUS COLUMNS, WE EXPLORED the miniaturization of computers from minis to micros to portable micros. Now we will look at yet another category of small computers—the handheld micro. When first introduced, the name "pocket computer" was frequently attached to those small units. However, when equipped with a printer, cassette interface, and other peripherals, the devices can scarcely be toted in the average pocket. "Briefcase computer" might evolve as a logical terminology—as the smaller portable computers (such as the recently-announced Hewlett-Packard *HP-75*) and the larger handhelds (such as the Radio Shack *PC-2*) move closer together in size and capabilities.

Who are those handheld computers best suited for, and what are their capabilities? Hobbyists form one large group of enthusiasts, but the handheld computer can also be recognized as a highly convenient solution to many data-processing problems faced by the professional person. Field engineers, surveyers, inventory clerks, and building contractors are all likely users, as are salesmen on business trips, and college students, stockbrokers, insurance-claim adjusters and tax advisors.

The handheld's key asset is still, of course, portability. As the technology matures, and as more and more handheld units are equipped with modems and data-communications software, the devices will become even more practical. Accessing the office from wherever you happen to be—and having the capability to transmit data files from remote locations—will open a whole new vista of professional applications.

What are the currently available products, and which one is best for your individual needs? Let's start by taking a look at the Sharp *PC1211* (also packaged by Tandy as the Radio Shack *PC-1*).

Radio Shack/Sharp handhelds

The overriding advantage to the *PC-1/PC1211* is its portability. It's one of the lightest (six ounces) and smallest of the pocket computers. But the tradeoff is that it does not offer some of the more sophisticated or advanced capabilities of its successors.

*Managing Editor, *Interface Age* magazine

FIG. 1

The computer is equipped with a 1.9K memory for programs and data. For $160, or less, the user is supplied with the basic unit, a 125-page manual, and a beginner's guide to BASIC programming. The computer will run for approximately 300 hours on a set of four mercury batteries. The *PC1211* will accept program lines of up to 80 characters in length, and display them on a 24-character liquid crystal dot-matrix display that scrolls automatically for lines with more than 24 characters. Full cursor-control allows scrolling up or down, left or right, and simple editing.

A printer/cassette interface is available for $130. The printer will print 16 characters per line at a rate of 60 lines-per-minute. A useful set of practical programs is available—including engineering, mathematics and business packages.

Though the *PC1211* lacks the memory capacity and bells-and-whistles features of more recent units, it is a good one for beginners.

Another Sharp handheld computer is the recently-introduced *1500* (also sold as the Radio Shack *PC-2*). Its outstanding features are its 8-bit microprocessor—allowing some capabilities that rival desktop micros—and its expandability via a 60-pin connector. As a bonus, programs written for the the *PC-1211* will also run on the *1500*.

The *1500* comes with 2.6K bytes of user-memory and is expandable through plug-in modules to 4, 8, or 16K. The operating system and BASIC are stored in a 16K-byte ROM. The computer includes a real-time clock and operates at 1.3 MHz. The *1500* is powered by four "AA" batteries that should let it run for about 50 hours.

A printer/plotter/dual-cassette interface is available for $240. That unit is powered by rechargeable nickel-cadmium batteries, but it includes an AC adapter/charger and will also power the *1500* computer. With that interface, 25 statements for easy plotting and printing are added to the computer's BASIC. Both upper- and lower-case characters are available, and four colors of graphics and nine sizes of text can be printed. The printed display is from 4 to 36 characters wide (depending on the type size chosen). Programs or data can be saved or loaded to or from cassette tapes using either one or two recorders.

For those who require simple graphics, ample programming capabilities, and future expansion from their handheld computer, the Sharp *1500* is a good choice.

Casio

Another handheld, the Casio *FX702P* will be of special interest to those with mathematical applications. Its extensive set of built-in functions includes trigonometric and hyperbolic functions, statistics, degree-to-decimal conversion and vice versa, random-number generation, natural logs, and many more functions that you would expect to find on a high quality scientific calculator.

The keyboard is layed-out alphabetically (as opposed to the typewriter-style "QWERTY" arrangement) and the numeric keys are to the right of the alphabetic ones.

A set of 73 programs is provided in the manual, and include scientific, mathematical, and business applications, as well as games. Several hundred additional programs are expected to be introduced in the near future.

The liquid-crystal display allows up to 20 characters at a time to be displayed. The maximum line-size is 30 characters—the display will automatically shift when 20–30 characters are in use.

Its simple BASIC subset of commonly-used variables, numerous mathematical functions, and portability (it weighs 6.3 ounces and measures ⅝ × 6½ × 3¼-inches) will make the Casio *FX-702P* an attractive alternative for many users. The price for the basic unit is just under $200. A cassette interface is available for $49.95, and the printer is available for $89.95.

The Panasonic/Quasar handheld

In many respects, the Panasonic *HHC* (Quasar sells a functionally similar handheld in a slightly different package) is the most useful pocket computer currently available for serious applications. Three versions are available: the *RL-H1000*, which comes equipped with 2K of RAM ($325); the *RL-H1400*, with 4K ($380); and the *RL-1800* with 8K of RAM ($480).

A large selection of software packages is available for the Panasonic system including *Portacalc* (a *VisiCalc*-like spreadsheet program) and *Portawriter*, a word-processing program. Many popular programming languages are also available. Several modes of operation provide versatile independent functions: a four-function calculator mode, a calendar-alarm mode for appointments, and a text mode (allowing creation of an 80-character record in free-format). Up to three 16K-byte ROM modules can be loaded at once.

Peripherals available include an I/O adapter, 15- or 40-character-per-line printers, a four-color plotter, an RS-232 interface, a modem, and a modem with a cassette interface for sending or receiving programs.

A color-TV interface is also available. With that, you can use a TV to display up to 16 lines (up to 32 characters per line) or up to 48 × 64 graphic elements in eight colors plus black. **R-E**

COMMUNICATIONS CORNER

Multi-band trap-antennas

HERB FRIEDMAN, COMMUNICATIONS EDITOR

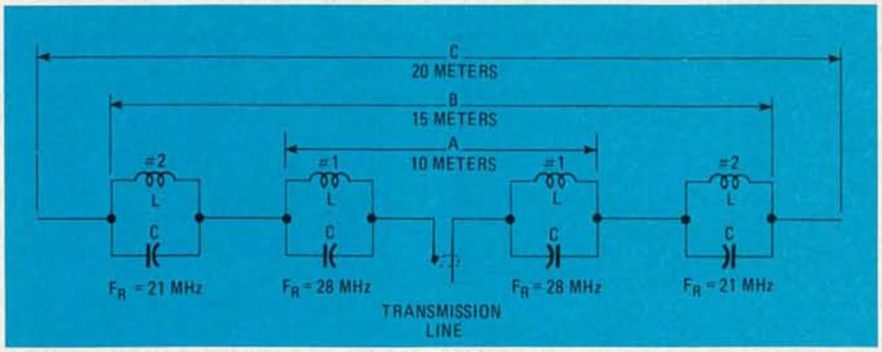


FIG. 1

WHILE RECENT ADVANCES IN ELECTRONics have improved transmitter and receiver performance tremendously, all that fancy high technology does very little good if you can't get a signal out (or in). Remember the old ham adage: "You can't work 'em if you can't hear 'em." We have yet to come up with a high-tech solid state antenna that is superior to a wire!

Current technology has made it possible to put full 3–30-MHz coverage in a transceiver not much larger than a shoebox. Band-hopping is so easy that most amateurs who operate HF can shift bands with a twist of the wrist. But, what's the advantage of a high-tech, full-coverage, broadband rig if it takes 10 minutes to tune up the antenna on a new frequency? For maximum convenience when band-hopping, many amateurs use multi-band antennas—dipoles, verticals, or directional beams. However, the fact remains that those multi-band HF antennas have not been improved much by high technology. They still use old-fashioned *traps*, a trap being an ordinary parallel-resonant circuit.

Let's look at a typical situation. Our new amateur has just purchased a Whiz-Banger All-Band Solid-State Digitized Signal Squirter, and to get his money's worth he wants full coverage with beams for 10, 15, and 20 meters, and dipoles for 40 and 80; all that on a 20-by-100-foot city house-lot. Because of the lack of space, and because the neighbors aren't too happy seeing a tower loaded with antenna elements swinging close to their homes, our all-band amateur cuts his antenna hardware down to a minimum—just two antennas for five bands.

How it's done

Imagine a quarter-wave dipole antenna for the 10 meter band. It measures about 16 feet end-to-end, and can be made of aluminum rod or thinwall tubing supported at the center feedpoint. Alternately, it can be made from wires strung from end-supporting insulators.

If we want to cover a lower frequency—say on 15 or 20 meters—with the same type of antenna, we need a length of approximately 23 feet for 15 meters and 35 feet for 20 meters. It seems that no single length will work for all three bands; yet we can purchase antennas where a single element serves for 10, 15 and 20 meters, or 40 and 80 meters, or even 80 through 10 meters.

The "magic" is performed by the traps we mentioned earlier, which make a single antenna element appear to be the correct electrical length for several bands. Let's look at Fig. 1, which illustrates how traps work for a three-band 10/15/20-meter dipole. (You can carry the idea through to a 5-band antenna.)

Antenna-segment "A" is the correct length for a 10-meter (28-MHz) quarter-wave dipole. The parallel-resonant "#1" L-C traps at the ends of that segment are tuned to the center of the 10-meter band and electrically isolate the "A" section of the antenna from the remaining wire. As far as the transmitter is concerned it "sees" only the dipole antenna represented by "A."

If the transmitter's output is changed to 15 meters (21 MHz) the "#1" L-C traps are no longer resonant at the operating frequency; they appear as a slight inductance in a dipole now having a total length "B." The "#2" traps at the ends of the "B" segment are tuned to the center of the 15-meter band and isolate "B" from the remaining wire length. Because of the slight inductive effect of the "#1" traps, the end-to-end length of the "B" antenna is slightly less than the calculated dipole length for 15 meters.

When the transmitter's output is changed to 20 meters (14 MHz) both the "#1" and "#2" traps are no longer resonant at the operating frequency; they appear as small inductances in a dipole of length "C." The total length "C," again because of the small inductive effects of the traps, is slightly less than what would ordinarily be calculated for a 20-meter dipole antenna.

Because of those inductive effects, it gets a little tricky to adjust element lengths for the lower frequencies—it's usually done by a final tweaking of the section lengths—but the process can be carried through two more sets of traps (for 20 and 40 meters), resulting in a five-band antenna covering 80 through 10 meters. Often, the 40 meter antenna is used on 15 meters. (But, when traps are used, the 40-meter antenna isn't all that great on 15 meters).

Trapped beams

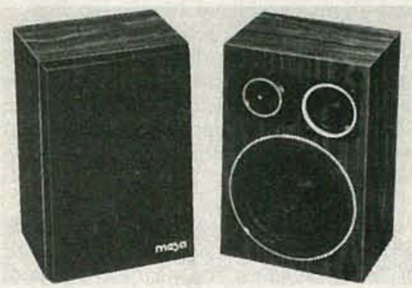
While we have illustrated traps using dipole antennas, the same theory applies to any other elements used in a directional beam, whether driven or parasitic. For example, the typical 10/15/20 meter beam is a parasitic array with a non-driven director and reflector. Each parasitic element is tuned to the band in use by means of traps, just like the driven dipole-antenna.

If you get the urge to build your own trap antenna keep these rules in mind: The traps must be "rock-stable." That means that they must be enclosed in a weatherproof housing so that moisture won't change their characteristics. Also remember that there is a very high RF-voltage present at the ends of the antenna, so low-voltage receiver-grade components mustn't be used. The inductors must be wound using heavy wire such as you would use for a transmitter tank-circuit, and the capacitors should be of the type known as "transmitting" micas. (There are lots of surplus transmitting micas around.) If you're not into building your own traps, it's possible to purchase commercial traps for home-brew amateur antennas. Inquire at any of the larger amateur-equipment distributors. **R-E**

NEW PRODUCTS

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

LOUDSPEAKER, the *Mini-Mesa 100,* is a 100-watt RMS, three-way speaker system that has a 1-inch soft dome tweeter, and 3½-inch mid-range, and an 8-inch rubber surround woofer. The system measures only 14 inches high × 9½ inches wide × 6¾-inches deep and is available in walnut-grained cabinetry.



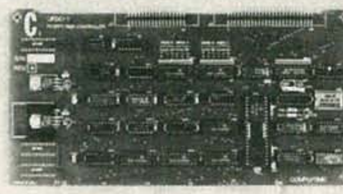
CIRCLE 121 ON FREE INFORMATION CARD

The *Mini-Mesa 100* is priced at $175.00 each.—**Mesa Electronics Sales, Ltd.,** 2940 Malmo Drive, Arlington Heights, IL 60005.

FLOPPY DISK CONTROLLER, *Model UFDC-1,* S-100 IEEE-696-designed board is capable of connecting up to four floppy-disk drives. Any combination of 5¼- or 8-inch drives with ANSI standard interfaces may be connected. Supported by the *Model UFDC-1* are single/double density formats and single/double-sided drives.

The *Model UFDC-1* synchronizes the processor to disk transfers by means of wait states. Data transfer, drive select, density, disk side and wait-state circuitry are all selected by means of external I/O control and status ports. It also uses 9216 digital-data circuitry for write precompensation and read data separation. A synchronous clock-distribution scheme is used so that the 1795 and all data-circuitry clocks are derived from the same source.

A unique feature of the S-100 bus controller is its ability to read and write differently sized and formatted disks. That is done by placing the CP/M boot program in ROM and the CP/M disk translation tables on the disk



CIRCLE 122 ON FREE INFORMATION CARD

sector normally containing the boot program. That allows automatic mixing of disk densities and the ability to read various types of formatted disks. There is also the capability of creating the user's own types of formats, because the source listing of the format program is included with the board.

The *Model UFDC-1* is available assembled and tested for $325.00; kit $295.00 or bare board $60.00.—**GSR Computers,** 60-10 69th Street, Maspeth, NY 11378.

SATELLITE VIDEO RECEIVER, *model RCV-650,* is an antenna-mount receiver with remote-control capability, digital channel select, and a self-contained LNA power supply.

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The channel select allows the user to set the channel and read it on the LED readout. The MGC/AGC switch, control and test-point allows the user to align the antenna to insure the best antenna position. The *model RCV-650* is priced at $2275.00.—**Comtech Data Corporation,** 613 South Rockford Drive, Tempe, AZ 85281.

VIDEO SWITCHER, *Model 0770,* permits the connection of four signal sources to two TV sets and one VCR. The completely passive switcher (no power is required) replaces bunches of cables, multiple switches, and splitters, and eliminates such problems as double images, herringbones, and seeing an adjacent channel's picture superimposed over the desired one. Each switch is completely shielded and impedance-matched to ensure isolation between all ports.

CIRCLE 124 ON FREE INFORMATION CARD

The *Model 0770* can accept any combination of the following components: outdoor antenna, pay-TV, VCR, videogames, satellite earth station, videodisc, and home computer. The user plugs in the components to produce a home-video system comparable to those used by professionals. The *Model 0770* has a suggested retail price of $49.95.—**Channel Master,** Division of Avnet, Inc., Ellenville, NY 12428.

PULSE/FUNCTION GENERATOR, *Model 524D,* contains two complete generators in one benchtop instrument, with each section having a broad range of capabilities.

The function-generator section offers sine, square, triangle, variable symmetry, trigger, and gate operation with output waveforms of up to 30 volts P-P. It operates from 0.001 Hz to 20 MHz and offers 80 dB of step attenuation, variable DC offset, VCF (*V*oltage *C*ontrolled *F*requency) input, and sync output. The frequency/period dial has a coarse and fine control, and the frequency/period is read out on a large, bright, 6-digit display with overranging capability. Frequency accuracy is ± (0.01% of setting +1 digit).

The pulse-generator section offers single pulse, double pulse, and delayed pulse over a frequency range of 0.001 to Hz to 40 MHz. The frequency/period dial sets the repetition rate and/or period. The period is adjustable from 1000 seconds to 25 nanoseconds. Pulse width and delay are both adjustable from 10 milliseconds to 10 nanoseconds.

CIRCLE 125 ON FREE INFORMATION CARD

The *Model 524D* provides most of the waveforms required on the lab bench for both analog and digital work, plus a convenient frequency/period counter. It is priced at $1795.00 F.O.B.—**Exact Electronics,** 2000 Arrowhead Dr., PO Box 1925, Carson City, NV 89701.

DESKTOP HOLDER, the *Disk-O-Tier,* holds up to 11 floppy diskettes, either the 5¼-inch or the 8-inch types. The staircase design of the holder displays all diskette titles, or ID numbers, for rapid disk location.

