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$1.25 SEPT. 1982

THE MAGAZINE FOR NEW IDEAS IN ELECTRONICS

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HEART RATE MONITOR

The ins and outs of
BUYING MAILORDER PARTS

How to
BIAS TRANSISTORS CORRECTLY
when designing analog circuits

Build a
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for concert hall effects

Troubleshoot and repair
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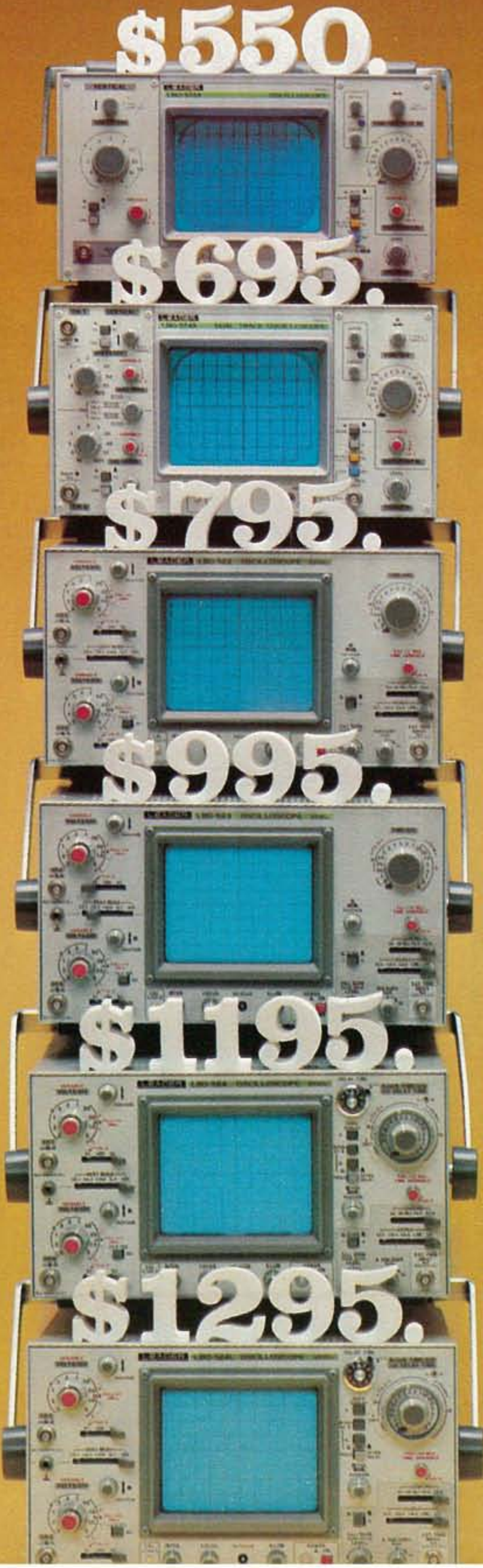
- ALTERNATE CHANNEL TRIGGERING
- AUTO FOCUS
- CHANNEL 1 OUTPUT

LBO-523: 35 MHz

- 7 kV PDA 6″ RECTANGULAR CRT
- INTERNAL GRATICULE
- 500 μV SENSITIVITY
- VARIABLE SWEEP HOLDOFF
- ALTERNATE CHANNEL TRIGGERING
- AUTO FOCUS
- CHANNEL 1 OUTPUT

CIRCLE 4 FOR PRODUCT DEMONSTRATION

CIRCLE 5 FOR PRODUCT INFORMATION



LBO-522: 20 MHz

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- INTERNAL GRATICULE
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- VARIABLE SWEEP HOLDOFF
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Introducing incredible tuning accuracy at an incredibly affordable price: The Command Series RF-3100 31-band AM/FM/SW receiver.* No other shortwave receiver brings in PLL quartz synthesized tuning and all-band digital readout for as low a price.† The tuner tracks and "locks" onto your signal, and the 5-digit display shows exactly what frequency you're on.

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†Based on a comparison of suggested retail prices.

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CIRCLE 7 ON FREE INFORMATION CARD

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8″ DSDD Soft Sector (Unformatted)	**3102**	3.34
8″ DSDD Soft Sector (128 B/S, 26 Sectors)	**3115**	3.34
8″ DSDD Soft Sector (256 B/S, 26 Sectors)	**3103**	3.34
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5¼″ SSDD 16 Hard Sector w/Hub Ring	**3485**	2.34
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DSDD = Double Sided Double Density; TPI = Tracks per inch

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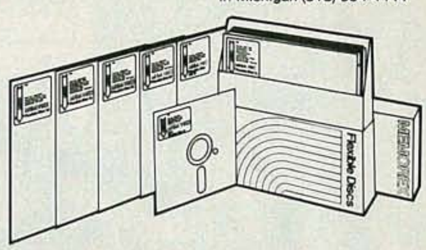

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Radio-Electronics

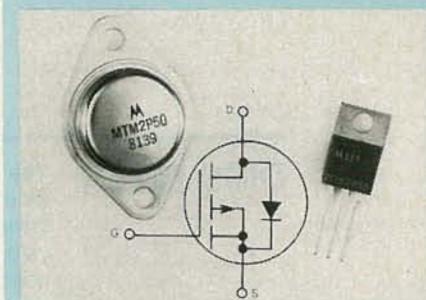
THE MAGAZINE FOR NEW IDEAS IN ELECTRONICS

Electronics publishers since 1908

September 1982 Vol. 53 No. 9

ON THE COVER

Using an otpo-electronic sensor that attaches to your finger, this battery-powered monitor displays your heart rate in beats-per-minute on a digital display. Knowing how your heart rate varies under different circumstances can give you an idea of your physical condition. Get started building yours today. The story starts on page 45.



HOW TO PROPERLY BIAS a transistor circuit is the subject of this month's analog design series. Must reading if your designs are to function the first time you plug them in. The story starts on page 59.

HOW TO TROUBLESHOOT AND REPAIR portable cassette recorders. The best results are obtained with a logical troubleshooting approach. The story starts on page 66.

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VIDEO ELECTRONICS

DAVID LACHENBRUCH
CONTRIBUTING EDITOR

DISC DATA

The often-postponed market launch of the Japanese VHD videodisc system is now scheduled for summer 1983. Pioneer (see photo) has expanded its line of LaserVision players to three—the original model at about $750, a new remote-control unit at $800, and a version without remote and random frame access at $600. RCA added a fourth CED player to its line described here last month—a model with wireless remote control and all-electronic on-set controls at $449.95.

DIGITAL TV

"Computer TV" could become a byword—or an advertising point—next year when the first sets with completely digital signal-processing circuits are scheduled to be introduced. The circuits are contained on five VSLI IC's developed by ITT Semiconductor and being offered worldwide to TV set makers. ITT claims the IC's replace an average of 20 IC's, 500 to 600 transistors and other components, and make possible production of a better TV set for the same or less money. Among the claimed advantages: The set can be self-testing and self-adjusting, automatically compensating for picture-tube aging. The same set can be "programmed" to accommodate NTSC or PAL color. Stereo audio, when available, comes "free" (except for the speakers), merely by programming. The design will accommodate digital sound input, or digital input from a computer. It makes possible the later addition of low-cost "peripherals," such as digital ghost elimination, high-definition by means of line interpolation, and elimination of flicker by interpolation of additional fields or frames. The first production prototype digital TV will be shown by ITT's Standard Elektrik Lorenz of Germany. Among at least eight set makers working with the ITT circuits is Zenith, which could be the first to introduce a digital set here.