The open design is unusual, because most

diskette storage devices have dust covers. However, dust covers are generally useless when diskettes are stored in the same area as the computer system. The diskette's own jacket is adequate protection; if dust were a problem, the computer would be damaged before the diskettes were affected.

CIRCLE 126 ON FREE INFORMATION CARD

The *Disk-O-Tier* is made of smoked thermoplastic and is priced at $9.50. (Add $2.00 postage if ordering direct; a twin-pak carton costs $19.00, which includes shipping charges.)—**Electronic Time Service Center,** PO Box 651 35026-A Turtle Trail, Willoughby, OH 44094.

SCREEN CLEANER, *CLR* provides quick cleaning combined with long-lasting anti-static properties. Airborne, static-charged particles mix with dirt and grime particles in the air, and are attracted to the CRT screen magnetically. When a film of such grime builds on the CRT screen, data-entry errors can be the result, due to poor visibility to the operator. *CLR* offers an anti-static chemical, originally designed for the Apollo space program, to slow down the buildup of those particles.

CIRCLE 127 ON FREE INFORMATION CARD

CLR is packaged in a 4-ounce spray-top dispenser for easy storage near the CRT terminal. It is priced at $5.95.—**Adamark, Incorporated,** PO Box 234, Ada, MI 49301.

AMPLIFIERS, *Model BA-3082* (shown), and *Model BA:7082,* are back-of-the-set TV amplifiers designed to improve reception where signal levels are low and pictures are snowy. They are also valuable for reception problems caused by adding couplers, splitters, and switches to systems, combining signals from several sources, or operating more than one set or receiver. They also provide sharp pictures for high VCR recording quality.

The *Model BA-3082* has a 300-ohm input and output, while the *Model BA-7082* has a 75-ohm input and output; either can be used with any outdoor or indoor antenna. Both are CATV compatible and amplify all VHF, mid, and super band channels, FM, and UHF channels 14 through 83.

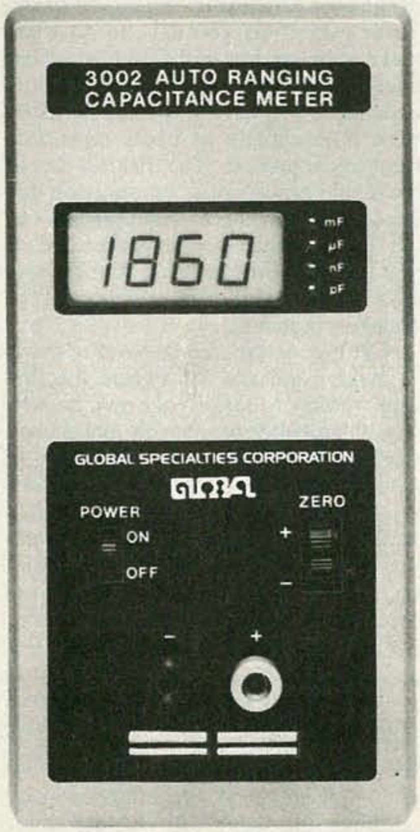
There is also an FM version—*Model FM-3000*—that cleans up fading distant FM stations and provides excellent stereo reception. It features 300-ohm input and output and amplifies 88-108 MHz. All three models attach out of sight, behind the TV set or FM tuner, and feature a UL-approved, calculator-type power supply, which plugs directly into an AC receptable.

The suggested retail price for *Model BA-3082* and Model BA-7082 is $29.95. *Model*

CIRCLE 128 ON FREE INFORMATION CARD

FM-3000 lists for $34.95.—**Winegard Company,** 3000 Kirkwood Street, PO Box 1007, Birlington, IA 52601.

AUTORANGING CAPACITANCE METER, *Model 3002,* combines the precision, range, and flexibility of benchtop models with the convenience and efficiency of a handheld portable unit. The unit weighs only twelve ounces and measures 7.6 × 3.75 × 1.72 inches. The digital LCD readout provides direct readings of capacitance from 1 pF to 199,900 μF, with 8 automatically selected ranges providing accurate measurements of capacitance without manual switching. Designed with dual threshold detectors, the *Model 3002* is accurate to 0.2% ±1 count in the 1 pF to 199.9 μF range and 1.0% ±1 count in the 200 μF to 19.99 mF range.



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The dual threshold measurement technique eliminates reading errors due to dielectric absorption. By using DC charging characteristics to determine true capacitance, the *Model 3002* can determine capacitance in cables, switches, and other electronics components and hardware, in addition to capacitors and capacitor networks. The front panel contains power ON/OFF and zero-calibration thumbwheel controls and both banana jacks and special low-insertion-force jacks. Low power consumption (maximum 75 mA) assures long battery life (16 hours of continuous operation).

The *Model 3002* operates on 6 AA batteries, or may be powered by an optional AC adapter/charger. A flip-up leg allows the user to see the LCD readout and operate controls easily while the unit is on a work bench. The *Model 3002* is priced at $210.00.—**Global Specialties Corporation,** 70 Fulton Terrace, PO Box 1942, New Haven, CT 06509.

JOYSTICK SYSTEM, *Game Mate 2,* is a remote-control joystick system for Atari, Sears, and Commodore videogames and home computers. The system lets you play videogames from 20 feet away, without requiring wires running along the floor. It is easily installed; just plug it in.

CIRCLE 130 ON FREE INFORMATION CARD

The *Game Mate 2* has a suggested retail price of $99.95.—**Cynex Manufacturing Corp.,** 28 Sager Place, Hillside, NJ 07205.

SOLDERING SYSTEM, *Model 9000,* allows tip temperature to be varied from 420° to 800°F with a resolution of ±10 degrees. Solid-state circuitry, including the newest microcircuit IC's, sample the tip temperature 120 times-per-second. LED's on the temperature controller instantly display each 20-degree temperature increment reached, creating a bar chart that clearly represents the tip temperature to within ±10°F.

The heating element, which combines a heater and sensitive tip-temperature sensor, recovers tip temperature after each solder joint. The smaller heating element also makes possible a thinner handle that is cooler than other models.

CIRCLE 131 ON FREE INFORMATION CARD

Electronic circuitry in the controller prevents tip-temperature overshoot that could easily cause faulty soldering. The controller can be calibrated by a front-panel adjustment, using room temperature as a reference. For ultra-precise soldering, any temperature within the temperature range can be calibrated to be accurate within 5°F.

The *Model 9000* is priced at $150.00.—**Ungar Division,** Eldon Industries, 100 W. Manville St., Compton, CA 90220. **R-E**

ANALOG CIRCUITS

continued from page 74

To keep a transistor from overheating, it's usually mounted on a metal surface known as a heat sink. Air flows over that surface, cooling it. In turn, it cools the case of the transistor. The heat sink reduces the thermal resistance from the case to the air, θ_{CA}. As $\theta_{CA} = \theta_{CS} + \theta_{SA}$, equation 1 can also be written as:

$$P_{diss} = \frac{T_J - T_A}{\theta_{JC} + \theta_{CA}}$$

The upper limit of P_{diss} that a transistor can tolerate is provided by the manufactuer of the device and can be found on the device's data sheet. That specification is usually given at a particular case temperature. The amount of power that the device can dissipate safely does not increase if the case temperature drops below that given in the specifications, but does drop if the temperature exceeds it. Curves may also be supplied to indicate the maximum power that the transistor can dissipate at different temperatures. When the curve is not made available, the manufacturer will supply a derating factor, given in watts/°C. That derating factor indicates how much the power dissipation rating must be reduced for every degree the temperature is above that specified in the maximum dissipation rating. Most often, the power dissipation is given at a case temperature of 25°C.

Let's look at an example of how to select and design a heat sink. Assume that the transistor you are using is specified as being capable of dissipating 115 watts when the case temperature is 25°C. If the derating factor is 0.8 wats/°C at a case temperature of 90°C, then the power-dissipation capability of the device drops to $115 - 60 = 55$ watts. Your circuit should be designed so that no more than 55 watts is dissipated by the transistor.

Using that information, assume that a silicon device with a maximum permissible junction temperature of 175°C is used. If the temperature of the air is 30°C, θ_{JA} is equal to:

$$\theta_{JA} = \frac{175°C - 30°C}{55 \text{ watts}} = 2.6°C/\text{watt}$$

If θ_{JC} is 1.25°C/watt, $\theta_{CA} = \theta_{JA} - \theta_{JC} = 2.6 - 1.25 = 1.35$°C/watt.

As θ_{CA} consists of $\theta_{CS} + \theta_{SA}$, it is desirable to make both factors as small as possible. θ_{CS} can be made very small by putting heat-conducting compound such as silicon grease between the case and sink. If the case is directly on the sink through that grease, θ_{CS} can become as low as 0.1°C/watt. Frequently, the case must be insulated from the sink with a mica washer. Now, θ_{CA} can rise to 0.4°C/watt.

Assume that a mica washer must be used. In our example, θ_{SA} becomes $1.35 - 0.4 = 0.95$°C/watt. It is possible to buy sinks with a similar or lower θ_{SA} resistance. A makeshift sink can be constructed from ⅛-inch-thick flat aluminum. If the total area on both surfaces of the metal is kept vertical and exposed to air, the areas of one side of the sink should be at least $750/\theta_{SA}{}^2$ square inches.

Some sinks are not merely a flat surface but have fins. Those sinks should be mounted in a location with good air flow and so that the fins are vertical.

Other important factors

In addition to case temperature, there are many other factors that affect the survival of a transistor. For one thing, over its lifetime, the case temperature of a transistor will rise and fall many times. There is a limit, however, to the number of times that can occur before the device will break down. That thermal cycling data is supplied by some manufacturers in the form of curves relating the power dissipated by the transistor, the amount the case-temperature rises, and the number of times this temperature can rise and fall, before the transistor may break down. A proper heat sink can help prevent that breakdown.

Another type of breakdown phenomenon in bipolar devices is when the base loses control of the collector current. Despite any drops in V_{CE}, the collector current keeps rising until the transistor is destroyed. To minimize that problem, select a transistor that will perform up to the highest frequency you need in your design but not above it and do not use a higher collector-emitter voltage than you absolutely require.

One final point: do not ignore the voltage, current, and power limits set for the bipolar or FET device you are using. Do not ignore transients—especially if an inductor is used in the circuit. Also, remember that the transistor will tolerate a higher collector-emitter voltage when the resistor shunting the base-emitter circuit of the transistor is at its lowest value. So keep that resistance small and keep some collector current flowing at all times.

Practical circuits

The information presented here can be used to design many different types of power amplifiers. Transformer coupling was used in the circuits described in this article because the essential operating characteristics of the different amplifier classes can be most easily described using those circuits. Most audio and other power amplifiers, however, do not use transformer coupling. Next time, we'll discuss modern power amplifier circuits, and how to keep them from breaking down in use. **R-E**

PC BOARDS

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The reason you've left the resist on the copper is because it saves you the trouble of tinning the board to keep the copper from oxidizing. The resist protects the copper and when you solder to the board, it vaporizes. It's really similiar to the neoprene covering on wire-wrap wire. The hot solder will vaporize the resist and a good joint will be made, but the copper traces will remain untarnished and protected from moisture.

Making printed-circuit boards is like a lot of things in life—it sounds much harder than it actually is. If you try to describe everything you have to do when you drive a car, that will sound incredibly complicated, too. Persevere, and a little experience will have you doing perfectly what is essentially an easily repeatable mechanical process. The trickiest part of the whole procedure is the spraying and exposing of the copper blank. If you can get that down pat, you've got it made. If you have difficulty, take a look at Table 1; it should help you overcome most of the common problems.

Get used to the idea that you're going to make a mistake somewhere the first time you try to make your own boards. You'll probably be able to make good masks, but the procedure from there to etching is a matter of patience and experience. Notice that we do not say that it is hard—it isn't. Once you find a system that works, it will always work. And, being able to make your own boards gives your projects a professional touch, regardless of how complex they are. **R-E**

COMMERCIAL EDITOR

continued from page 58

to the RECORD mode (note that in many machines the latter will be done automatically for you). At the preset time the recorder will start and tape the movie, but without the commercials. If you happened to select a color program, the editor will delete the first 4½ to 5 minutes of it, then tape the rest without stopping for commercials.

Finally, a few closing words about using the editor. Sometimes, when several commercials are shown in sequence, the color-burst signal is turned off between them. Also, the color burst may sometimes be present during those rare black-and-white commercials. Those circumstances depend on the particular practices of the TV station, and may result in the recorder starting and stopping several times during the commercials. In that case, you may see several very brief bursts of commercials on playback of your tape. That's to be expected, and does not indicate that there is anything wrong with the editor. **R-E**

NEW BOOKS

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

PASCAL, by David L. Heiserman, Tab Books, Inc., Blue Ridge Summit, PA 17214; 350 pages, including appendix and index; 5 × 8 inches; softcover; $9.95.

Learning to use a new programming language for a computer is never easy, and this book does not pretend that it is. However, PASCAL, the newest of computer languages, is rewarding to learn because it has taken the best elements of all the other computer languages and eliminated their drawbacks. However, unless a computer system has been designed specifically to work in PASCAL, at least 32K of RAM, and two disc drives are required.

That problem has been overcome by the development of a scaled-down version of PASCAL, that is now commonly known as Tiny PASCAL. Tiny PASCAL, the subject of this book, fits into a 16K personal computing system. The author covers it in depth, showing how it can be loaded easily into a *TRS-80* computer and used for virtually any purpose: practice program development, math problem-solving, unusual games, etc.

Starting with an explanation of how to load a Tiny PASCAL cassette into a *TRS-80* system, the author goes through all the steps necessary for the reader to become proficient in the language. There is an explanation of how to read syntax diagrams; use WRITE statements to print characters and do *TRS-80* graphics; enter integers with READ statements; use logic with AND, OR, and NOT; write and use REPEAT...UNTIL loops, etc. It's all here for Tiny PASCAL and Supersoft Tiny PASCAL, as well as for the standard version. Step-by-step data make it easier to learn.

CIRCLE 151 ON FREE INFORMATION CARD

DIGITAL LOGIC: Operation and Analysis (Second Edition), by Jefferson C. Boyce. Prentice-Hall, Inc., Englewood Cliffs, NJ 07632. 492 pages, including appendices, bibliography, and index; 6⅛ × 9⅛ inches; hardcover; $24.95.

This book has been completely revised and updated because so much has happened since publication of the first edition, when digital logic was in its infancy. Chapters 1 and 2 are introductory and discuss the basic concepts of digital logic, numbers, and counting. The fundamentals of combinational logic (gates) are presented in chapters 3 and 4; chapters 5 and 6 discuss algebraic and graphical simplification of logic expressions, and chapter 7 summarizes combinational logic and goes into troubleshooting flow charts.

Chapter 8 investigates sequential (time-department) logic. Chapter 9 deals with troubleshooting circuits that contain both combinational and sequential logic elements.

The remaining chapters discuss specific types of logic circuits: counters, registers, adders, comparators, multiplexers, etc. An overview of the complete digital field is presented in the final chapter (16). **R-E**

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VIDEOGAME CONTEST WINNERS

Due to the large number of entries to the Videogame Concert Contest that appeared in our July and August 1982 issues, we decided to extend our entry deadline for several weeks. At last, here are the winners.