BETA HI-FI

How can you get true high-fidelity stereo from a half-inch home video recorder? The VHS manufacturers are adding a second audio track and Dolby noise reduction, but that provides a 50-10,000 Hz frequency response, at most. Headed by Sony, the Beta group has been showing a proposed new "Beta Hi-Fi" system that can provide better audio specs than an open-reel tape recorder, but is still compatible with existing Beta recorders and tapes.

Beta's magic trick is to leave the current longitudinal audio track alone and put a new stereo sound track on an FM carrier in the helical video track. The result is "nearly digital" sound, with an 80-dB range, far above the 30- to 40-dB range of current recorders, with a frequency response of 20-20,000 Hz at 0.3% distortion, and inaudible wow and flutter. Recorders built for the hi-fi system would also be able to play the longitudinal track on old tapes, and new prerecorded tapes would have a longitudinal mono track plus the helical hi-fi stereo pair, to preserve compatibility. An extra bonus is the ability to have three separate soundtracks on mono tapes—three different languages, for example. Sony claims that such a helical-audio feat can't be accomplished on VHS recorders because their head drums are too small, resulting in picture degradation. But the VHS camp has yet to be heard from on the subject. If they go ahead with the project, Beta manufacturers say they can have recorders in the hi-fi format on the market around mid-1983. **R-E**

WHAT'S NEWS

Sharp reducing copier talks back to user

A new dry, any-paper desktop copier that talks to its user, makes reduced-size copies, can be automated, and helps diagnose its own troubles, has been introduced by Sharp Electronics Corp., headquartered in the United States at Paramus, NJ.

The new model *SF-781* speaks from a built-in voice synthesizer that emits electronic tones in a series that the ear hears as clear, easily understood sentences. When the user makes a reduced-size copy, the machine reminds him: "Check the paper size," and if he leaves his material in the machine and starts to walk away, it calls out: "Remove the original." If there is a paper misfeed, the *SF-781* warns the user and tells where to look for the cause.

The machine also warns if paper or toner needs replenishing, and if the machine is out of order. The copier's total vocabulary is nine sentences, all selected to boost efficiency and save time.

An advanced self-diagnostic system, aided by a microcomputer, pinpoints many problems by voice or LED alphanumeric display—quick but thorough diagnostic tests can be run from the front panel by pressing buttons.

The copier will take originals up to 11 × 17 inches. From that size, copies can be reduced to 8½ × 14 or 8½ × 11 inches. Line artwork can often be reduced so cleanly that it can be used for reproduction. Two 8½ × 11-inch pieces can be placed side-by-side for reproduction. The *SF-781* picks up a broad range of colors, including the difficult blue tones.

SECRETARY IS USING THE *SF-781* with *SF-461* automatic document feeder (right) and *SF-410* sorter (in front of the secretary). Those can be added to the copier to permit the equipment to grow as the user's needs may require.

Transistors move into high-voltage range

Motorola, in what it refers to as "a major expansion of MOS power transistor technology," has introduced eight new devices in the "sparsely populated 550-volt and up" field. The new devices are intended for power supplies operating from 230 and 460-volt lines. They are supplied in four voltages, with breakdown rating from 550 to 900 volts, and up to 3 amperes of continuous drain current.

The new devices are intended for such equipment as transmitters, radar, and medical electronics using high-power, high-voltage, tube-operated circuitry. Prices are in the $7 to $10 range. Data sheets are available from Motorola at P.O. Box 20912, Phoenix, AZ 85036.

Children, aged 3 to 13, are new computer market

The Learning Co. of Portola Valley, CA, is henceforth devoting its efforts to developing and selling interactive computer software for children whose ages range from 3 to 13 years. The programs are for use in the home, and include play with learning, encouraging participation by both children and their parents.

The first two programs offered are *Moptown* and *Magic Spells*. They are available from Apple Computer distributors under Apple's Special Delivery Software programs. *Moptown* is a set of 11 logic games; *Magic Spells* is a word game that combines large text, color graphics, and music.

The games are designed for parents who wish to encourage their children to learn in an entertaining and unthreatening way. The program guides the child through a series of adventures that promote original thinking. There is no violence and no wrong answers to discourage the child.

Founded in 1980 as Advanced Learning Technology by Dr. Ann Piestrup, the company pioneered the development of children's programs with interactive software featuring color graphics and animation, working under grants from the National Science Foundation and the Apple Education Foundation. Its change of name marks its move from a grant-funded organization to a commercial firm.

New plant will meet videodisc demands

RCA has commenced construction in Indianapolis of a new $19 million facility for manufacturing the compound essential in making "CED" videodiscs. That will be used to support the expanding disc manufacture at the company's Rockville Road plant in Indianapolis, as well as to supply other manufacturers worldwide.

The compounding facility blends the plastic, carbon, and other materials that are used in pressing the conductive RCA discs. The blended material is in the form of pellets, which are formed into a mass and then placed between the two stampers of an automatic compression molding press to make the final disc. The new plant will be able to process 50,000 pounds of raw material daily.

In addition to the new 55,000-square-foot compounding facility, RCA has completed a new power plant that will be able to produce the energy that will be needed for 60 disc presses.

Satellite-to-home broadcasts in sight

The Satellite Television Corp (STC) a subsidiary of COMSAT, has received four bids to construct direct-broadcast satellites (DBS) for STC's satellite-to-home pay-TV service. The companies bidding were Ford Aerospace and Communications Corp, General Elec-

continued on page 12

TEK 2200 MULTI-PURPOSE OSCILLOSCOPES — THE PERFORMANCE/ PRICE STANDARD

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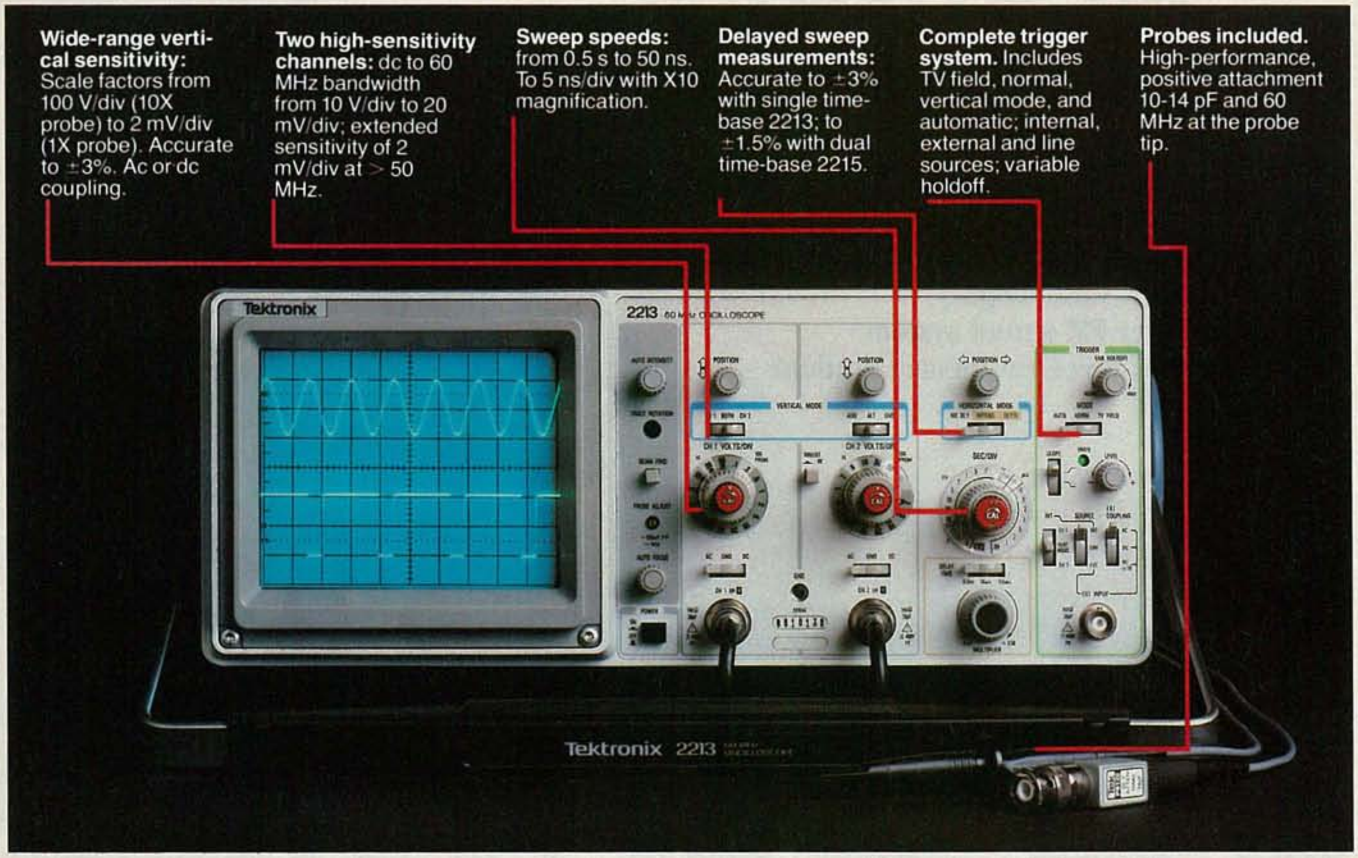

In 30 years of Tektronix oscilloscope leadership, no other scopes have recorded the immediate popular appeal of the Tek 2200 Series. The Tek 2213 and 2215 are unapproached for the performance and reliability they offer at a surprisingly affordable price.

There's no compromise with Tektronix quality: The low cost is the result of a new design concept that cut mechanical parts by 65%. Cut cabling by 90%. Virtually eliminated board electrical connectors. And obviated the usual cooling fan.

Yet performance is written all over the front panels. There's the bandwidth for digital and analog circuits. The sensitivity for low signal measurements. The sweep speeds for fast logic families. And delayed sweep for fast, accurate timing measurements.

The cost: $1100 for the 2213*. $1400 for the dual time base 2215. You can order, or obtain more information, through the Tektronix National Marketing Center, where technical personnel can answer your questions and expedite delivery. Your direct order includes probes, operating manuals, 15-day return policy and full Tektronix warranty.

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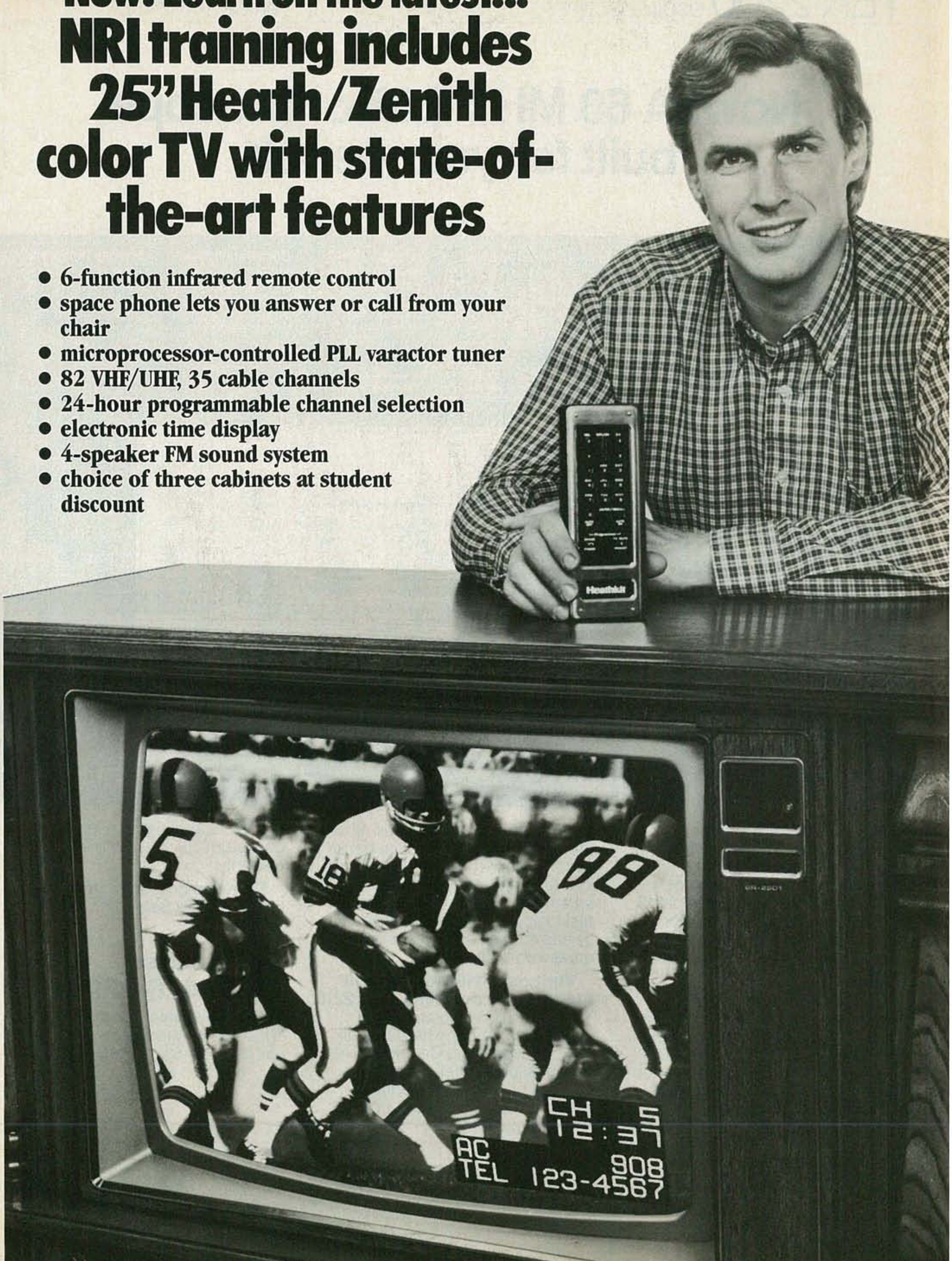


WHAT'S NEWS

continued from page 16

tric Co., Hughes Aircraft Co., and RCA Astro Electronics.