Each of the following winners was judged as the best entry for each of the four categories and each winner will receive a Kenwood KV901 14-day programmable VCR, a Kenwood KVA-502 Audio/Video Amplifier, and ten Kenwood videocassettes:

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Mattel:
Craig Lichter

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The following was judged to be the best overall entry in terms of musical score and the winner will receive a Kenwood KR-1000 Stereo Computer Receiver and a pair of Kenwood LS-1000 speakers:

Jeff Shapiro

The following was judged to be the best overall entry in terms of originality and will receive a Kenwood DC-20 integrated stereo system:

Ben Selvin

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OPTICAL FIBER SYSTEMS: Technology, Design, and Applications. *By* C. K. Kao. *197 pp., illus.* From a basic explanation of optical fiber systems to the economic ramifications of their use, this volume provides full coverage of a rapidly developing field.
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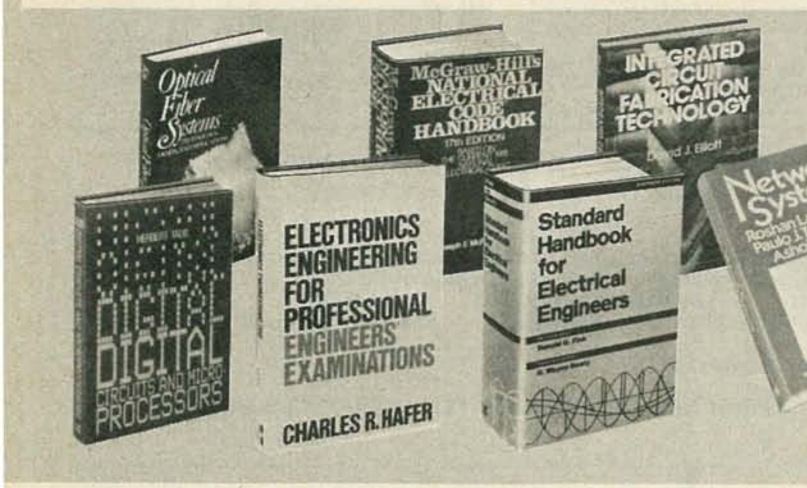

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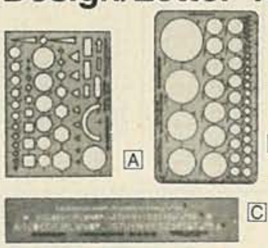

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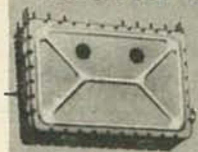

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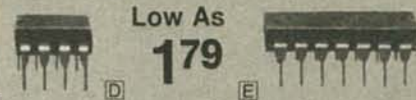

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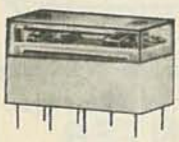

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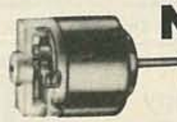

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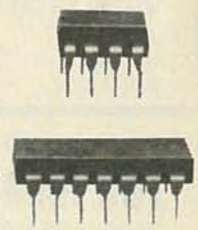

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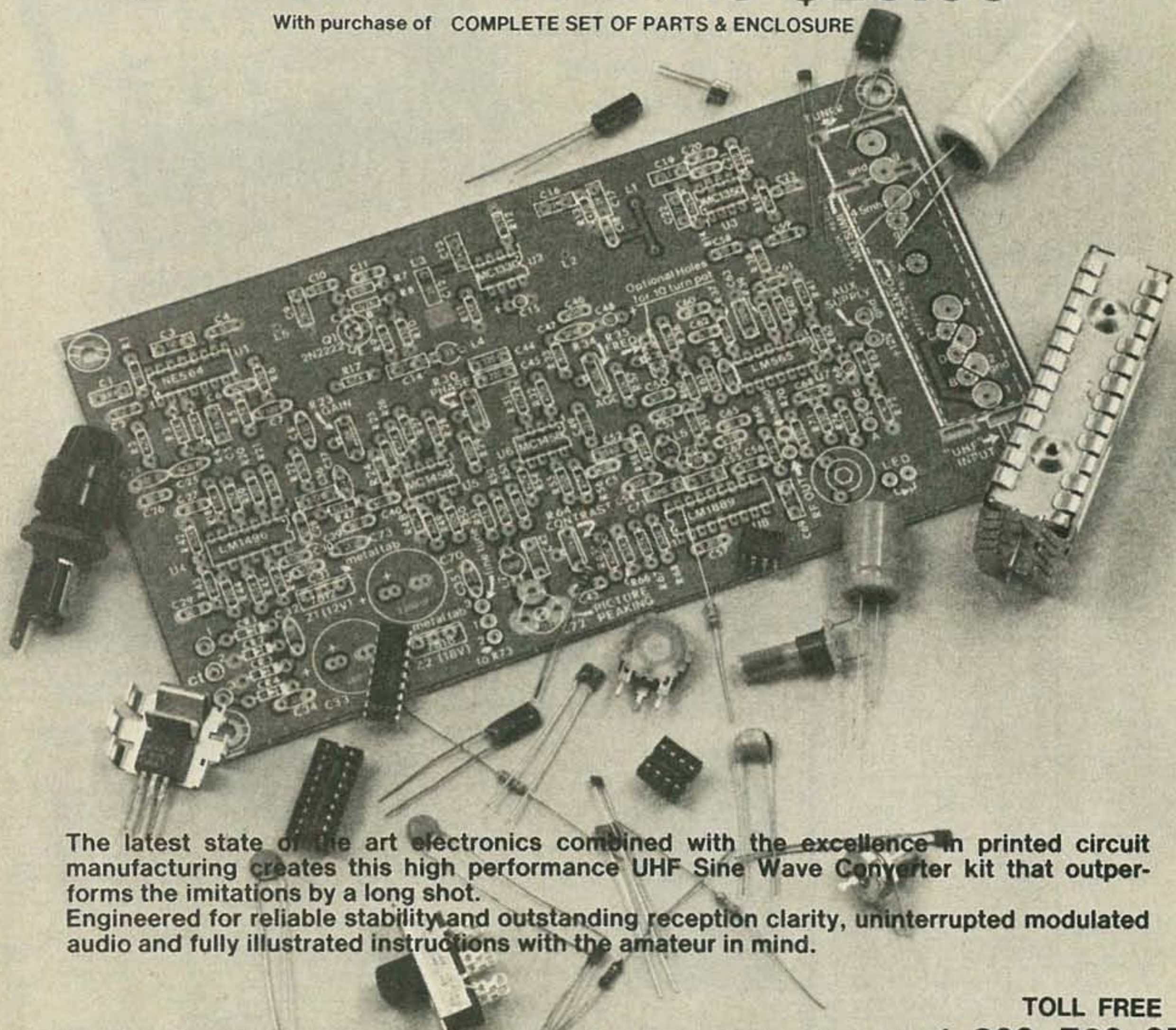

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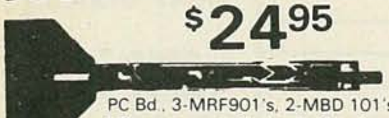

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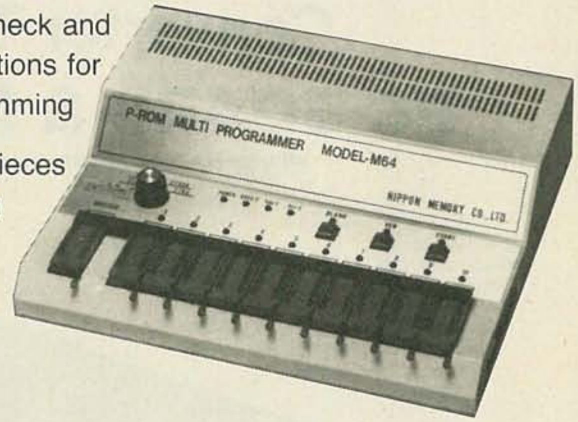

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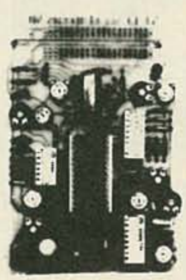

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REVISION 2

\$24.95

(Basic Kit)

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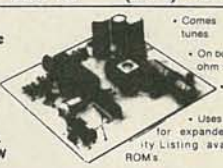

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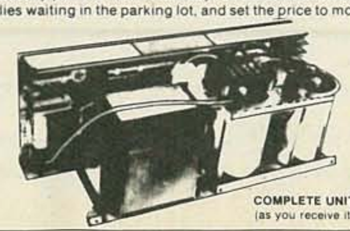

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Range:	20 Hz to 600 MHz
Sensitivity:	Less than 10 MV to 150 MHz Less than 50 MV to 500 MHz
Resolution:	0.1 Hz (10 MHz range) 1.0 Hz (60 MHz range) 10.0 Hz (600 MHz range)
Display:	9 digits 0.4" LED
Time base:	Standard-10.000 mHz, 1.0 ppm 20-40°C. Optional Micro-power oven-0.1 ppm 20-40°C
Power:	8-15 VAC @ 250 ma

7 DIGITS 525 MHz $99.95 WIRED

SPECIFICATIONS:

Range:	20 Hz to 525 MHz
Sensitivity:	Less than 50 MV to 150 MHz Less than 150 MV to 500 MHz
Resolution:	1.0 Hz (5 MHz range) 10.0 Hz (50 MHz range) 100.0 Hz (500 MHz range)
Display:	7 digits 0.4" LED
Time base:	1.0 ppm TCXO 20-40°C
Power:	12 VAC @ 250 ma

The CT-70 breaks the price barrier on lab quality frequency counters. Deluxe features such as; three frequency ranges - each with pre-amplification, dual selectable gate times, and gate activity indication make measurements a snap. The wide frequency range enables you to accurately measure signals from audio thru UHF with 1.0 ppm accuracy - that's .0001%! The CT-70 is the answer to all your measurement needs, in the field, lab or ham shack.

PRICES:

CT-70 wired, 1 year warranty	$99.95
CT-70 Kit, 90 day parts warranty	84.95
AC-1 AC adapter	3.95
BP-1 Nicad pack + AC adapter/charger	12.95

7 DIGITS 500 MHz $79.95 WIRED

PRICES:

MINI-100 wired, 1 year warranty	$79.95
AC-Z Ac adapter for MINI-100	3.95
BP-Z Nicad pack and AC adapter/charger	12.95

Here's a handy, general purpose counter that provides most counter functions at an unbelievable price. The MINI-100 doesn't have the full frequency range or input impedance qualities found in higher price units, but for basic RF signal measurements, it can't be beat! Accurate measurements can be made from 1 MHz all the way up to 500 MHz with excellent sensitivity throughout the range, and the two gate times let you select the resolution desired. Add the nicad pack option and the MINI-100 makes an ideal addition to your tool box for "in-the-field" frequency checks and repairs.

SPECIFICATIONS:

Range:	1 MHz to 500 MHz
Sensitivity:	Less than 25 MV
Resolution:	100 Hz (slow gate) 1.0 KHz (fast gate)
Display:	7 digits, 0.4" LED
Time base:	2.0 ppm 20-40°C
Power:	5 VDC @ 200 ma

8 DIGITS 600 MHz $159.95 WIRED

NEW READ RECEIVER FREQUENCY

SPECIFICATIONS:

Range:	20 Hz to 600 MHz
Sensitivity:	Less than 25 mv to 150 MHz Less than 150 mv to 600 MHz
Resolution:	1.0 Hz (60 MHz range) 10.0 Hz (600 MHz range)
Display:	8 digits 0.4" LED
Time base:	2.0 ppm 20-40°C
Power:	110 VAC or 12 VDC

The CT-50 is a versatile lab bench counter that will measure up to 600 MHz with 8 digit precision. And, one of its best features is the Receive Frequency Adapter, which turns the CT-50 into a digital readout for any receiver. The adapter is easily programmed for any receiver and a simple connection to the receiver's VFO is all that is required for use. Adding the receiver adapter in no way limits the operation of the CT-50, the adapter can be conveniently switched on or off. The CT-50, a counter that can work double-duty!

PRICES:

CT-50 wired, 1 year warranty	$159.95
CT-50 Kit, 90 day parts warranty	119.95
RA-1, receiver adapter kit	14.95
RA-1 wired and pre-programmed (send copy of receiver schematic)	29.95

DIGITAL MULTIMETER $99.95 WIRED

PRICES:

DM-700 wired, 1 year warranty	$99.95
DM-700 Kit, 90 day parts warranty	79.95
AC-1, AC adaptor	3.95
BP-3, Nicad pack +AC adapter/charger	19.95
MP-1, Probe kit	2.95

The DM-700 offers professional quality performance at a hobbyist price. Features include; 26 different ranges and 5 functions, all arranged in a convenient, easy to use format. Measurements are displayed on a large 3½ digit, ½ inch LED readout with automatic decimal placement, automatic polarity, overrange indication and overload protection up to 1250 volts on all ranges, making it virtually goof-proof! The DM-700 looks great, a handsome, jet black, rugged ABS case with convenient retractable tilt bail makes it an ideal addition to any shop.

SPECIFICATIONS:

DC/AC volts:	100uV to 1 KV, 5 ranges
DC/AC current:	0.1uA to 2.0 Amps, 5 ranges
Resistance:	0.1 ohms to 20 Megohms, 6 ranges
Input impedance:	10 Megohms, DC/AC volts
Accuracy:	0.1% basic DC volts
Power:	4 'C' cells

AUDIO SCALER

For high resolution audio measurements, multiplies UP in frequency.

- Great for PL tones
- Multiplies by 10 or 100
- 0.01 Hz resolution!

$29.95 Kit $39.95 Wired

ACCESSORIES

Telescopic whip antenna - BNC plug	$ 7.95
High impedance probe, light loading	15.95
Low pass probe, for audio measurements	15.95
Direct probe, general purpose usage	12.95
Tilt bail, for CT 70, 90, MINI-100	3.95
Color burst calibration unit, calibrates counter against color TV signal	14.95

COUNTER PREAMP

For measuring extremely weak signals from 10 to 1,000 MHz. Small size, powered by plug transformer-included.

- Flat 25 db gain
- BNC Connectors
- Great for sniffing RF with pick-up loop

$34.95 Kit $44.95 Wired

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TMM2016 2KX8 STATIC 200 NS $4^15

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STATIC RAMS

2101	256 x 4 (450ns)	1.95
5101	256 x 4 (450ns) (cmos)	3.95
2102-1	1024 x 1 (450ns)	.89
2102L-4	1024 x 1 (450ns) (LP)	1.29
2102L-2	1024 x 1 (250ns) (LP)	1.69
2111	256 x 4 (450ns)	2.99
2112	256 x 4 (450ns)	2.99
2114	1024 x 4 (450ns)	8/14.95
2114L-4	1024 x 4 (450ns) (LP)	8/15.25
2114L-3	1024 x 4 (300ns) (LP)	8/15.45
2114L-2	1024 x 4 (200ns) (LP)	8/15.95
2147	4096 x 1 (55ns)	4.95
TMS4044-4	4096 x 1 (450ns)	3.49
TMS4044-3	4096 x 1 (300ns)	3.99
TMS4044-2	4096 x 1 (200ns)	4.49
MK4118	1024 x 8 (250ns)	9.95
TMM2016-200	2048 x 8 (200ns)	4.15
TMM2016-150	2048 x 8 (150ns)	4.95
TMM2016-100	2048 x 8 (100ns)	6.15
HM6116-4	2048 x 8 (200ns) (cmos)	4.95
HM6116-3	2048 x 8 (150ns) (cmos)	5.95
HM6116-2	2048 x 8 (120ns) (cmos)	8.95
HM6116LP-4	2048 x 8 (200ns) (cmos)(LP)	6.95
HM6116LP-3	2048 x 8 (150ns) (cmos)(LP)	8.95
HM6116LP-2	2048 x 8 (120ns) (cmos)(LP)	10.95
Z-6132	4096 x 8 (300ns) (Qstat)	34.95

LP = Low Power   Qstat = Quasi-Static

DYNAMIC RAMS

TMS4027	4096 x 1 (250ns)	1.99
UPD411	4096 x 1 (300ns)	3.00
MM5280	4096 x 1 (300ns)	3.00
MK4108	8192 x 1 (200ns)	1.95
MM5298	8192 x 1 (250ns)	1.85
4116-300	16384 x 1 (300ns)	8/11.75
4116-250	16384 x 1 (250ns)	8/11.95
4116-200	16384 x 1 (200ns)	8/13.95
4116-150	16384 x 1 (150ns)	8/15.95
4116-120	16384 x 1 (120ns)	8/29.95
2118	16384 x 1 (150ns) (5v)	4.95
4164-200	65536 x 1 (200ns) (5v)	6.25
4164-150	65536 x 1 (150ns) (5v)	7.25

5V = single 5 volt supply

EPROMS

1702	256 x 8 (1us)	4.50
2708	1024 x 8 (450ns)	3.95
2758	1024 x 8 (450ns)(5v)	5.95
2716	2048 x 8 (450ns)(5v)	3.95
2716-1	2048 x 8 (350ns)(5v)	6.25
TMS2516	2048 x 8 (450ns)(5v)	5.50
TMS2716	2048 x 8 (450ns)	7.95
TMS2532	4096 x 8 (450ns)(5v)	7.95
2732	4096 x 8 (450ns)(5v)	4.95
2732-250	4096 x 8 (250ns)(5v)	12.95
2732-200	4096 x 8 (200ns)(5v)	16.95
2764	8192 x 8 (450ns)(5v)	16.95
2764-250	8192 x 8 (250ns)(5v)	18.95
2764-200	8192 x 8 (200ns)(5v)	24.95
TMS2564	8192 x 8 (450ns)(5v)	24.95
MC68764	8192 x 8 (450ns)(5v)(24 pin)	39.95

5v = Single 5 Volt Supply

EPROM ERASERS

	Timer	Capacity Chip	Intensity (uW/Cm²)	
PE-14		6	5,200	83.00
PE-14T	X	6	5,200	119.00
PE-24T	X	9	6,700	175.00
PL-265T	X	20	6,700	255.00
PR-125T	X	16	15,000	349.00
PR-320	X	32	15,000	595.00

DISC CONTROLLERS

1771	16.95
1791	29.95
1793	38.95
1795	54.95
1797	54.95
6843	34.95
8272	39.95
UPD765	39.95
1691	18.95
2143	18.95

INTERFACE

8T26	1.69
8T28	2.49
8T95	.99
8T96	.99
8T97	.99
8T98	.99
DM8131	2.95
DP8304	2.29
DS8835	1.99
DS8836	.99

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3242	7.95
3341	4.95
MC3470	4.95
MC3480	9.00
11C90	13.95
95H90	7.95
2513-001 UP	9.95
2513-002 LOW	9.95

SOUND CHIPS

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76489	8.95
AY3-8910	12.95
MC3340	1.49

CRT CONTROLLERS

6845	14.95
68B45	35.95
HD46505SP	15.95
6847	12.25
MC1372	6.95
68047	24.95
8275	29.95
7220	99.95
CRT5027	39.95
CRT5037	49.95
TMS9918A	39.95
DP8350	49.95

BIT-RATE GENERATORS

MC14411	11.95
BR1941	11.95
4702	12.95
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MM5307	10.95

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AY3-1014	6.95
AY5-1013	3.95
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PT1472	9.95
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CLOCK CIRCUITS

MM5314	4.95
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2.5 Mhz

Z80-CPU	3.95
Z80-CTC	5.95
Z80-DART	15.25
Z80-DMA	17.50
Z80-PIO	5.75
Z80-SIO/0	18.50
Z80-SIO/1	18.50
Z80-SIO/2	18.50
Z80-SIO/9	16.95

4.0 Mhz

Z80A-CPU	6.00
Z80A-CTC	8.65
Z80A-DART	18.75
Z80A-DMA	27.50
Z80A-PIO	6.00
Z80A-SIO/0	22.50
Z80A-SIO/1	22.50
Z80A-SIO/2	22.50
Z80A-SIO/9	19.95

6.0 Mhz

Z80B-CPU	17.95
Z80B-CTC	15.50
Z80B-PIO	15.50

ZILOG

Z6132	34.95
Z8671	39.95

CRYSTALS

32.768 khz	1.95
1.0 mhz	4.95
1.8432	4.95
2.0	3.95
2.097152	3.95
2.4576	3.95
3.2768	3.95
3.579535	3.95
4.0	3.95
5.0	3.95
5.0688	3.95
5.185	3.95
5.7143	3.95
6.0	3.95
6.144	3.95
6.5536	3.95
8.0	3.95
10.738635	3.95
14.31818	3.95
15.0	3.95
16.0	3.95
17.430	3.95
18.0	3.95
18.432	3.95
20.0	3.95
22.1184	3.95
32.0	3.95

DATA ACQUISITION

ADC0800	15.55
ADC0804	3.49
ADC0809	4.49
ADC0817	9.95
DAC0800	4.95
DAC0806	1.95
DAC0808	2.95
DAC1020	8.25
DAC1022	5.95
MC1408L6	1.95
MC1408L8	2.95

8000

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INS-8060	17.95
INS-8073	24.95
8080	3.95
8085	5.95
8085A-2	11.95
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8087	CALL
8088	39.95
8089	89.95
8155	7.95
8156	8.95
8185	29.95
8185-2	39.95
8741	39.95
8748	29.95
8755	32.00

8200

8202	29.95
8203	39.95
8205	3.50
8212	1.80
8214	3.85
8216	1.75
8224	2.25
8226	1.80
8228	3.49
8237	19.95
8238	4.49
8243	4.45
8250	10.95
8251	4.49
8253	6.95
8253-5	7.95
8255	4.49
8255-5	5.25
8257	7.95
8257-5	8.95
8259	6.90
8259-5	7.50
8271	39.95
8272	39.95
8275	29.95
8279	8.95
8279-5	10.00
8282	6.50
8283	6.50
8284	5.50
8286	6.50
8287	6.50
8288	25.00
8289	49.95

FUNCTION GENERATORS

MC4024	3.95
LM566	1.49
XR2206	3.75
8038	3.95

INTERSIL

ICL7103	9.50
ICL7106	9.95
ICL7107	12.95
ICL7660	2.95
ICL8038	3.95
ICM7207A	5.59
ICM7208	15.95

6800

68000	59.95
6800	4.95
6802	7.95
6808	13.90
6809E	19.95
6809	12.95
6810	2.95
6820	4.95
6821	3.25
6828	14.95
6840	12.95
6843	34.95
6844	25.95
6845	14.95
6847	12.25
6850	3.45
6852	5.75
6860	9.95
6862	11.95
6875	6.95
6880	2.25
6883	24.95
68047	24.95
68488	19.95

6800 = 1MHZ

68B00	10.95
68B02	22.25
68B09E	29.95
68B09	29.95
68B10	7.95
68B21	12.95
68B45	35.95
68B50	12.95

68B00 = 2 MHZ

6500

1 MHZ

6502	5.95
6504	6.95
6505	8.95
6507	9.95
6520	4.35
6522	8.75
6532	11.25
6545	22.50
6551	11.85

2 MHZ

6502A	9.95
6522A	11.70
6532A	12.40
6545A	28.50
6551A	12.95

3 MHZ

6502B	14.95

EXAR

XR 2206	3.75
XR 2207	3.85
XR 2208	3.90
XR 2211	5.25
XR 2240	3.25

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9334	2.50
9368	3.95
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9601	.75
9602	1.50
96S02	1.95

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74LS00	.24	74LS86	.39	74LS169	1.75	74LS323	3.50
74LS01	.25	74LS90	.55	74LS170	1.49	74LS324	1.75
74LS02	.25	74LS91	.89	74LS173	.69	74LS352	1.29
74LS03	.25	74LS92	.55	74LS174	.55	74LS353	1.29
74LS04	.24	74LS93	.55	74LS175	.55	74LS363	1.35
74LS05	.25	74LS95	.75	74LS181	2.15	74LS364	1.95
74LS08	.28	74LS96	.89	74LS189	8.95	74LS365	.49
74LS09	.29	74LS107	.39	74LS190	.89	74LS366	.49
74LS10	.25	74LS109	.39	74LS191	.89	74LS367	.45
74LS11	.35	74LS112	.39	74LS192	.79	74LS368	.45
74LS12	.35	74LS113	.39	74LS193	.79	74LS373	.99
74LS13	.45	74LS114	.39	74LS194	.69	74LS374	.99
74LS14	.59	74LS122	.45	74LS195	.69	74LS377	1.39
74LS15	.35	74LS123	.79	74LS196	.79	74LS378	1.18
74LS20	.25	74LS124	2.90	74LS197	.79	74LS379	1.35
74LS21	.29	74LS125	.49	74LS221	.89	74LS385	1.90
74LS22	.25	74LS126	.49	74LS240	.95	74LS386	.45
74LS26	.29	74LS132	.59	74LS241	.99	74LS390	1.19
74LS27	.29	74LS133	.59	74LS242	.99	74LS393	1.19
74LS28	.35	74LS136	.39	74LS243	.99	74LS395	1.19
74LS30	.25	74LS137	.99	74LS244	.99	74LS399	1.49
74LS32	.29	74LS138	.55	74LS245	1.49	74LS424	2.95
74LS33	.55	74LS139	.55	74LS247	.75	74LS447	.37
74LS37	.35	74LS145	1.20	74LS248	.99	74LS490	1.95
74LS38	.35	74LS147	2.49	74LS249	.99	74LS624	3.99
74LS40	.25	74LS148	1.35	74LS251	.59	74LS668	1.69
74LS42	.49	74LS151	.55	74LS253	.59	74LS669	1.89
74LS47	.75	74LS153	.55	74LS257	.59	74LS670	1.49
74LS48	.75	74LS154	1.90	74LS258	.59	74LS674	9.65
74LS49	.75	74LS155	.69	74LS259	2.75	74LS682	3.20
74LS51	.25	74LS156	.69	74LS260	.59	74LS683	3.20
74LS54	.29	74LS157	.65	74LS266	.55	74LS684	3.20
74LS55	.29	74LS158	.59	74LS273	1.49	74LS685	3.20
74LS63	1.25	74LS160	.69	74LS275	3.35	74LS688	2.40
74LS73	.39	74LS161	.65	74LS279	.49	74LS689	3.20
74LS74	.35	74LS162	.69	74LS280	1.98	74LS783	24.95
74LS75	.39	74LS163	.65	74LS283	.69	81LS95	1.49
74LS76	.39	74LS164	.69	74LS290	.89	81LS96	1.49
74LS78	.49	74LS165	.65	74LS293	.89	81LS97	1.49
74LS83	.60	74LS166	1.95	74LS295	.99	81LS98	1.49
74LS85	.69	74LS168	1.75	74LS298	.89	25LS2521	2.80
				74LS299	1.75	25LS2569	4.25

IC SOCKETS

	1-99	100
8 pin ST	.13	.11
14 pin ST	.15	.12
16 pin ST	.17	.13
18 pin ST	.20	.18
20 pin ST	.29	.27
22 pin ST	.30	.27
24 pin ST	.30	.27
28 pin ST	.40	.32
40 pin ST	.49	.39
64 pin ST	4.25	call
ST = SOLDERTAIL		
8 pin WW	.59	.49
14 pin WW	.69	.52
16 pin WW	.69	.58
18 pin WW	.99	.90
20 pin WW	1.09	.98
22 pin WW	1.39	1.28
24 pin WW	1.49	1.35
28 pin WW	1.69	1.49
40 pin WW	1.99	1.80
WW = WIREWRAP		
16 pin ZIF	6.75	call
24 pin ZIF	9.95	call
28 pin ZIF	10.95	call

ZIF = TEXTOOL (Zero Insertion Force)

CONNECTORS

RS232 MALE	2.95
RS232 FEMALE	3.50
RS232 FEMALE RIGHT ANGLE	5.25
RS232 HOOD	1.25
S-100 ST	3.95
S-100 WW	4.95

DIP SWITCHES

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

7400

7400	.19	74132	.45
7401	.19	74136	.50
7402	.19	74141	.65
7403	.19	74142	2.95
7404	.19	74143	2.95
7405	.25	74145	.60
7406	.29	74147	1.75
7407	.29	74148	1.20
7408	.24	74150	1.35
7409	.19	74151	.55
7410	.19	74152	.65
7411	.25	74153	.55
7412	.30	74154	1.25
7413	.35	74155	.75
7414	.49	74156	.65
7416	.25	74157	.55
7417	.25	74159	1.65
7420	.19	74160	.85
7421	.35	74161	.69
7422	.35	74162	.85
7423	.29	74163	.69
7425	.29	74164	.85
7426	.29	74165	.85
7427	.29	74166	1.00
7428	.45	74167	2.95
7430	.19	74170	1.65
7432	.29	74172	5.95
7433	.45	74173	.75
7437	.29	74174	.89
7438	.29	74175	.89
7440	.19	74176	.89
7442	.49	74177	.75
7443	.65	74178	1.15
7444	.69	74179	1.75
7445	.69	74180	.75
7446	.69	74181	2.25
7447	.69	74182	.75
7448	.69	74184	2.00
7450	.19	74185	2.00
7451	.23	74186	18.50
7453	.23	74190	1.15
7454	.23	74191	1.15
7460	.23	74192	.79
7470	.35	74193	.79
7472	.29	74194	.85
7473	.34	74195	.85
7474	.33	74196	.79
7475	.45	74197	.75
7476	.35	74198	1.35
7480	.59	74199	1.35
7481	1.10	74221	1.35
7482	.95	74246	1.35
7483	.50	74247	1.25
7485	.59	74248	1.85
7486	.35	74249	1.95
7489	2.15	74251	.75
7490	.35	74259	2.25
7491	.40	74265	1.35
7492	.50	74273	1.95
7493	.35	74276	1.25
7494	.65	74279	.75
7495	.55	74283	2.00
7496	.70	74284	3.75
7497	2.75	74285	3.75
74100	1.75	74290	.95
74107	.30	74293	.75
74109	.45	74298	.85
74110	.45	74351	2.25
74111	.55	74365	.65
74116	1.55	74366	.65
74120	1.20	74367	.65
74121	.29	74368	.65
74122	.45	74376	2.20
74123	.49	74390	1.75
74125	.45	74393	1.35
74126	.45	74425	3.15
74128	.55	74426	.85
		74490	2.55

CMOS

4000	.29	4527	1.95
4001	.25	4528	1.19
4002	.25	4531	.95
4006	.89	4532	1.95
4007	.29	4538	1.95
4008	.95	4539	1.95
4009	.39	4541	2.64
4010	.45	4543	1.19
4011	.25	4553	5.79
4012	.25	4555	.95
4013	.38	4556	.95
4014	.79	4581	1.95
4015	.39	4582	1.95
4016	.39	4584	.75
4017	.69	4585	.75
4018	.79	4702	12.95
4019	.39	74C00	.35
4020	.75	74C02	.35
4021	.79	74C04	.35
4022	.79	74C08	.35
4023	.29	74C10	.35
4024	.65	74C14	.59
4025	.29	74C20	.35
4026	1.65	74C30	.35
4027	.45	74C32	.39
4028	.69	74C42	1.29
4029	.79	74C48	1.99
4030	.39	74C73	.65
4034	1.95	74C74	.65
4035	.85	74C76	.80
4040	.75	74C83	1.95
4041	.75	74C85	1.95
4042	.69	74C86	.39
4043	.85	74C89	4.50
4044	.79	74C90	1.19
4046	.85	74C93	1.75
4047	.95	74C95	.99
4049	.35	74C107	.89
4050	.35	74C150	5.75
4051	.79	74C151	2.25
4053	.79	74C154	3.25
4060	.89	74C157	1.75
4066	.39	74C160	1.19
4068	.39	74C161	1.19
4069	.29	74C162	1.19
4070	.35	74C163	1.19
4071	.29	74C164	1.39
4072	.29	74C165	2.00
4073	.29	74C173	.79
4075	.29	74C174	1.19
4076	.79	74C175	1.19
4078	.29	74C192	1.49
4081	.29	74C193	1.49
4082	.29	74C195	1.39
4085	.95	74C200	5.75
4086	.95	74C221	1.75
4093	.49	74C373	2.45
4098	2.49	74C374	2.45
4099	1.95	74C901	.39
14409	12.95	74C902	.85
14410	12.95	74C903	.85
14411	11.95	74C905	10.95
14412	12.95	74C906	.95
14419	7.95	74C907	1.00
14433	4.18	74C908	2.00
4502	.95	74C909	2.75
4503	.65	74C911	8.95
4508	1.95	74C912	8.95
4510	.85	74C914	1.95
4511	.85	74C915	1.19
4512	.85	74C918	2.75
4514	1.25	74C920	17.95
4515	1.79	74C921	15.95
4516	1.55	74C922	4.49
4518	.89	74C923	4.95
4519	.39	74C925	5.95
4520	.79	74C926	7.95
4522	1.25	74C928	7.95
4526	1.25	74C929	19.95

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74S00	.32	74S163	1.95
74S02	.35	74S168	3.95
74S03	.35	74S169	3.95
74S04	.35	74S174	.95
74S05	.35	74S175	.95
74S08	.35	74S181	3.95
74S09	.40	74S182	2.95
74S10	.35	74S188	1.95
74S11	.35	74S189	6.95
74S15	.35	74S194	1.49
74S20	.35	74S195	1.49
74S22	.35	74S196	1.49
74S30	.35	74S197	1.49
74S32	.40	74S201	6.95
74S37	.88	74S225	7.95
74S38	.85	74S240	2.20
74S40	.35	74S241	2.20
74S51	.35	74S244	2.20
74S64	.40	74S251	.95
74S65	.40	74S253	.95
74S74	.50	74S257	.95
74S85	1.99	74S258	.95
74S86	.50	74S260	.79
74S112	.50	74S274	19.95
74S113	.50	74S275	19.95
74S114	.55	74S280	1.95
74S124	2.75	74S287	1.90
74S132	1.24	74S288	1.90
74S133	.45	74S289	6.89
74S134	.50	74S301	6.95
74S135	.89	74S373	2.45
74S138	.85	74S374	2.45
74S139	.85	74S381	7.95
74S140	.55	74S387	1.95
74S151	.95	74S412	2.98
74S153	.95	74S471	4.95
74S157	.95	74S472	4.95
74S158	.95	74S474	4.95
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		74S571	2.95