STC's Request for Proposals (issued January 13) were for construction of two satellites (one operating and one spare) which STC would use for satellite-to-home pay-TV service over an area approximating the U.S. Eastern Time Zone. The satellites are scheduled to operate on the 12- and 17-GHz bands.

The construction program is expected to take more than three years, and the service would begin in late 1985 or early 1986. STC will offer three channels of premium pay television, without advertising. Individual subscribers would receive STC's pay-TV service on small, inexpensive home receiving-antennas.

Optical system tracks distant satellites

The first of five Ground-based Electro-Optical Deep Space Surveillance Systems (GEODSS) has gone into action at the White Sands Missile Range in New Mexico. It will track optically satellites that orbit well above the range of most radars. GEODSS replaces an older camera system that required developing photographic plates and examining them with a microscope, usually about an hour's work. Sighting and identification with GEODSS is almost instantaneous.

GEODSS's telescopes can pinpoint the location of all satellites above 3,000 miles, especially those that orbit at 22,000 miles above the equator. The telescopes combine camera optics and computers and can see objects 10,000 times dimmer than the human eye can detect. They are are able to spot an object the size of a soccer ball more than 22,000 miles away. In operation, they fix on the stars and pick up any objects moving in front of them.

The telescope search is automatic, and the images it captures are recorded on a television camera. One hundred pictures a minute are converted into digital pulses and fed into a computer that filters out the (relatively) stationary surrounding stars and displays the satellites as streaks of light on video monitors.

To protect its own satellites from possible destruction, the Air Force must know what is in space and whether it is friend or foe. That information will be supplied by the GEODSS network. Sites in Korea and Hawaii are expected to be operational sometime this year, and an Eastern Atlantic and an Indian Ocean station will be in operation by the mid-1980's.

AIR FORCE TECHNICIANS TRACK SATELLITES at the ground-based Electro-Optical Deep Space Surveillance System facility in New Mexico. It is the first of five world-wide stations that will keep track of all man-made satellites in orbit within a range of 22,000 miles.

Anti-scanner ordinance tossed out in Philly

Municipal Court Judge J. Earl Simons ruled that Section 10-817 of the Code of Philadelphia Ordinances is unconstitutional. The ordinance, enacted in 1967, made access to police and fire radio channels illegal. It was not enforced until late in 1981, when the city interpreted the law to apply to radio scanners and arrested several owners and employees of retail stores for selling scanners.

The judge stated, among other things: "Individuals use scanner radios for personal entertainment or security purposes. Group use is endorsed—and in fact encouraged—by local law enforcement agencies, which conduct programs to teach the use of such scanner radios as a crime combatant. ... There is no evidence to suport the contention that access to police or fire channels increases crime, or the risk thereof ... on the contrary, it demonstrates a markedly decreased risk of criminality when such scanners are employed by the citizenry. The conclusion is compelled that the ordinance is unconstitutional."

The judge then ruled that the citations be dismissed and the defendants discharged.

New state voice network promises greater economy

The State of Washington has contracted with the Action Communications System Div of Honeywell for a *Roadrunner* Network Management System, to replace a Common Channel Switching Arrangement (CCSA) leased from Pacific Northwest Bell.

The state has spent nearly $12 million annually for long-distance telephone services provided by the CCSA leased network system. It is expected that the new systems can save about $5 million in annual long-distance costs. Average calling rates will be reduced from 12 cents to 6.5 cents per minute by using the least-cost routing and management possibilities offered.

A network of intermachine trunks and PBX tie lines will interconnect four switching centers at Olympia, Seattle, Spokane, and Vancouver with government PBX facilities across the state. The 2,656 port statewide network will utilize 4,800-baud data links between the four switching centers for "look ahead" routing and database maintenance and diagnostics.

G-E applies for a new consumer phone service

The General Electric Co. has applied for a total of 9 MHz in the 900-MHz band, for a new consumer-oriented mobile communications service. The allocation would be divided into two 4.5-MHz bands separated by 45 MHz. That would provide 150 channels of 30 kHz each.

The new Personal Radio Home Communications Service (PRCS) would be designed to augment the limited communications services already available to mobile consumers. It would provide the user with an affordable quality service for private communications within a user's normal driving area.

The system will consist of a base station tied into the user's telephone, and mobile units installed by users in their vehicles. The typcial range with the system would be in the order of 5 miles, which can be increased to approximately 15 miles by using strategically located repeater stations. There would be a nominal charge access of any of those. Repeaters would not be interconnected.

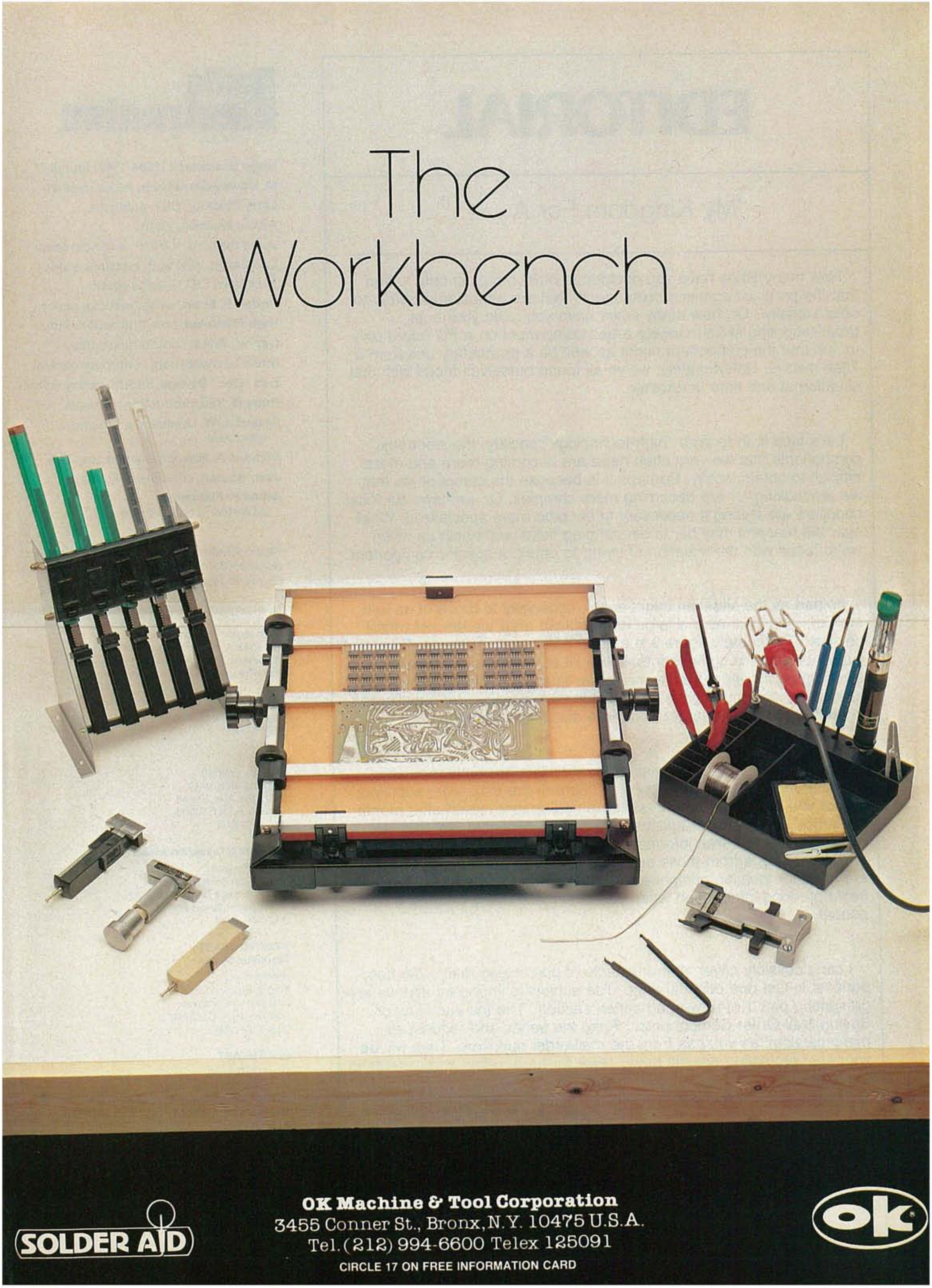
An additional communications feature is automatic interconnection to the public telephone network through the base station.

New photovoltaic cell works with low light

A high-performance photovoltaic module that produces 40 watts of peak power with 35 solar cells has been developed by Arco Solar (a subsidiary of Atlantic Richfield) at Chatsworth, CA.

Using single-crystal silicon cells, the module can charge batteries at 5 to 10 percent of noonday sun. The manufacturer claims that under such low light conditions, the new cells can deliver up to 25 percent more energy than typical modules of polycrystalline design.

The new module, M51, measures 1 × 4 feet and is 10.75 percent efficient. **R-E**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EDITORIAL

"My Kingdom For A ...."

How many times have you decided to build a project only to find that the parts list contains components that are almost impossible to obtain locally? Or, how many times have you used your best troubleshooting skills to locate a bad component on a PC board only to find that the component might as well be a proprietary unit from a Titan missile. Unfortunately, we've all found ourselves faced with that situation at one time or another.

Let's face it, in today's "high-technology" society, the electronic components that we very often need are becoming more and more difficult to obtain locally. Perhaps it is because the components that we are looking for are becoming more complex. Or, perhaps our local suppliers are finding it necessary to become more specialized. Whatever the reasons may be, understanding them won't help us when we're faced with the situation of trying to obtain a specific component.

As bad as the situation might seem, especially to those of us that are not living in or near a large metropolitan area, we are not totally helpless. Fortunately, there are a large number of mail-order firms that supply electronics components. While I'll admit that ordering an electronic component from a mail-order supplier is not as convenient as walking into your local supplier, at least the mail-order supplier is more likely to have a larger and more diversified inventory.

While the majority of the mail-order suppliers are quite reputable, not all of them are on the up and up. Screen the mail-order suppliers before you buy from them. First, if the ads appear month after month in **Radio-Electronics** magazine, you can be confident that they are reputable. Use the free information card at the back of the magazine to order catalogs from those suppliers and keep them handy. Catalogs are great for locating components that you need and they contain valuable ordering information when you're actually ready to order a component.

I can't possibly cover all the aspects of purchasing mail-order components in just one editorial page. The subject is important and we are presenting part 1 of a two-part series entitled "The Ins and Outs of Buying Mail-Order Components." Read the series and request as many catalogs as you can from the mail-order suppliers. They will be your best protection against being stuck for hard-to-find components in the future.

Art Kleiman

ART KLEIMAN
Editor

Radio-Electronics

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The ZX81 is also very convenient to use. It hooks up to any television set to produce a clear 32-column by 24-line display. It comes with a comprehensive programming guide and operating manual designed for both beginners and experienced computer users. And you can use a regular cassette recorder to store and recall programs by name.

Sinclair technology is also available in Timex/Sinclair computers under a license from Sinclair Research Ltd.

Order at no risk.**

We'll give you 10 days to try out the ZX81. If you're not completely satisfied, just return it to Sinclair Research and we'll give you a full refund.

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Ask for operator #509. In Ohio call: 800-582-1364; in Canada call: 513-729-4300. Ask for operator #509. Phones open 24 hours a day, 7 days a week. Have your MasterCard or VISA ready.

These numbers are for orders only. If you just want information, please write: Sinclair Research Ltd., 2 Sinclair Plaza, Nashua, NH 03061.

*Plus shipping and handling. Price includes connectors for TV and cassette, AC adaptor, and FREE manual.
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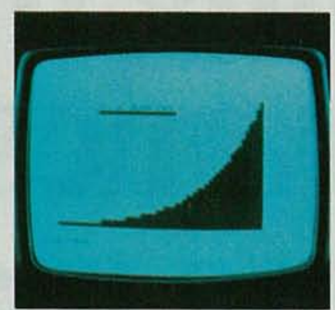

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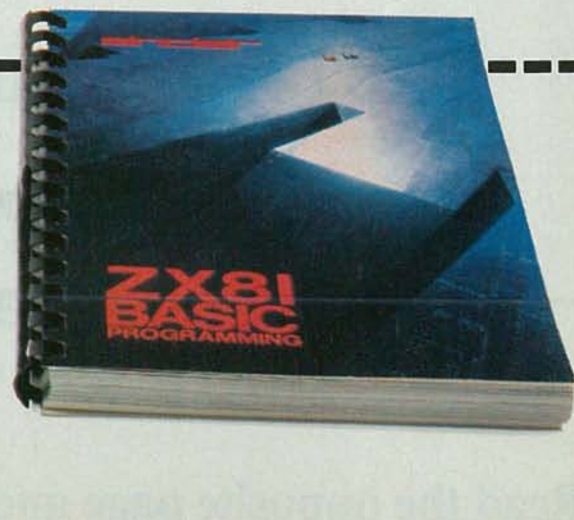

If you have put off learning more electronics for any of these reasons, act now!

☐ I don't have the time.

☐ High school was hard for me and electronics sounds like it may be hard to learn.

☐ I can't afford any more education.

☐ I have a family now.

☐ I'm here. You're there. I've never learned that way before. I'm not sure it will work for me.

Read the opposite page and see how you can get started today!

Be honest with yourself. Are the reasons really excuses? You already know enough about electronics to be interested in reading this magazine. So why not learn more? If you need encouragement, read on and see how excuses can be turned into results.

You don't have the time. Be realistic. All you have in life is a period of time. Use it. Try to know more tomorrow than you do today. That's the proven way to success. CIE studies require just about 12 hours of your time a week, two hours a day. You probably do have the time.

Electronics sounds like it may be hard to learn. You already know something about electronics or you wouldn't be reading this. Now, build on that. CIE Auto-Programmed® Lessons help you learn. Topics are presented in simple, logical sequence. All text is clear and concise for quick, easy understanding. You learn step by step, at your own pace. No classes to attend. Nobody pressures you. You **can** learn.