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SN7402N	14	.25	SN7474N	14	.35	SN74160N	16	.69
SN7403N	14	.25	SN7475N	16	.45	SN74161N	16	.69
SN7404N	14	.25	SN7476N	16	.35	SN74162N	16	.69
SN7405N	14	.25	SN7479N	14	4.95	SN74163N	16	.69
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SN7407N	14	.29	SN7482N	14	1.19	SN74165N	16	.69
SN7408N	14	.25	SN7483N	16	.59	SN74166N	16	.89
SN7409N	14	.25	SN7485N	16	.59	SN74167N	16	2.79
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SN7416N	14	.25	SN7493N	14	.39	SN74176N	14	.69
SN7417N	14	.25	SN7494N	14	.69	SN74177N	14	.69
SN7420N	14	.19	SN7495N	14	.49	SN74179N	16	1.49
SN7421N	14	.35	SN7496N	16	.49	SN74180N	14	.69
SN7422N	14	.45	SN7497N	16	2.75	SN74181N	24	1.95
SN7423N	16	.59	SN74100N	24	1.49	SN74182N	16	.89
SN7425N	14	.29	SN74104N	14	.89	SN74184N	16	1.95
SN7426N	14	.29	SN74105N	14	.89	SN74185N	16	1.95
SN7427N	14	.25	**SN74107N**	**14**	**.29**	SN74190N	16	.69
SN7428N	14	.49	**SN74109N**	**16**	**.39**	SN74191N	16	.69
SN7430N	14	.25	SN74116N	24	1.49	SN74192N	16	.69
SN7432N	14	.29	SN74121N	14	.39	SN74193N	16	.69
SN7437N	14	.25	SN74122N	14	.55	SN74194N	16	.69
SN7438N	14	.29	SN74123N	16	.49	SN74195N	16	.69
SN7439N	14	.59	SN74125N	14	.45	SN74196N	14	.89
SN7440N	14	.19	SN74126N	14	.45	SN74197N	14	.89
SN7441N	16	.89	SN74132N	14	.49	SN74198N	24	1.19
SN7442N	16	.45	SN74136N	14	.69	SN74199N	24	1.19
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SN7447N	16	.69	SN74145N	16	.59	SN74283N	16	1.49
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SN7459A	14	.25	SN74153N	16	.59	SN74368N	16	.55
SN7460N	14	.19	SN74154N	24	1.25	SN74390N	16	1.49
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74LS00	14	.25	74LS92	14	.55	74LS192	16	.79
74LS01	14	.25	74LS93	14	.55	74LS193	16	.79
74LS02	14	.25	74LS95	14	.79	74LS194	16	.69
74LS03	14	.25	74LS96	16	.89	74LS195	16	.69
74LS04	14	.29	74LS107	14	.39	74LS197	14	.79
74LS05	14	.29	74LS109	16	.39	74LS221	16	.89
74LS08	14	.29	74LS112	16	.39	74LS240	20	1.09
74LS09	14	.29	74LS113	14	.39	74LS241	20	1.09
74LS10	14	.29	74LS114	14	.39	74LS242	14	1.09
74LS11	14	.35	74LS122	14	.49	74LS243	14	1.09
74LS12	14	.35	74LS123	16	.79	74LS244	20	1.09
74LS13	14	.39	74LS125	14	.49	74LS245	20	1.49
74LS14	14	.59	74LS126	14	.49	74LS247	16	1.09
74LS15	14	.35	74LS132	14	.59	74LS248	16	1.09
74LS20	14	.29	74LS133	16	.59	74LS249	16	1.09
74LS21	14	.29	74LS136	14	.39	74LS251	16	.59
74LS22	**14**	**.29**	74LS138	16	.59	74LS253	16	.59
74LS26	14	.29	74LS139	16	.59	74LS257	16	.59
74LS27	14	.29	74LS151	16	.59	74LS258	16	.59
74LS28	14	.35	74LS153	16	.59	74LS260	14	.59
74LS30	14	.29	74LS154	24	.99	74LS266	14	.69
74LS32	14	.35	74LS155	16	.69	74LS273	20	1.49
74LS33	14	.55	74LS156	16	.69	74LS279	16	.49
74LS37	14	.35	74LS157	16	.69	74LS283	16	.69
74LS38	14	.35	74LS158	16	.59	74LS290	14	.89
74LS40	14	.29	74LS160	16	.69	74LS293	14	.79
74LS42	16	.55	74LS161	16	.69	74LS298	16	.89
74LS47	16	.75	74LS162	16	.69	74LS352	16	1.29
74LS48	16	.75	74LS163	16	.69	74LS353	16	1.29
74LS49	14	.75	74LS164	14	.69	74LS365	16	.49
74LS51	14	.25	74LS165	16	1.19	74LS366	16	.49
74LS54	14	.25	74LS166	16	1.19	74LS367	16	.49
74LS55	14	.29	74LS168	16	1.19	74LS368	16	.49
74LS73	14	.39	74LS169	16	1.19	74LS373	20	1.29
74LS74	14	.39	74LS170	16	1.49	74LS374	20	1.29
74LS75	16	.39	74LS173	16	.69	74LS375	16	.69
74LS76	16	.39	74LS174	16	.59	74LS386	14	.45
74LS78	14	.39	74LS175	16	.59	74LS393	14	1.19
74LS83	16	.65	74LS181	24	2.49	74LS399	16	1.49
74LS85	16	.69	74LS190	16	.89	74LS670	16	1.49
74LS86	14	.39	74LS191	16	.89	81LS95	20	1.49
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74S02	14	.35	74S133	16	.45	74S244	20	2.49
74S03	14	.35	74S134	16	.50	74S251	16	1.19
74S04	14	.45	74S135	16	.69	74S253	16	1.19
74S05	14	.45	74S136	14	1.39	74S257	16	1.19
74S08	14	.39	74S138	16	.89	74S258	16	1.19
74S09	14	.39	74S139	16	.89	74S260	14	.79
74S10	14	.35	74S140	14	.55	74S280	14	1.95
74S11	14	.35	74S151	16	.99	74S287*	16	1.95
74S15	14	.35	74S153	16	.99	74S288*	16	1.95
74S20	14	.35	74S157	16	.99	74S373	20	2.49
74S22	14	.35	74S158	16	.99	74S374	20	2.49
74S30	14	.35	74S160	16	2.49	74S387*	16	1.95
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74S40	14	.39	74S188*	16	1.49	74S473*	20	4.95
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74S64	14	.39	74S195	16	1.49	74S475*	24	4.95
74S65	14	.39	74S196	14	1.49	74S570*	16	2.95
74S74	14	.55	74S240	20	2.25	74S571*	16	2.95
74S86	14	.55	74S241	20	2.25	74S572*	18	4.95
74S112	16	.55	74S242	14	2.49	74S573*	18	4.95
74S113	14	.55				74S940	20	2.49
74S114	14	.55				74S941	20	2.49

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CA3059N	14	3.25				CA3600N	14	3.95

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CD4007	14	.29	CD4044	16	.79	CD4510	16	.89
CD4009	**16**	**.39**	CD4046	16	.89	CD4511	16	.89
CD4010	16	.39	CD4047	14	.89	CD4512	16	.89
CD4011	14	.29	CD4048	16	.39	CD4514	24	1.79
CD4012	**14**	**.15**	**CD4049**	**16**	**.39**	CD4515	24	1.79
CD4013	14	.39	CD4050	16	.39	CD4516	16	.99
CD4014	16	.79	CD4051	16	.79	CD4518	16	.99
CD4015	**16**	**.39**	CD4052	16	.79	CD4519	16	.39
CD4016	14	.39	CD4053	16	.79	CD4520	16	.79
CD4017	16	.75	CD4056	16	2.95	CD4526	16	1.19
CD4018	16	.79	CD4059	24	7.95	CD4528	16	1.19
CD4019	16	.39	CD4060	16	.89	CD4529	16	1.19
CD4020	16	.75	CD4066	14	.39	CD4543	16	1.19
CD4021	16	.79	CD4068	14	.39	CD4562	14	6.95
CD4022	16	.79	CD4069	14	.29	CD4566	16	1.39
CD4023	14	.29	CD4070	14	.39	CD4583	16	2.49
CD4024	14	.69	CD4071	14	.29	CD4584	14	.59
CD4025	14	.23	CD4072	14	.29	CD4723	16	1.19
CD4026	16	2.49	CD4073	14	.29	CD4724	16	1.19
CD4027	16	.45	CD4075	14	.29	MC14409	16	13.95
CD4028	16	.69	CD4076	16	.79	MC14410	16	13.95
CD4029	16	.79	CD4078	14	.49	MC14411	24	11.95
CD4030	14	.39	**CD4081**	**14**	**.29**	MC14412	16	13.95
CD4034	24	1.95	CD4082	14	.29	MC14419	16	7.95
CD4035	16	.89	CD4093	14	.49	MC14433	24	13.95
						MC14538	16	1.19
						MC14541	14	1.19

(More in Catalog)

MICROPROCESSOR COMPONENTS

MICROPROCESSOR CHIPS

Part No.	**Pins	Function	Price
CDP1802	40	CPU	$9.95
2650	40	MPU	14.95
IDM2901ADC	40	CPU—4-bit slice (Com. Temp. Gr.)	19.95
MCS6502	40	MPU w/Clock (65K bytes mem.)	9.95
MC6802CP	40	MPU w/Clock and RAM	7.95
INS8035N-6	40	MPU—8-bit (6MHz)	5.95
INS8039N-6	40	CPU-Sgl. chip 8-bit (128 bts. Ram)	5.95
INS8040N-6	40	CPU (256 bytes RAM)	5.95
INS8070N	40	CPU (64 bytes RAM)	11.95
INS8073N	40	CPU w/Basic Micro Interpreter	14.95
P8085A	40	CPU	5.95

Z80, Z80A, Z80B, Z8000 SERIES

Part No.	**Pins	Function	Price
Z80	40	CPU (MK3880N)(780C) 2MHz	$4.95
Z80-CTC	28	Counter Timer Circuit	5.95
Z80-DART	40	Dual Asynchronous Rec./Trans.	11.95
Z80-DMA	40	Direct Memory Access Circuit	15.95
Z80-P10	40	Parallel I/O Interface Controller	5.95
Z80-S10/0	40	Serial I/O (TxCB and RxCB Bonded)	15.95
Z80-S10/1	40	Serial I/O (Lacks DTRB)	15.95
Z80-S10/2	40	Serial I/O (Lacks SYNCB)	15.95
Z80-S10/9	40	Serial I/O	15.95
Z80A	40	CPU (MK3880N-4)(780C-1) 4MHz	5.95
Z80A-CTC	28	Counter Timer Circuit	5.95
Z80A-DART	40	Dual Asynchronous Rec./Trans.	11.95
Z80A-DMA	40	Direct Memory Access Circuit	17.95
Z80A-P10	40	Parallel I/O Interface Controller	5.95
Z80A-S10/0	40	Serial I/O (TxCB and RxCB bonded)	16.95
Z80A-S10/1	40	Serial I/O (Lacks DTRB)	16.95
Z80A-S10/2	40	Serial I/O (Lacks SYNCB)	16.95
Z80A-S10/9	40	Serial I/O	16.95
Z80B	40	CPU (MK3880N-6) 6MHz	11.95
Z80B-CTC	28	Counter Timer Circuit	13.95
Z80B-P10	40	Parallel I/O Interface Controller	13.95
Z8001	48	CPU Segmented	51.95
Z8002	40	CPU Non-Segmented	55.95
Z8030	40	Serial Comm. Controller	44.95
Z8036	40	Counter/Timer & Parallel I/O Unit	29.95

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Part No.	**Pins	Function	Price
MC6800	40	MPU	4.95
MC6802CP	40	MPU with clock and RAM	7.95
MC6810API	24	128x8 Static RAM	3.95
MC6821	40	Peripheral Inter. Adapt (MC6820)	4.95
MC6828	24	Priority Interrupt Controller	15.95
MC6830L8	24	1024x8-bit ROM (MC68A30-8)	10.95
MC6850	24	Asynchronous Comm. Adapter	5.95
MC6852	24	Synchronous Serial Data Adapter	5.75
MC6860	24	0-600bps Digital MODEM	9.95
MC6862	24	2400bps Modulator	12.95
MC6880A	16	Quad 3-state bus. trans. (MC8T26)	2.25
MC68000L8	64	MPU 16-Bit (8MHz)	69.95
MC68488P	40	General Purpose Int. Adapter	8.95
MC68652P2	40	Multi. Protocol Comm. Controller	24.95
MC68661PB	28	Enhanced Prog. Comm. Int.	8.95

8080A SERIES

Part No.	**Pins	Function	Price
INS8080A	40	CPU	3.95
TMS5501	40	Synchronous Data Interface (SIRC)	14.95
INS8154	40	128 Byte RAM 16-Bit I/O	19.95
INS82C06	20	Octal D Flip Flop Tri-State (74C374)	2.49
DP8212	24	8-bit Input/Output (74S412)	2.25
DP8214	24	Priority Interrupt Control	3.95
DP8216	16	Bi-Directional Bus Driver	2.25
DP8224	16	Clock Generator/Driver	2.25
DP8226	16	Bus Driver	2.25
DP8228	28	System/Cont./Bus Driver (74S428)	4.49
DP8238	28	System Controller (74S438)	4.49
INS8243	24	I/O Expander for 48 Series	5.95
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INS8246	20	20-Key Keyboard Encoder (74C923)	4.49
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INS8248	28	Display Controller (74C912)	8.95
INS8250N	40	Asyn. Comm. Element (INS8250)	10.95
DP8251	28	Prog. Comm. I/O (USART)	4.49
DP8253	24	Prog. Interval Timer	6.95
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DP8257	40	Prog. DMA Control	7.95
DP8259	28	Prog. Interrupt Control	6.95
DP8275	40	Prog. CRT Controller	29.95
DP8279	40	Prog. Keyboard/Display Interface	9.95
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DP8304	20	8-bit Bi-Directional Receiver	2.49
DP8307	20	8-bit Bi-Directional Receiver	2.49
DP8308	20	8-bit Bi-Directional Receiver	2.49
DP8310	20	Octal Latched Peripheral Driver	4.95
DP8311	20	Octal Latched Peripheral Driver	4.95

MICROPROCESSOR MANUALS & DATA BOOKS

M-Z80	User Manual	7.50
M-CDP1802	User Manual	7.50
M-2650	User Manual	5.00
10400	1982 Intel Data Book (1405 pg.)	14.95
30001	1981 Nat. CMOS Book (628 pg.)	6.95
30002	1980 Nat. Interface Book (640 pg.)	6.95
30003	1982 Nat. Linear Book (1952 pg.)	11.95
30005	1981 Nat. TTL Book (624 pg.)	9.95
30008	1980 Nat. Memory Data Book (464 pg.)	6.95
30011	1980 Nat. Linear Applications (736 pg.)	15.95
30013	1983 Zilog Data Book (641 pg.)	7.95
205610	1981 Intel Peripheral Design (828 pg.)	9.95

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Part No.	**Pins		Price
1103	18	1024x1 (300ns)	.99
4027	**16**	**4096x1 (250ns)**	**2.49**
4116N-2	16	16,384x1 (150ns)	1.89 - 8/14.95
4116N-3	16	16,384x1 (200ns)	1.69 - 8/12.95
4116N-4	16	16,384x1 (250ns)	1.49 - 8/10.95
4164N-150	16	65,536x1 (150ns)	7.95 - 8/59.95
4164N-200	16	65,536x1 (200ns)	7.49 - 8/54.95
MM5261	18	1024x1 (300ns)	.49 - 8/1.95
MM5262	**22**	**2048x1 (365ns)**	**.49 - 8/1.95**
MM5270	18	4096x1 (250ns) MK4096	4.95
MM5280	22	4096x1 (200ns) 2107	3.95
MM5290-2	16	16,384x1 (150ns)	1.89 - 8/14.95
MM5290-3	16	16,384x1 (200ns)	1.69 - 8/12.95
MM5290-4	16	16,384x1 (250ns)	1.49 - 8/10.95
MM5298-3	16	8192x1 (200ns)	1.69