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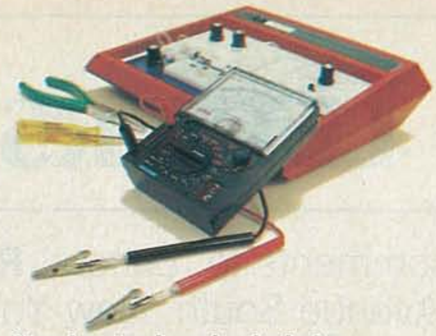

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The kind of professional you want to be needs more than theory. That's why some of our courses include the Personal Training Laboratory, which helps you put lesson theory into actual practice. Other courses train you to use tools of the trade such as a 5MHz triggered-sweep, solid-state oscilloscope you build yourself—and use to practice troubleshooting. Or a Digital Learning Laboratory to let you apply the digital theory that's essential today for anyone who wants to keep pace with electronics in the eighties.

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LETTERS

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

DATABASE MANAGEMENT SYSTEMS

I have just finished reading the June 1982 issue of **Radio-Electronics.** Your article on database management systems was an interesting summary of available products and vendors, but I should like to correct a few oversights.

First, Compco has had to move to a larger facility. I don't believe that the post office is forwarding our mail any longer (it's been a year), so I would appreciate having this letter published with our correct address. It is:

Compco, 7110 W. Fond Du Lac Avenue, Milwaukee, WI 53218. We can be reached by telephone through calling (414) 438-0610 or (414) 438-8611.

Secondly, Compco carries a wide variety of database management packages, for many different computers. Apple, Altos, and DEC are the principle lines. CP/M, MP/M, Apple DOS 3.3, Apple CP/M, and RT-11 are the principal operating systems that our products run under. We also carry a variety of word processing, scientific, and entertainment software and hardware.
THOMAS M. PETERS,
Compco, Sales Manager

OPENING THE DOOR

What a wonderful "opening of the door" to the world of electronics the simple building blocks described in "Hobby Corner," in **Radio-Electronics,** June 1982 provide!

The beginner is generally confronted with completely enclosed "black boxes" that defy understanding. First encounters are most important; and since most learning is through the eyes, the inner working parts should be exposed by removing all covers.

Touching is another great avenue for learning. (Beginners will soon be adjusting battery clips and switch tensions on their own.)

As learning progresses, open-type potentiometers and transformers with visible windings may be added. Also, the *name* of each component may be lettered simply on each block, along with its schematic symbol.

You cannot imagine how fast your youngster can learn, or how importantly those beginning blocks can shape his or her life!
GENE BRIZENDINE, W4ATE,
Huntsville, AL

DIGITAL THERMOMETER

This is an addition to the digital thermometer article by Michael Ribgy that appeared in the February 1982 issue of **Radio-Electronics.** I have used this circuit on my MA1026 clock module to vary the brightness of the LED display automatically with changes in the room light. The circuit uses only three components, all of which are readi-

ly available, and I have had it in service for over a year.

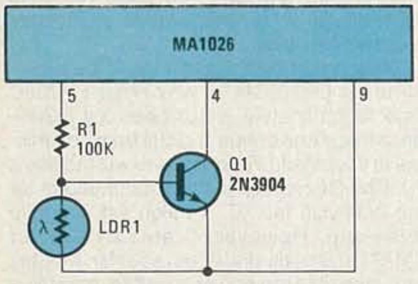

FIG. 1

Figure 1 tells the story. As the room light goes down, the resistance of LDR1 (Radio-Shack No. 276-116) increases. At a given point, determined by the value of R1, Q1 begins to conduct. That lowers the voltage on pin 4, and dims the display. Use any low-leakage transistor for Q1, with a gain (h_{fe}) of 100 or more. Select the value of R1 to get the desired dimming action, and remember that raising the value of R1 will slow the dimming action.
HERBERT DEAN,
Orono, ME

NIKOLA TESLA'S CONTRIBUTIONS

In your comment on Vince Marasco's letter about Nikola Tesla ("Letters," **Radio-Electronics,** June 1982) you pointed out that Mr. Marasco had failed to list any of the principles relating to everyday things that nearly all of us now take for granted that Tesla discovered.

The list is impressive: First, there is the AC motor. It is doubtful that there are any motor-driven devices in the home that do *not* use an AC motor, rather than the older DC units. Air conditioners, refrigerators, fans—all are built on Tesla's principle that he developed for Westinghouse.

Add to that his discovery in 1890 of applying high-frequency electricity to the body for deep heat treatment. Diathermy, in other words.

Then there is the Tesla coil—an air core transformer with resonating primary and secondary coils. Such units are used to test the effects of high-frequency electricity on switches and regulating circuits in the utility industry.

Marconi's patents on radio were upset by the U.S. Supreme Court, which ruled that they were an infringement on another's idea—Tesla. Robots, radar, and radio-controlled ships for military use, as well as the basic idea for a plane with vertical take-off and landing capabilities give you some idea—though really far from adequate—of the scope of that man's creative genius.

To anyone interested in Nikola Tesla, I recommend Margaret Cheney's book, an excellent biography titled, *Tesla, Man Out of Time.* In spite of one or two technical faults, it is worth reading; you will understand why there are so many who rate Edison second to Tesla, without denying the worth of Edison's contributions.
GEORGE deLUCENAY LEON,
New York, NY

SPEAKING OUT

I can keep silent no longer!

I'm an electronics buff, and have been receiving **Radio-Electronics** for about a year. I am also currently subscribing to a number of other somewhat similar magazines, but have decided that the ony ones to which I shall renew my subscription are **Radio-Electronics** and *The Audio Amateur.*

I consider **Radio-Electronics** to be by far the best electronics magazine on the market at the present time, and look forward to receiving it each month. I cannot recommend it too highly!

To date, I have built eight of the construction projects that you have published. They were easy to complete, and all function as intended. I would like to compliment you on the clarity and completeness of your projects—such that one does not need a high degree of electronics theory or expertise to build them, nor run into difficulty because of exotic or highly expensive components. I also applaud the fact that, to date, you have resisted the temptation to make **Radio-Electronics** into a computer magazine; there are a plethora of those available. Please continue your emphasis on construction electronics with a broad-base appeal.
PAUL T. KELLY,
Fort Wayne, IN

POCKET CALIBRATOR

Gary McClellan's statement that the LM723N voltage regulator has more stable temperature characteristics than the LM723C ("Pocket Calibrator for Volts and Ohms," **Radio-Electronics,** June 1982) is open to misinterpretation. The premium device is the LM723. The relaxed-specifications version is the LM723C. The suffix "N" refers not to quality but to package type, in this case a dual-in-line plastic one.

Thus, an LM723N would, indeed, be superior to an LM723CN, or any other LM723C type. Unfortunately, it has been my experience that if one orders a 723N from advertisers in your Market Section, one will receive a 723CN. Of course, in most applications for the hobbyist, the "C" version will be quite adequate. However, if an LM723N (or LM723H) is really preferred, as in Mr. McClellan's nice little project your readers may have to order it from one of the major electronics parts distributors.

LAWRENCE WALLCAVE,
Santa Rosa, CA

THE IBM COMPUTER

I have just finished reading your April 1982 issue, and noticed an article about IBM's *first* personal computer. In 1975, IBM was testing a rather heavy portable computer that was configured much like the *Osborne 1*. It had a non-removable keyboard, a small (perhaps 5 × 6-inch) monitor screen, and used data cassettes for loading. It was, I believe, the brainchild of Dick Doyle.

Time and time again, we see IBM showing all the youthful vigor of a tortoise, and, in personal-computer hardware, they've shown it again. I think that's a shame, because I like them.

JESSE THARIN,
Tucson, AZ

R-E

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Designed and built exclusively for the Electra Company, makers of Bearcat® Scanners, the Freedom Phone 3500 provides crisp and clear cordless calls. An audible tone and pulsing light confirm dialing. The touch of a button automatically redials the last number entered.

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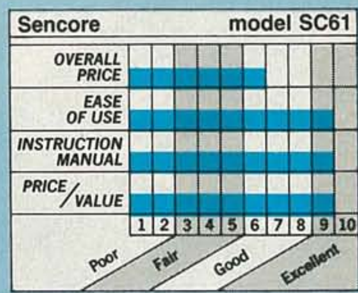
CIRCLE 19 ON FREE INFORMATION CARD

EQUIPMENT REPORTS

Sencore Model SC61 Waveform Analyzer



CIRCLE 106 ON FREE INFORMATION CARD

FOR QUITE A FEW YEARS NOW, SENCORE (3200 Sencore Drive, Sioux Falls, SD 57107) has been manufacturing "analyzers"—composite instruments that are useful for a wide variety of electronics testing and measuring. One of their newest products is the *model SC61* waveform analyzer. Whether you're working with analog or digital circuitry, you'll find a great many applications for this device no matter what kind of electronics work you do. It is really a quite versatile instrument, as you'll soon see.

The *model SC61* has two main sections. One is a dual-trace scope that can be used with waveforms of up to 100 MHz and voltages from 2 millivolts to 2 kilovolts. The unit's wide bandwidth (60 MHz), which is useable right up to the upper frequency limit, can come in very handy when working with high-speed digital circuitry. All of the standard features are there, including triggered sweep, a special delayed sweep mode called the delta mode (more on that later), and sync separators. The other section of this instrument is a built-in digital voltmeter with a 6-digit LCD display. The DVM display, incidentally, is located right across

continued on page 30

Your guide to the world of microprocessors.

The Micro-Professor™ -A low cost tool for learning, teaching and prototyping.

Here in one attractive package and at a price of only $149.00 is a Z80* based microcomputer to lead you step by step to a thorough knowledge of the world of microprocessors.

The Micro-Professor is a complete hardware and software system whose extensive teaching manual gives you detailed schematics and examples of program code. A superb learning tool for students, hobbyists and microprocessor enthusiasts, as well as an excellent teaching aid for instructors of electrical engineering and computer science courses.

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All this plus a built-in speaker, a cassette interface, and sockets to accept optional CTC/PIO. Bus is extendable.

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* Z80 is a trademark of Zilog Inc.

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EPB-MPF EPROM Programming Board	$169.00		
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Display: 4½ digit duplex LCD (19,999 count)

A/D Converter: Dual slope converter, autozero, autopolarity.

Conversion: TRMS, AC coupled

Display Annunciators: BT, low battery indication.

REL, relative reference mode activated. [8060A: **(k)Hz,** frequency function activated. **dB,** dB function activated.] —⟩⟨— continuity activated.))), continuity tone activated.—,continuity detected indicator.

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EQUIPMENT REPORTS

continued from page 26

the top of the scope screen for easy reading. Pushbuttons are used for ease of operation. You can read the peak-to-peak voltage of any waveform on the screen and then simply push a button and read the DC level in the circuit (more on that later), or push another button and read the frequency of the displayed signal.

All of the circuitry of the *model SC61*, aside from the manual scope controls, is microprocessor-controlled. That microprocessor monitors the vertical and horizontal circuits at all times; to make any kind of measurement, just push a button and the microprocessor does the rest. It controls the digital readout, and also "lights" one of the 12 display annunciators that tell you what you're reading, and where (which channel). The decimal point is automatically set for all ranges and functions.

Getting back to the scope, the TIME-BASE-FREQ switch controls the horizontal sweep. That switch has 19 calibrated ranges. Those are set up in the usual 1-2-5 sequence and range from 0.1 microsecond to 100 milliseconds; a frequency scale is also provided. That switch is also used to place the unit in the video-preset mode that is used to analyze video signals. In the video-preset mode, pushing one of two buttons will display either two vertical fields or two horizonal lines. The sync here is very steady due to the use of special sync-separators. The horizontal position control positions the trace; pull the knob and the waveform is expanded 10 times. While you could take an analog reading of time or frequency from the sweep-setting and the graticule, if you want to, it is much easier and faster to use the frequency readout for that, and the readings will be much more accurate. The readout is not affected by the setting of the timebase switch; whether you display one cycle, or several, the frequency will be picked off and read out by the microprocessor.

The sweep trigger circuits can be used on either channel, the AC line, or external trigger. A LEVEL control selects triggering on either positive- or negative-going edges of the displayed signal. When analyzing video signals, the peak-to-peak voltage of either horizontal or vertical waveforms can be measured by adjusting the LEVEL control. One thing that can cause problems in horizontal waveforms is the presence of some of the vertical sync; that also can be eliminated by adjusting the LEVEL control. The presence of the vertical sync can confuse the microprocessor, which will throw the peak-to-peak voltage readings off.

The unit has special sync-separator circuitry that helps in eliminating that confusion. That circuitry triggers on the vertical or horizontal pulses present in almost all TV signals. However, the manual mentions that if you're trying to read the output of a stage like the color-bandpass amplifier, where sync pulses are removed by the filtering action of the circuits, you may have instability. To eliminate that problem, simply hook the probe of the other channel to some point that does have sync, such as the video-detector output, etc. Now, trigger the sweep with the pulses from that channel.

Every one of the tests mentioned, as well as others we'll look at later on, can be done by just hooking up a probe and a ground lead. When that is done, just about anything about the circuit can be measured simply by pushing the appropriate buttons. Incidently, while two of the probes supplied look like the standard hook-tipped probes, they are not. They are, instead, 10:1 low-capacitance probes; each has a special "separator" circuit built into it. That circuit lets you read waveforms and DC voltages at the same time! A separate, isolated, DC connector on the probe is plugged into a jack labeled DCV. The DC component is picked off by that separator circuit before the scope input and fed to the microprocessor, which does the rest. Because of that, both the reading displayed on the meter and the trace displayed on the scope are correct.