STATIC RAMS

1101	16	256x1 (650ns)	1.49
2101	22	256x4 (450ns) 8101	2.49
2102	16	1024x1 (350ns)	.89
21L02	16	1024x1 (450ns) L.P.	1.49
2111	18	256x4 (450ns) 8111	2.95
2112	16	256x4 (450ns) MOS	2.95
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2114L	18	1024x4 (450ns) L.P.	2.25 - 8/15.95
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2114L-2	18	1024x4 (200ns) L.P.	2.49 - 8/17.95
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TMS4045	18	1024x4 (450ns)	3.95
5101	22	256x4 (450ns) CMOS	4.95
MM5257	18	4096x1 (450ns) 4044	3.95
HM6116P-3	24	2048x8 (150ns) CMOS	7.95
HM6116-4	24	2048x8 (200ns) CMOS	6.95
HM6116LP-4	24	2048x8 (200ns) L.P. CMOS	7.95
7489	16	16x4 (50ns) 3101	2.25
74C920	22	256x4 (250ns) CMOS	3.95
74C921	18	256x4 (250ns) CMOS	3.95
74C929	16	1024x1 (250ns) CMOS (6551)	3.95
74C930	18	1024x1 (250ns) CMOS (6518)	3.95
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74S206	16	256x1 (60ns) 93411	3.95
74S289	16	16x4 (35ns) 3101	2.25
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2708-5	24	1024x8 (450ns) SM00246	2.95
TMS2516	24	2048x8 (450ns) 2716	6.95
TMS2532	24	4096x8 (450ns) NMC2532	9.95
TMS2564	28	8192x8 (450ns)	19.95
TMS2716	24	2048x8 (450ns) 3 voltage	7.95
2716	24	2048x8 (450ns)	4.95
2716-1	24	2048x8 (350ns)	6.95
2732	24	4096x8 (450ns)	7.95
2758Q	24	1024x8 (450ns) single +5V	2.95
MM2764	28	8192x8 (450ns)	16.95
MM2764-3	28	8192x8 (300ns)	19.95

PROMS

74S188	16	32x8	PROM O.C. (6330-1)	1.49
74S287	16	256x4	PROM T.S. (6301-1)	1.95
74S288	16	32x8	PROM T.S. (6331-1)	1.95
74S387	16	256x4	PROM O.C. (6300-1)	1.95
74S471	20	256x8	PROM T.S. (6309-1)	5.95
74S472	20	512x8	PROM T.S. (6349-1)	4.95
74S473	20	512x8	PROM O.C. (6348)	4.95
74S474	24	512x8	PROM O.C. (DM87S296N)	4.95
74S475	24	512x8	PROM O.C. (6340)	4.95
74S478	24	1024x8	PROM T.S. (TBP28S86)	8.95
74S570	16	512x4	PROM O.C. (6305)	2.95
74S571	16	512x4	PROM T.S. (6306)	2.95
74S572	18	1024x4	PROM O.C. (6352)	4.95
74S573	18	1024x4	PROM T.S. (6353-1)	4.95
82S23	16	32x8	PROM O.C. (27S18)	2.95
82S115	24	512x8	PROM T.S. (27S15)	9.95
82S123	16	32x8	PROM T.S. (27S19)	2.95
82S126	16	256x4	PROM O.C. (27S20)	3.95
82S129	16	256x4	PROM T.S. (27S21)	3.95
82S130	16	512x4	PROM O.C. (27S12)	5.95
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DM87S180N	24	1024x8	PROM O.C. (82S180)	9.95
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MC1408L7	16	8-bit D/A Converter (DAC0807LCN)	2.49
MC1408L8	16	8-bit D/A Converter (DAC0808LCN)	2.95
ADC0804	20	8-bit A/D Converter (1 LSB)	3.49
DAC0806	16	8-bit D/A Converter (0.78% Lin.)	1.95
ADC0809	28	8-bit A/D Converter (8-Ch. Multi.)	4.49
AY-5-1013A	**40**	**30K Baud Uart (TR1602)**	**4.95**

INTERSIL

*Evaluation Kits

Part No.	**Pins	Function		Price
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7045EV/Kit*	28	Stopwatch Chip, XTL		19.95
7106CPL	40	3½ Digit A/D (LCD Drive)		9.95
7106EV/Kit*	40	IC, Circuit Board, Display		34.95
7107CPL	40	3½ Digit A/D (LED Drive)		11.95
7107EV/Kit*	40	IC, Circuit Board, Display		29.95
7116CPL	40	3½ Digit A/D LCD Dis. HLD		16.95
7117CPL	40	3½ Digit A/D LED Dis. HLD		15.95
7201IUS		Low Battery Volt Indicator		2.25
7205IPG	24	CMOS LED Stopwatch/Timer		12.95
7205EV/Kit*	24	Stopwatch Chip, XTL		14.95
7206CJPE	16	Tone Generator		4.95
7206CEV/Kit*	16	Tone Generator Chip, XTL		7.95
7207AIPD	14	Oscillator Controller		5.95
7207AEV/Kit*	14	Freq. Counter Chip, XTL		7.95
7208IPI	28	Seven Decade Counter		15.95
7209IPA	8	Clock Generator		3.95
7215IPG	24	4 Func. CMOS Stopwatch CKT		13.95
7215EV/Kit*	24	4 Func. Stopwatch Chip, XTL		14.95
7216AIJI	28	8 Digit Univ. Counter C.A.		29.95
7216CIJI	28	8 Digit Freq. Counter C.A.		24.95
7216DIPI	28	8 Digit Freq. Counter C.C.		19.95
7217IJI	28	4 Digit LED Up/Down Counter C.A.		10.95
7217AIPI	28	4 Digit LED Up/Down Counter C.C.		11.95
7224IPL	40	LCD 4½ Digit Up Counter DRI		10.95
7226AIJL	40	8 Digit Univ. Counter		29.95
7226AEV/Kit*	40	5 Function Counter Chip, XTL		74.95
7240IJE	16	CMOS Bin Prog. Timer/Counter		4.95
7242IJA	8	CMOS Divide-by-256 RC Timer		2.25
7250IJE	16	CMOS BCD Prog. Timer/Counter		6.00
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7555IPA	8	CMOS 555 Timer		1.45
7556IPD	14	CMOS 556 Timer		2.20
7611BCPA	8	CMOS Op Amp Comparator	5MV	2.25
7612BCPA	8	CMOS Op Amp Ext. Cmvr.	5MV	2.95
7621BCPA	8	CMOS Dual Op Amp Comp.	5MV	3.95
7631CCPE	16	CMOS Tri Op Amp Comp.	10MV	5.35
7641CCPD	14	CMOS Quad Op Amp Comp.	10MV	7.50
7642CCPD	14	CMOS Quad Op Amp Comp.	10MV	7.50
7660CPA	8	Voltage Converter		2.95
8038CCPD	14	Waveform Generator		3.95
8048CCPE	16	Monolithic Logarithmic Amp		16.95
8069CCQ		50ppm Band—GAP Volt Ref. Diode		2.50
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74C—C/MOS

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74C02	14	.35	74C107	14	.89	74C240	20	1.95
74C04	14	.29	74C151	16	2.49	74C244	20	1.95
74C08	14	.35	74C154	24	3.49	74C373	20	2.49
74C10	14	.35	74C157	16	2.25	74C374	20	2.49
74C14	14	.59	74C160	16	1.19	74C901	14	.59
74C20	14	.35	74C161	16	1.19	74C903	14	.59
74C30	14	.35	74C162	16	1.19	74C906	14	.59
74C32	14	.39	74C163	16	1.19	74C911	28	8.95
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74C48	16	1.95	74C173	16	.79	74C915	18	1.19
74C73	14	.79	74C174	16	1.19	74C917	28	8.95
74C74	14	.69	74C175	16	1.19	74C922	18	4.49
74C85	16	1.95	74C192	16	1.49	74C923	20	4.95
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74C89	16	5.95	74C195	16	1.39	74C926	18	5.95
74C90	14	1.19				80C95	16	.39
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74HC20	14	.75	74HC160	16	1.79	74HC374	20	3.95
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74HC86	14	.99	74HC175	16	1.39	74HC4538	16	2.95
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*74HCU04 is unbuffered. All others are buffered. **Send $.30 for Data Sheet**

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PAL10L8	20	Octal 10-Input AND-OR-Invert Gate Array (Low Output)	5.95
PAL12L6	20	Hex 12-Input AND-OR-Invert Gate Array (Low Output)	5.95
PAL14L4	20	Quad 14-Input AND-OR-Invert Gate Array (Low Output)	5.95
PAL16L8	20	Octal 16-Input AND-OR-Invert Gate Array (Low Output)	9.95
PAL16R8	20	Octal 16-Input Register AND-OR Gate Array	9.95
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LINEAR

TL071CP	8	.79	LM340K-15		1.35	NE570N	16	3.95
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TL074CN	14	1.95	LM340T-12		.79	LM709N	14	.49
TL081CP	8	.59	LM340T-15		.79	LM710N	14	.69
TL082CP	8	1.19	LM348N	14	.99	LM711N	14	.79
TL084CN	14	1.95	LM350K		4.95	LM723N	14	.55
LM301CN	8	.35	LF355N	8	1.10	LM733N	14	1.00
LM302H		1.95	LF356N	8	1.10	LM739N	14	1.95
LM304H		1.95	LM370N	14	4.49	LM741CN	8	.35
LM305H		.99	LM373N	14	3.95	LM747N	14	.69
LM307CN	8	.45	LM377N	14	1.95	LM748N	8	.59
LM308CN	8	.69	LM380N	14	.89	LM1310N	14	1.49
LM309K		1.25	LM381N	14	1.79	LM1458CN	8	.59
LM310CN	8	1.75	LM382N	14	1.39	LM1488N	14	.69
LM311CN	8	.69	LM384N	14	1.79	LM1489N	14	.69
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LM317K		3.95	TL496CP	8	1.19	LM1889N	18	1.95
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LM319N	14	1.95	NE529A	14	2.95	LM2002T		1.49
LM320K-5		1.35	NE531V	8	2.95	LM3189N	16	1.59
LM320K-12		1.35	NE536H		8.95	LM3900N	14	.59
LM320K-15		1.35	NE540H		4.95	LM3905CN	8	1.19
LM320T-5		.89	NE544N	14	2.95	LM3909N	8	.99
LM320T-12		.89	NE550A	14	1.95	LM3914N	18	3.49
LM320T-15		.89	NE555V	8	.35	LM3915N	18	3.49
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LM340K-12		1.35				MORE AVAILABLE		

CONNECTORS

DB25 — D Subminiature (meets RS232)

Part No.	Description	Price
DE9P	9 Pin Plug	$1.79
DE9S	9 Pin Socket	1.95
DA15P	15 Pin Plug	1.95
DA15S	15 Pin Socket	2.95
DB25P	**25 Pin Plug (Meets RS232)**	**2.49**
DB25S	**25 Pin Socket (Meets RS232)**	**3.25**
DB25P-B31	25 Pin Right Angle Plug	4.95
DB25S-B31	25 Pin Right Angle Socket	5.25
DC37P	37 Pin Plug	4.95
DC37S	37 Pin Socket	5.95
DD50P	50 Pin Plug	6.95
DD50S	50 Pin Socket	8.95

Accessories

DE-9H	Hood for DE-9 Series Connectors	$1.19
DA-15H	Hood for DA-15 Series Connectors	1.29
DB25H	Hood for DB25 Series Connectors	1.25
DC37H	Hood for DC37 Series Connectors	1.39
DD50H	Hood for DD50 Series Connectors	1.49
D20418-2	2 screws for mtg. connectors to a panel	.79

Solder Eyelet/Wire Wrap Edge Card

Part No.	Cnts.	Sp.	Description	Price
15/30SE	15/30	.156	Solder Eyelet	$1.79
18/36SE	18/36	.156	Solder Eyelet	1.95
22/44SE	22/44	.156	Solder Eyelet	2.49
22/44PC	22/44	.156	PC type (no mtg. ears)	.99
50/100SE	50/100	.125	Solder Eyelet	9.95
22/44WW	22/44	.156	Wire Wrap - Level 3	4.95
67031-5	22/44	.156	WW (Pins .0625x.03x.75)	3.95
R-681-1	50/100	.125	Wire Wrap - Level 3	7.95
R-681-2	50/100	.125	Wire Wrap - Level 1	6.95

RF Coaxial Connectors

Part No.	Description	Price
PL259	UHF Plug	$ .89
SO239	UHF Panel Receptacle	.69
PL258	UHF Straight Adapter	.89
UG175/U	UHF-Reducing Adapter	.49
UG88/U	BNC Plug	1.49
UG89/U	BNC Jack	1.69
UG306/U	BNC Angle Adapter	2.49
UG260/U	BNC Plug	1.49
UG1094/U	BNC Bulkhead Receptacle	.89

IC SOCKETS

For Socket Required, See Column After The IC Part No.

LOW PROFILE (TIN) SOCKETS

	1-9	10-99	100-999
8 pin LP	.16	.14	.13
14 pin LP	.17	.15	.14
16 pin LP	.19	.17	.15
18 pin LP	.26	.24	.23
20 pin LP	.30	.27	.25
22 pin LP	.30	.28	.26
24 pin LP	.33	.30	.28
28 pin LP	.40	.37	.35
36 pin LP	.59	.45	.42
40 pin LP	.49	.46	.43

— Soldertail Standard Tin & Gold Also Available —

WIRE WRAP (GOLD) SOCKETS LEVEL #3

	1-9	10-99	100-999
8 pin WW	.55	.49	.45
14 pin WW	.65	.62	.59
16 pin WW	.65	.62	.59
18 pin WW	.89	.85	.79
20 pin WW	1.09	1.05	.99
22 pin WW	1.25	1.19	1.15
24 pin WW	1.25	1.19	1.15
28 pin WW	1.49	1.23	1.18
36 pin WW	1.85	1.75	1.69
40 pin WW	1.99	1.89	1.79

$10.00 Minimum Order — U.S. Funds Only
California Residents Add 6½% Sales Tax
Postage — Add 5% plus $1.50 Insurance
Send S.A.S.E. for Monthly Sales Flyer!

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Digitalker™

DT1050 — Applications: Teaching aids, appliances, clocks, automotive, telecommunications, language translations, etc.

The DT1050 is a standard DIGITALKER kit encoded with 137 separate and useful words, 2 tones, and 5 different silence durations. The words and tones have been assigned discrete addresses, making it possible to output single words or words concatenated into phrases or even sentences. The "voice" output of the DT1050 is a highly intelligible male voice. Female and children's voices can be synthesized. The vocabulary is chosen so that it is applicable to many products and markets.

The DT1050 consists of a Speech Professor Chip, MM54104 (40-pin) and two (2) Speech ROMs MM52164SSR1 and MM52164SSR2 (24-pin) along with a Master Word list and a recommended schematic diagram on the application sheet.

DT1050 Digitalker™ . . . . $34.95 ea.

DT1057 — Expands the DT1050 vocabulary from 137 to over 260 words. Incl. 2 ROMs and specs.

DT1057 . . . . $24.95 ea.

CIRCLE 16 ON FREE INFORMATION CARD

ATARI

JOYSTICKS
JSA (2) . . . $6.95/pair

PADDLES
JSP (2) . . . $4.95/pair

TV GAME SWITCH

Switches TV to video game or computer operation. Used on Atari.

TGS-1 . . . $2.95 ea.

JOYSTICKS

JS-5K (Pictured)

JS-5K	5K Linear Taper Pots	$5.25
JS-100K	100K Linear Taper Pots	$4.95
JS-150K	150K Linear Taper Pots	$4.75
JVC-40	40K (2) Video Controller in Case	$4.95

JS KNOB Knob for JS5K,100K,150K . . . . . $.99 ea.
JVC KNOB Knob for JVC-40 . . . . $.99 ea.

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Ideal to use for:
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- Consumer remote data links
- Energy-saving, remotely switched lighting systems

A complete 6-channel digital encoder and RF transmitter; low power, at frequency of 27MHz or 49MHz, a field strength of 10,000uV meter at 3 meters. 9V operation on chip RF oscillator/transmitter, on chip 4.6 regulator. Up to 80MHz carrier frequency operation.

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A complete RF receiver/decoder, used at either 27MHz, 49MHz or 72MHz. It provides 4 independent channels when used with LM1871 (2 analog, 2 dig.) operates from four 1.5V cells. Crystal controlled.

LM1872N RC Receiver/Decoder Chip $2.49
SRX1504 49.435MHz Crystal (LM1872N) . . . $3.95
SRX1505 49.890MHz Crystal (LM1871N) . . . $3.95

Jameco ELECTRONICS Digital Thermometer Kit

Dual sensors — switch controls for indoor/outdoor or dual monitoring — can be extended to 500 feet. Continuous LED .8" ht. display. Range: -40°F to 199°F, -40°C to 100°C. Accuracy ±1° nominal. Calibrate for Fahrenheit/Celsius. Simulated walnut case. AC wall adapter included. Size: 6⅝"L x 3⅞"H x 1⅞"D.

JE300 . . . . . . $39.95

BOOKS

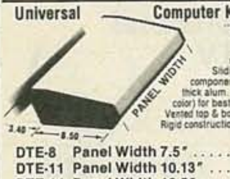
NATIONAL SEMICONDUCTOR — INTERSIL — INTEL

30001	National CMOS Data Book (1981) (640 pages) 74C, CD4000, and A/D Converters	$6.95
30002	National Interface Data Book (1980) (704 pages) DP, DS8000, DS3600, DS5700, etc.	$6.95
30003	National Linear Data Book (1982) (1376 pages) LM, LF, ADC, DAC, LH Series	$11.95
30004	National Series 80 — Board Level Computer (1980) (224 pages)	$4.95
30005	National TTL Logic Data Book (1981) (624 pages) 7400,LS,L,H,S, and DM8000 Series	$9.95

30006 Above (3) 30001,3,5 as set . . $24.95

30008	National Memory Data Book (1980) (464 pages) RAMs, ROMs, PROMs, EPROMs Series	$6.95
30009	Intersil Data Book (1983) (1356 pages) Complete line	$9.95
30010	National Audio/Radio Handbook (1980) (240 pages) Pre-Amps, AM, FM & FM Stereo, Power Amps	$5.95
30011	National Linear Application Handbook (1980) (736 pages) Application Notes, Linear Briefs, etc.	$15.95
30012	National PAL Data Book (1982) (176 pages) Data Sheet, PAL Design	$5.95
30013	Zilog Data Book (1983) (641 pages) Microprocessors and Support Chips	$7.95
010400	Intel Component Data Book (1982) (1405 pg.) Full data sheets for Intel's products incl. mem. devices, microproc., periph. & ind./mil. products	$14.95
205610	Intel Peripheral Design Handbook (1981) (828 pages) Full data sheets, application notes for Intel peripheral device components	$9.95

Universal Computer Keyboard Enclosures



"DTE" Blank Desk-Top Enclosures are designed for easy modification. High strength epoxy molded end pieces in mocha brown finish. Sliding rear/bottom panel for service/component access. Top/bott. panels .080" thick alum. alodine type 1200 finish (gold tint color) for best paint adhesion after modification. Vented top & bottom panels for cooling efficiency. Rigid construction provides unlimited applications. Assembly instructions included.

DTE-8 Panel Width 7.5" $24.95
DTE-11 Panel Width 10.13" $27.95
DTE-14 Panel Width 13.5" $29.95
DTE-20 Panel Width 19.25" $34.95

Mostek DC/DC Converter +5 VOLTS TO -9 VOLTS

Input: +5V. Output: -9V (regulated) @ 30mA. Printed circuit mounting. Specifications incl.

DC10 . . . . $2.95 ea. or 2/$4.95

Battery Checker

Easy-to-use hand-held battery checker tests AA, AAA, C, D, and 216 batteries. A multi-colored meter shows if battery is good, weak or needs replacing. Size: 6¼"L x 2¼"W x 1-7/8"H.

BC-1 . . . . $6.95 ea.

POWER SUPPLIES — KEYBOARDS

POWER SUPPLY +5VDC @ 1 AMP REGULATED *Transaction Tech*
Output +5VDC @ 1A (also +30VDC) reg. Input 115VAC 60Hz. 2-tone (black/beige) self-enclosed case. 6 ft. 3 cond. black power cord. 6½"W x 7"D x 2⅛"H. Wt. 3 lbs. Data sheet incl.
Part No. PS51194 . . . . $19.95 each

POWER SUPPLY +5VDC @ 1 AMP REGULATED *B Industries*
Output +5VDC @ 1 amp, +36-42VDC adj. 400mA or less, 30VAC (isol.) @ 1.5 amp. Input 115VAC 60Hz. Circ. brkr, re-set button, Blk. self-encl. case w/4 rubber feet. 6 ft. 3 cond. blk. pow. cord. On/off switch. 6⅞"W x 7⅞"D x 3-7/8"H - wt. 7 lbs. Data sheet included.
Part No. PS4070 . . . . $24.95 each

POWER SUPPLY +5VDC @ 3 AMP REGULATED *Deltron*
Input: 115VAC, 47-440Hz. Output: 5VDC Adjustable @ 3 amp. 6VDC @ 2.5 amp. Adjustable current limit. Ripple & Noise: 1MV rms, 5MV p-p — 2 mounting surfaces. UL recognized. Size: 4"W x 4⅞"L x 2-7/16"H - wt. 2 lbs. Data sheet included.
Part No. OPS-1 . . . . $29.95 each

POWER SUPPLY +5VDC @ 7.5 AMP, 12VDC @ 1.5 AMP SWITCHING
Input: 115VAC, 50-60Hz @ 3 amp/230VAC, 50Hz @ 1.6 amp. Fan vol./power supply select switches (115/230VAC). Output: 5VDC @ 7.6 amp, 12VDC @ 1.6 amp. 8 ft. blk. pow. cord. 11½"W x 13⅛"D x 3⅞"H. Wt. 6 lbs.
Part No. PS94V0 . . . . $49.95 each

POWER SUPPLY 4-Channel Switching Power Supply
Microprocessor, mini-computer, terminal, medical equipment and process control applications. Input: 90-130VAC 47-440Hz. Output: +5VDC @ 5A, -5VDC @ 1A, +12VDC @ 1A, -12VDC @ 1A. Line reg.: ±0.2%. Ripple: 30mV p-p. Load reg.: ±1%. Overcurrent protection. Adj: 5V main output±10%. 6-3/8"L x 1-7/8"W x 4-15/16"H. Wt. 1½ lbs.
Part No. FCS-604A . . . . $69.95 each

POWER SUPPLY Adjustable Switching 4-24VDC to 5 Amps
Adj. 4-24VDC: 5VDC @ 5A, 6VDC @ 4.8A, 9VDC @ 4.1A, 12VDC @ 3.3A, 18VDC @ 1.9A, 24VDC @ .5A. Overvoltage Protection. Input: 115VAC 50/60Hz. Output variations within 20mV. 8.25"L x 4.25"W x 2.25"H. Wt. 3.25 lbs.
JE224 Kit . . . . $79.95 each
JE224A Assembled & Tested . . . . $99.95 each

MICRO SWITCH 69-KEY KEYBOARD
Data Entry Keyboard. Encoded Output: 8-bit Parallel EBC DIC. Switching: Hall Effect, 24-pin Edge Card Connection. Complete w/Pin Connection. Can easily be modified to ASCII code.
16⅞"L x 5¼"W x 1⅞"H
Part No. KB69SD12-2 (Fits into DTE-20 Enclosure) . . . . . . $19.95 each

MICRO SWITCH 85-KEY KEYBOARD
Word Processing Keyboard, 25 Pin Edge Card Connection. Supply Voltage +5VDC. Main Keyboard is QWERTY. Additional Key Pads for Cursor and word processing functions.
23"Lx5¾"Wx1-3/8"H
Part No. 85SD18-1 . . . . $29.95 each

MICRO SWITCH 88-KEY KEYBOARD (PARALLEL)
Data Entry Keyboard used in a Diablo 1640 Terminal. Supply Voltage: +5V, -12V. Switching: Hall Effect — 10-pin Edge Card Connection. Schematic included. Uses 8048 Encoder Chip.
18¼"L x 5¾"W x 1⅞"H
Part No. 88SD22 (Fits into DTE-20 Enclosure) . . . . . . $69.95 each

HI-TEK 58-KEY KEYBOARD
SPST switching, mechanical, monolithic housing, charcoal grey keycaps. Keyboard is not mounted on circuit board (each key is individually accessible). Used to replace touch-membrane found on Sinclair, Atari, and TRS-80 computers.
Part No. K-58 . . . . $19.95

84-Key Keyboard

CA153A $69.95

104-Key Keyboard

CA148 . . . . $99.95

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30" Interface Cable
Attractive Case

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CA154A $79.95

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CA150C $89.95

Color; keycaps: black, blue, red - cover: black w/beige base. 21½"x9"x3½". 6 lbs.

BUG BOX™ — 30 individual compartments • Stores 60 8-pin or 30 14- or 16-pin DIPs • Heavy duty injection molded plastic • Clear plastic cover slides & locks • Cover marked w/numbers 1-30 • Compartment size: 1" x 3.75" x .5" deep • Box size: 4.9" x 3.3" x .6" • Weight: 1.75 oz.

BUG BOX™ STORAGE SYSTEMS

BUG CAGE™ (BGC-001-____) with Bug Boxes

BUG BOX™

Please specify color code: (B) Blue, (R) Red, (W) White, (Y) Yellow

Part No./Color Code	QTY	PRICE
BGX-001-( )	1	$ 2.29
BGX-010-( )	10	19.99
ANTI-STATIC		
BGX-001-( )AS	1	$ 3.29
BGX-010-( )AS	10	28.89

BUG CAGE™ — 12 locations store Bug Boxes, Big Bug Boxes or Bug Trays • Modular and interlocking • Heavy duty injection molded plastic • Each cage has 6 slip-on locations • 2 cages per pkg. • Cage size: 5-1/8" x 5" x 3-7/8" • 4 colors available — please specify color code: (B) Blue, (R) Red, (W) White, (Y) Yellow

Part No./Color Code	Price
BGC-001-( ) 2 Cages (6 loc. ea.)	$11.95/pkg.

BUG TRAY™ — Stores in Bug Cage • Molded plastic • Three styles: Open (1 compartment 3.05" x 4.6" x .6"); Vertical (5 compartments .5" x 4.6" x .6"); and Horizontal (8 compartments .4" x 3.95" x .6") • Ideal for tools, hardware, components, etc. • Tray size: 3.55" x 5.05" x .6" • Black color only

PART NO.	DESCRIPTION	PRICE
BTH-001	Horizontal Bug Tray	$1.95
BTV-001	Vertical Bug Tray	1.95
BTO-001	Open Bug Tray	1.95
BTX-003	1 of each Bug Tray (3)	4.98

LSI BIG BUG BOX™ — Designed to store large IC's, Resistors, Capacitors and Diodes • Divided into three compartments measuring 1" x 4.15" x .5" deep • Three vertical and three horizontal dividers included • Heavy duty injection molded plastic • Box size: 4.9" x 3.3" x .6" • Weight: 1.75 oz.

LSI BIG BUG BOX™

Please specify color code: (B) Blue, (R) Red, (W) White, (Y) Yellow

PART NO./COLOR CODE	QTY	PRICE
BLX-001-( )	1	$ 3.29
BLX-010-( )	10	28.79
ANTI-STATIC		
BLX-001-( )AS	1	$ 4.29
BLX-010-( )AS	10	37.89

BACK PACK™ — Self-adhesive labels for the back of ICs • Shows exact internal logic in relation to IC pins • 532 labels in each package (including several blank labels) • Each package for 8, 14, 16, 24, 28 and 40-pin ICs • Combo package includes 1,068 labels for TTL and CMOS ICs • Microprocessor package contains 744 labels

Part No.	Description	Price
BPT-012	TTL	$7.95
BPC-012	CMOS	8.95
BPM-012	Combo	14.95
BPU-012	Microprocessor	9.95

JUMPER AND CABLE ASSEMBLIES

Custom Jumpers! *Custom Cables!*

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All jumpers use low profile dip plugs with heavy duty pins for repeated disconnect applications.

JAMECO Part No.	AP Cross Reference	No. Pins	Description	Wire Length	Price
DJ14-1	924102-12	14	single end	12"	$1.79
DJ14-2	924102-24	14	single end	24"	2.05
DJ14-3	924102-36	14	single end	36"	2.35
DJ14-1-14	924106-12	14	double end	12"	2.95
DJ14-2-14	924106-24	14	double end	24"	3.19
DJ14-3-14	924106-36	14	double end	36"	3.49
DJ16-1	924112-12	16	single end	12"	1.89
DJ16-2	924112-24	16	single end	24"	2.19
DJ16-3	924112-36	16	single end	36"	2.59
DJ16-1-16	924116-12	16	double end	12"	2.95
DJ16-2-16	924116-24	16	double end	24"	3.29
DJ16-3-16	924116-36	16	double end	36"	3.59
DJ24-1	924122-12	24	single end	12"	2.69
DJ24-2	924122-24	24	single end	24"	3.19
DJ24-3	924122-36	24	single end	36"	3.59
DJ24-1-24	924126-12	24	double end	12"	4.49
DJ24-2-24	924126-24	24	double end	24"	4.95
DJ24-3-24	924126-36	24	double end	36"	5.39
DJ40-1	924132-12	40	single end	12"	5.39
DJ40-2	924132-24	40	single end	24"	6.19
DJ40-3	924132-36	40	single end	36"	6.89
DJ40-1-40	924136-12	40	double end	12"	9.49
DJ40-2-40	924136-24	40	double end	24"	10.29
DJ40-3-40	924136-36	40	double end	36"	10.95

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Now you can order DB25 P or S connectors with the cable necessary to fit your application. Choose from our standard flat cable in 4-foot lengths. **Call today.**

STANDARD CABLES

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DB25S-4	4 feet	1-DB25S	8.49
DB25P-4-P	4 feet	2-DB25P	13.49
DB25P-4-S	4 feet	1-DB25P/1-DB25S	13.75
DB25S-4-S	4 feet	2-DB25S	13.95

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California Residents Add 6½% Sales Tax
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EXPAND YOUR MEMORY

TRS-80 to 16K, 32K, or 48K

**Model 1 = From 4K to 16K Requires (1) One Kit
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Color = From 4K to 16K Requires (1) One Kit

**Model 1 equipped with Expansion Board up to 48K Two Kits Required — One Kit Required for each 16K of Expansion —

TRS-16K3 *200ns for Color & Model III $12.95
TRS-16K4 *250ns for Model I $10.95

TRS-80 Color 32K or 64K Conversion Kit

Kit comes complete with 8 each 4164-2 (200ns) 64K dynamic RAMs and conversion documentation. Converts TRS-80 color computers with E-revision boards and 1.1 ROMs to 32K of memory. Minor modifications of 32K memory will allow the use of all 64K of the dynamic RAM.

TRS-64K2 (200ns) $54.95

5¼" Mini-Floppy Disk Drive

Pertec Computer Corp.

FOR TRS-80 MODEL I (Industry Standard)
Features single or double density. Recording mode: FM single, MFM double density. Power: +12VDC (±0.6V) 1.6A max., +5VDC (±0.25V) 0.8A max. Unit as pic. at left (does not incl. case, power supply, cables). 30-pg. data book incl. Wt. 3½ lbs. Size: 5¾"W x 8"D x 3¼"H.

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Single-sided, 40 tracks, 250K bytes capacity
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Siemens 8" Floppy Disk Drive

- Single-Sided
- 77 Tracks
- 400/800K Bytes Capacity
- Industry Standard

The **FDD100-8 8" Floppy Disk Drive** (Industry Standard) features single or double density. Recording mode: FM single, MFM double density. Transfer rate: 250K bits/sec. single density; 500K bits/sec. double density. The FDD100-8 is designed to work with the single-sided soft sectored IBM Diskette I, or eq. disk cartridge. Hard-sectored option available. Power: 115/230VAC @ 50-60Hz, +24VDC @ 1.7 amps max., +5VDC @ 1.2 amps max. Unit as pictured above (does not include case, power supply, or cables). Size: 8.55"W x 14"L x 4.5"H. Weighs 12 lbs. Incl. 96-pg. manual.

Part No.		Price
FDD100-8	Buy 1 for	$269.95 each
FDD100-8	Buy 2 for	$259.95 each
FDD100-8	*Buy 10 for*	*$249.95 each*

2708,2716,2732 & 2764 EPROM Programmer

JE664 EPROM PROGRAMMER

8K TO 64K EPROMS — 24 AND 28 PIN PACKAGES
Self-Contained — Requires No Additional Systems for Operation

NEW!

• Programs, validates, and checks for properly erased EPROMs • Emulates PROMs or EPROMs • RS232C Computer Interface for editing/program loading • Loads data into RAM by keyboard • Changes data in RAM by keyboard • Loads RAM from an EPROM • Compares EPROMs for content differences • Copies EPROMs • Power Input: 115VAC, 60Hz, ◄ 10W power consumption • Enclosure: Color-coordinated, light tan panels w/molded mocha brown end pieces • Size: 15-5/8"L x 8¾"D x 3½"H • Wt.: 5¾ lbs.

JE664-A EPROM Programmer $995.00
Assembled & Tested (Includes JM16A Module)

JE665 — RS232C INTERFACE OPTION — The JE665 RS232C Interface Option implements computer access to the JE664's RAM. Sample software written in BASIC provided for TRS-80® Model I, Level II Computer. Baud rate: 9600. Word Lgth: 8 bits - odd parity. Stop bits: 2. Option may be adapted to other computers.

JE664-ARS EPROM Prog. w/JE665 Option $1195.00
Assembled and Tested (Includes JM16A Module)

EPROM JUMPER MODULES — The JE664's JUMPER MODULE (Personality Module) is a plug-in Module that pre-sets JE664 for proper programming pulses to the EPROM & configures EPROM socket connections for that particular EPROM.

Part No.	EPROM	EPROM MANUFACTURER	PRICE
JM08A	2708	AMD, Motorola, National, Intel, TI	$14.95
JM16A	2716, TMS2516	Intel, Motorola, National, NEC, TI	$14.95
JM16B	TMS2716	Motorola, TI (+5,-12,+12)	$14.95
JM32A	TMS2532	Motorola, TI	$14.95
JM32B	2732	AMD, Fujitsu, NEC, Hitachi, Intel	$14.95
JM64A	MCM68764, MCM68L764	Motorola	$14.95
JM64B	2764	Intel	$14.95
JM64C	TMS2564	TI	$14.95

UV-EPROM Eraser

8 Chips — 51 Minutes

1 Chip — 37 Minutes

Erases 2708, 2716, 2732, 2764, 2516, 2532, 2564. Erases up to 8 chips within 51 minutes (1 chip in 37 minutes). Maintains constant exposure distance of one inch. Special conductive foam liner eliminates static build-up. Built-in safety lock to prevent UV exposure. Compact — only 9.00" x 3.70" x 2.60". Complete with holding tray for 8 chips.

UVS-11EL Replacement Bulb $16.95
DE-4 UV-EPROM Eraser $79.95

Sprite-style Fan

- 36cfm free air delivery
- 3.125" sq. x 1.665" depth
- 10 yrs. cont. duty at 20°C
- 115V 50/60Hz

Metal Frame

PWS2107U Cleaned & tested (used) . . . . $ 9.95 ea.
*PWS2107F New . . . . $14.95 ea.

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- Impedance protected, ambients to 70°C
- 115V 50/60Hz 14W Wt. 17 oz.

Metal Frame

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*MU2A-1N New . . . . $14.95 ea.

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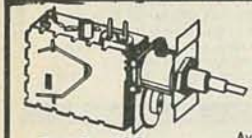

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Freq. Range UHF470-889MHz Channels 14-83
Output Channel 3.
Available on request: Ch 2 or 4.

Part No. B20
Modified High Gain Tuner. **$15.00**

1. The first thing we do is change the standard diode found in every tuner to a Hot Carrier Diode.
2. The tuners output is then measured and compared to our computer derived chart from which we determine the correct value coil to add across the IF output for maximum Pre-Peaked gain.
3. The tuner is fed a standard 10db antenna input, and while monitoring the output on our Spectrum Analyzer, the tuner is tuned to the desired channel and its oscillator is offset for the desired output frequency as follows:
   Ch. 2:58Mhz Ch. 3: 63Mhz Ch. 4: 68Mhz
   We call this step peaking because the tuners output looks like a peak on our spectrum analyzer and the highest point of that peak is actually adjusted for the desired output.
4. Finally, we measure the tuners output one more time which is again compared to our computer derived performance chart to ascertain the correct value of the second coil which is added to the tuners internal connections.

This procedure was developed by GILCO and its our computer derived performance charts that make our tuner better. That's because almost every tuner gets a different value coil before it's peaked and then a different value coil after it's peaked. The combinations are endless and the way we determine the values is our secret.

PRINTED CIRCUIT BOARDS

Part No. B21 Printed Circuit Board. **$17.00**

1. This Printed Circuit Board uses only one jumper, others use 9.
2. The component layout is screen printed on the Component side of the pre-drilled P/C Board.
3. The solder side of the P/C Board is covered with High Temperature Solder Resist for ease of assembly.
4. This P/C board was designed to take advantage of the Gilco High Gain Tuner which means its circuitry is simpler and more efficient than those circuits that require inferior Varactor Tuners.

ELECTRONIC PARTS KITS

Part No. B22 Complete Parts Kit. **$80.00**

All resistors (30), Potentiometers (1-5K, 3-10K), Panel Mount Potentiometer (10K), Electrolytic Capacitors (6), Ceramic and Mylar Disc Capacitors (35), Variable Capacitors (4), All Intergrated Circuits (7), Voltage Regulator, Heat Sink, Diodes (4), IC Sockets (4-8 pin, 3-14 pin), Power Transformer (24V/1A), Coil Kit with No. 26 wire (4), Speaker (4"-3 Oz.), Standoffs, Coaxial cable, All misc. Hardware, etc. All parts are individually packaged and labeled.

All components including the wire, Hardware, Coaxial Cable and heat sinks are included in the parts kit. This means your assembly time from start to finish is only 4 hours.

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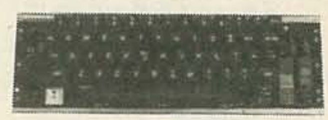

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DC Servo feedback circuit makes this power supply a must for our TA-2000 amplifier. The TR-747 will monitor the operating conditions of the TA-2000 power amplifiers. MODEL TR-747

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Brilliant fluorescent lantern with 9" 6 watt fluorescent tube. Features include: Powerful direct beam spotlight with 9V prefocus bulb; Buzzer horn - either constant or time intervals of sonic alarm; Twin blinker -red amber flashing or red & amber flashing on time intervals; fully adjustable nylon strap. Operates from D size batteries or plugs into vehicle cigar lighter socket.

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Complete with 5" fluorescent tube, powerful bulb and handy Strap. Runs on 3 pcs. 15 V "C" size batteries (not included). It's a practical, convenient, powerful spotlight and fluorescent light. Its superior quality is ideal for indoor or outdoor use.

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±10-30 VDC @ 250 ma adjustable, fully regulated. Kit includes all electronic parts, filter capacitors, IC's, heat sinks and PC Board.

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MARK IV — 15 STEP LED POWER LEVEL INDICATOR KIT

This new stereo level indicator kit consists of 36 4-color LED's (15 per channel) to indicate the sound level output of your amplifier from −36dB to +3dB. Comes with a well designed silk screen printed plastic panel and has a selector switch to allow floating or gradual output indicating. Power supply is 6-12VDC with THG on board input sensitivity controls. This unit can work with any amplifier from 1W to 200W! Kit includes 70 pcs driver transistors, 38 pcs matched 4-color LED's, all other electronic components, PC Board and front panel.

MARK IV KIT
$31.50

SUPER FM WIRELESS MIC KIT — MARK III

This new designed circuit uses high FREQ FET transistors with 2 stage pre-amp. Transmits FM range (88-120MHz) up to 2 blocks away and with the ultra sensitive condenser microphone that comes with the kit allows you to pick up any sound within 15 ft. away. Kit includes all electronic parts. OSC coils and PC Board. Power supply 9VDC.

FMC-105

$11.50 Per Kit

6-WAY A/C ADAPTOR

Input 110VAC Output 3V, 4.5V, 6V, 7.5V & 12VDC Current 300mA

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Black anodized front panel with black textured case

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PROFESSIONAL FM WIRELESS MICROPHONE

Made by one of the leading Japanese manufacturers. This factory assembled FM wireless microphone is powered by two AA size batteries. It transmits in the range of 88-108 MHz. Element is built in a plastic tube type case with an omni-directional electronic condensor microphone unit. By using a standard FM radio, signal can be heard anywhere on a one-acre lot. Sound quality was judged "very good." MODEL WEM-36.

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SANYO UHF VARACTOR TUNER

FOR UHF CHANNEL 14-83

Tuning voltage +1-+28VDC. Input impedance 75Ω. IF band width 7-16MHz. Noise figure 11.5dB Max. Size 2⅝" x 1¼" x ¾". Supply voltage 15VDC.

Model 115-B-403A, Video IF 45.0MHz
Model 115-B-405A, Video IF 62.5MHz
$35.00 ea.

Tuner is the most important part of the circuit. Don't let those $19.00 tuners fool you.
All units are brand new from Sanyo. When ordering please specify model number.

LOW TIM DC STEREO PRE-AMP KIT TA-1020

Incorporates brand-new DC design that gives a frequency response from 0-100Khz ±0.5dB. Added features like tone defeat and loudness control let you tailor your own frequency supplies to eliminate power fluctuation!
Specifications: • THD/TIM less than .005% • Frequency response DC to 100KHz ±0.5dB • RIAA deviation ±0.2dB • S/N ratio better than 70dB • Sensitivity Phono 2mV 47K/Aux 100mV 100K • Output level 1.3V • Max output 15V • Tone controls Bass ±10dB @ 50Hz/Treble ±10dB @ 15Hz • Power supply ±24VDC @ 0.5A. Kit comes with regulated power supply, all you need is a 48VCT transformer @ 0.5A.

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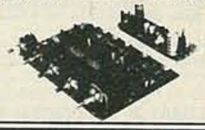

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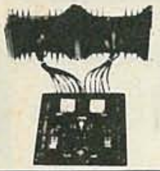
By using four stages of modern P.P. Super Mirror Circuit, THD and TIM are kept under 0.01% at rated output!
SPECIFICATIONS: 200W RMS into 4 or 8Ω



- 0 to 100,000 Hz (at 1W) +OdB, — 1dB
- S/N better than 100dB
- Less than 0.01% total Harmonic Distortion.

MODEL TA-2000
$83.95 per kit

120W PURE DC POWER STEREO AMP KIT

A GOOD BUY at $65.00

TA-800

Getting power hungry from your small amp? Have to watch your budget? Here's a good solution! The TA-800 is a pure DC amplifier with a built in pre-amp. All coupling capacitors are eliminated to give you a true reproduction of the music. On board tone and volume controls combined with built in power supply make the TA-800 the most compact stereo amp available. Specifications: 60W x 2 into 8Ω. Freq. range: 0Hz-100KHz ±3dB. THD .01% or better. S/N ratio: 80dB. Sensitivity: 3mV into 47K. Power Requirement: ±24-40 Volts.

AUDIO FREQUENCY SPECTRUM ANALYSER KIT TA-2900

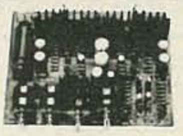
This Audio Frequency Spectrum Analyser analyses audio signals in 10 octaves over a dynamic range of 30dB. The technique allows the sound coloration introduced by unwanted room and speaker resonances to be substantially eliminated.

The TA-2900 provides a visual presentation of the changing spectrum thru 100 red LED displays, so you can actually see proof of the equalized sound you've achieved. The TA-2900 kit comes with all the electronic components, IC's, predrilled PC board, the instructions and a 19" Rack Mount type metal cabinet with professional silk-screen printed front panel.

- Input Sensitivity Tape Monitor/10mV - 18mV 50K Ω. Speaker Terminal/0.2W - 100W 8Ω
- Display Level Range (all octaves) 2dB per step/−14dB to −4dB.
- Delay Time (1KHz) Fast/18dB/s Slow/6dB/s
- Power Input 117V or 220V AC 50/60 Hz.
- Power Consumption 36W
- Dimensions 482(W) x 102(H) x 250(D) mm.

$99.50 per kit

★SPECIAL★



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MODEL 001-0034
$29.50 Per Kit
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TA-323 60 WATTS TOTAL 30W + 30W STEREO AMP KIT

This is a solid state all transistor circuitry with on board stereo pre-amp for most microphone or phone input. Power output employs 2 pairs matching Darlington Transistors driven by the popular 2N3053 Driver Transistors. Four built on board controls for, volume, balance, treble and bass. Power supply requires 48VCT 2.5A transformer. THD of less than 0.1% between 100Hz-10Khz at full power. (30 Watts + 30 Watts loaded into 8Ω).

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This Booster is specially designed for UHF Channels (14-83). After installing (between the antenna input cable and the UHF tuner), this unit will provide a minimum of 10dB gain, that is approximately 2 times better than you are seeing now. Ideal for those who live in apartments that can not put up an outdoor antenna. Small in size, only 2" x 1½" x 1". Supply voltage is 15 VDC. Back In Stock.

★NEW ITEM★
MODEL 001-0076
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MAIN AMP (15W × 2). Kit includes 2 pcs. Fisher PA 301 Hybnd IC, all electronic parts with PC Board. Power supply ±16VDC (not included). Power band with KF 1%+3dB). Voltage gain 33dB. 20Hz-20KHz.

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Only $18.50

ELECTRONIC SWITCH KIT

CONDENSER TYPE. Touch On – Touch Off. Uses 7473 IC and 12V relay ———— $5.50

POWER SUPPLY KIT

0-30VDC REGULATED. Uses UA723 and 2N3055 power transistor. Output can be adjusted from 0-30V @ 2A. Complete with PC Board and all electronic parts.

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All solid state circuitry with high efficiency power transistor 2SD388 and IC voltage regulator MC1733. Output voltage can be adjusted from 0-30V at 1A current limited or 0-15V at 2A current limited. Internal resistance is less than 0.005Ω, ripple and noise less than 1mV, dual on panel meters for voltage and amp reading, also with on board LED and audible over load indicator. Kit comes with pre-drilled PC Board, instructions, all necessary electronic components, transformer and a professional looking metal cabinet. The best project for school and the most useful instrument for repairmen. Build one today!

MODEL TR88A
0-15VDC @ 2A

MODEL TR88B
0-30VDC @ 1A

$59.50 Per Kit

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All boards are pre-assembled and tested. Your whistle to its FET condenser microphone from a distance, as far as 30 feet away (sensitivity can be easily adjusted), will turn the switch on and if you whistle again, it will turn off. Ideal for remote control toys, electrical appliance such as lights, coffee pots, TV, Hi-Fi, radio or other projects. Unit works on 9VDC.

MODEL 968 .... $4.50 ea.

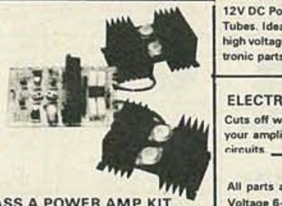
ULTRASONIC SWITCH KIT

Kit includes the Ultra Sonic Transducers, 2 PC Boards for transmitter and receiver, all electronic parts and instructions. Easy to build and a lot of uses such as remote control for TV, garage door, alarm system or counter. Unit operates by 9-12VDC.

$15.50 ea.

100W CLASS A POWER AMP KIT

TA-1000 KIT
$51.95
Power Transformer
$24.00 ea.



Dynamic Bias Class "A" circuit design makes this unit unique in its class. Crystal clear, 100 watts power output will satisfy the most picky fans. A perfect combination with the TA-1020 low TIM stereo pre-amp.
Specifications: • Output power 100W RMS into 8Ω, 125W RMS into 4Ω • Frequency response 10Hz-100KHz • THD less than 0.01% • S/N ratio better than 80dB • Input sensitivity 1V max. • Power supply ±40V @ 5A.

FLUORESCENT LIGHT DRIVER KIT

12V DC Powered ... Lights up 8-15 Watt Fluorescent Light Tubes. Ideal for camper, outdoor, auto or boat. Kit includes high voltage coil, power transistor, heat sink, all other electronic parts and PC Board. Light tube not included.

———— $6.50 Per Kit ————

ELECTRONIC DUAL SPEAKER PROTECTOR

Cuts off when circuit is shorted or over loaded to protect your amplifier as well as your speakers. A must for OCL circuits ———— KIT FORM $8.75 ea.

1 WATT AUDIO AMP

All parts are pre-assembled on a mini PC Board. Supply Voltage 6-9VDC ———— SPECIAL PRICE $1.95

6W AUDIO AMP KIT

TBA810 with Volume Control. Power Supply 6-18VDC
———— Only $7.50 ea. ————

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0.5V 200MA. Ideal for all kinds of solar projects, cells can be put in series to double voltage or parallel to double current. ———— $1.99 ea.

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(ULN) 2232 $2.99 5/$10.00
IC ONLY (Not mounted on Board)
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CRYSTALS—3.579545 MHz 99¢ **6.0 MHz** 2.95

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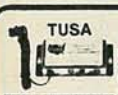

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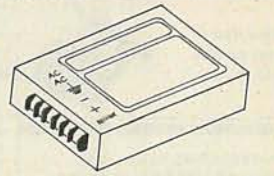

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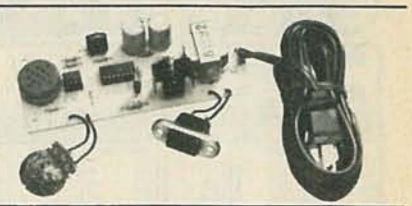

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