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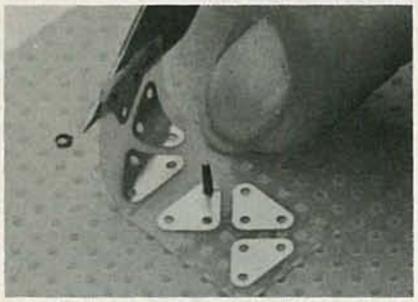

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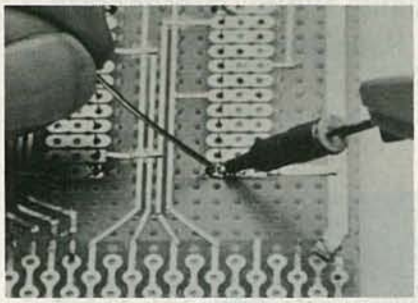

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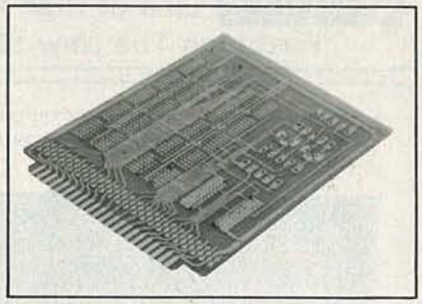

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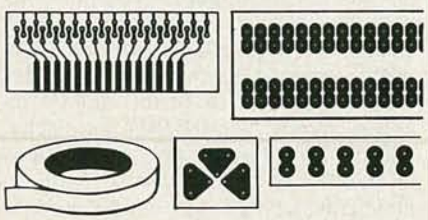

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The scope settings, as we said before, do not affect the meter readings in any way. In addition to the 10:1 low-capacitance probes, the unit is also supplied with a direct-reading DC probe and a 48-inch-long ground lead.

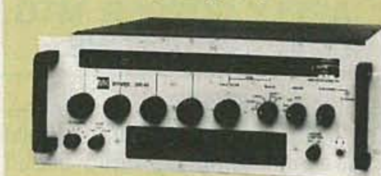
Among the features that sets this unit apart is its special delayed sweep mode that is called the delta-measurement mode. That mode lets you measure the peak-to-peak voltage, frequency, or period of only the section of the waveform that you are interested in. It can be set for any portion of the waveform using the ΔBEGIN and the ΔEND controls. Those controls position the beginning and end of a bright "bar" on the display. The part of the waveform within the span of that bar is the only part that is measured when the scope is in the delta mode. Trigger controls work in the usual manner in that mode.

Among other things, the delta mode is useful for reading the frequency of only one cycle. If you have more than one frequency present, such as with a modulated waveform, you can read any one by isolating that part of the waveform within the delta bar.

To try out the delta mode, we used it to troubleshoot a DC supply in a solid-state television set. That supply's output waveform showed some unusual symptoms, but ones that were obviously caused by feedback. On what should have been a clean DC signal, we found tiny high-frequency "bursts;" the frequency of those bursts turned out to be about 40 kHz, the ringing frequency of the flyback pulse. As the DC supply came from the flyback, that seemed to indicate that the DC supply was not adequately filtered. From that point it was relatively easy to track the problem down to an open filter capacitor in the DC line; that open capacitor was allowing the ringing to get into the signal circuits.

This instrument is a real pleasure to use. All the controls are grouped by function and channnel for maximum efficiency. The built-in digital display eliminates the need for graticule counting, allowing you to analyze a waveform quicker, and more accurately, than ever before. All this sophistication comes at a price, of course, as the *model SC61* lists for $3275.00, including probes. However, if you do a lot of work with a scope, and consider the time and eye strain this instrument will save you, the price is well worth it. **R-E**

McKay/Dymek General Coverage Receiving System



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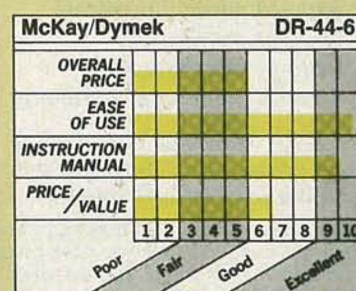

ALTHOUGH A LARGE PERCENTAGE OF McKay/Dymek (Post Office Box 5000, Department B, Claremont, CA 91711) products are for shipboard use on vessels of foreign registry, many items in their catalog are of interest to serious shortwave/longwave listeners as well. One such system consists of the *DR44-6* receiver (shown), the *DP4044* preselector, and the *DS111* audio processing speaker. We'll look at each one of those individually, with the main emphasis on the *DR44-6* receiver.

The *DR44-6* receiver

Designed to fit in a standard 19-inch rack-panel mount, the *model DR44-6* is a

general-coverage frequency-synthesized receiver that displays the received frequency on six large (0.5 inch) LED characters with an accuracy of 100 Hz.

The rear panel features a variety of connectors for increased flexibility in custom installations. Those include a high-impedance audio output with an associated level control, a mute jack, a 50-ohm BNC antenna connector, a low-impedance speaker output and a separate 600-ohm line output (both available from spring-loaded terminals), and an IF output (455 kHz) for a panoramic display or teletype converter.

Receiving modes include AM, SSB, CW, and RTTY. A separate rotary switch allows selection of either 4- or 8-kHz bandwidth filtering of the upper/lower sidebands. Two additional unoccupied positions can accommodate the installation of optional filters by the user.

A noise-limiter circuit provides attenuation of pulse-type interference on any mode except AM. The AGC decay rates (fast or slow) may be selected or defeated entirely.

Frequency is selected through the combined use of 5 rotary controls, each adding or subtracting a frequency interval on the display (10 MHz, 1 MHz, 100 kHz, 5 kHz). The 5th control is variable, providing infinite resolution of the last 5 kHz.

Frequency displacement on upper and lower sidebands is compensated in the readout so that the user will see the actual window frequency (suppressed carrier) without the mental gymnastics frequently necessary with other receivers.

Our lab tests

The *DR44-6* was used with a 135-foot dipole antenna and in conjunction with its companion *DP4044* preselector.

We found little advantage in using the preselector for the vast majority of applications; the preselector would best be used when there is a nearby source of strong RF interference.

Thermal and mechanical stability of the receiver were excellent. Little or no frequency drift was observed during reasonable periods of listening time after initial warmup. Frequency coverage for the *DR44-6* is specified as 50 kHz through 29.7 MHz. Actual reception over that frequency range was confirmed.

RF sensitivity was excellent, certainly equivalent to or greater than that of most competitors.

"Birdies" are spurious signals caused by the frequency synthesizer. They are always present on receivers that use a frequency synthesizer to generate the local oscillator signal. While also present on the *DR44-6,* none was found too loud to detract from the readability of incoming radio signals. Two extremely loud birdies appeared to have been generated by the BFO, and were heard on 10 and 20 MHz; but those two frequencies are occupied by full-carrier WWV, and they disappeared in the AM mode.

Image rejection is specified as 70 dB, and in our lab tests images were certainly no problem. Additional specifications include cross-modulation and intermodulation suppression of 65 dB (referred to 1 microvolt) and RF blocking of 100 dB (also referred to 1 microvolt). A 25-dB 5-kHz audio-notch filter removes any heterodyne interference from adjacent channel broadcasts.

A 2-MHz high-pass filter provides useful suppression of interfering signals from the AM broadcast bands and below when the receiver is being used only for shortwave reception. RF signal attenuation may be used to reduce overload from strong signals.

Two watts of audio output into a 4-ohm load impedance is available at the rear panel as well as a 1-volt RMS line output (5,000-ohms impedance). AC power required is 120 or 240 volts, 50/60 Hz (30 watts).

The internal circuitry is very clean and well laid out, featuring 56 IC's, 31 FET's, 20 transistors, and 66 diodes.

The accompanying instruction manual is well written and comprehensive, presenting descriptions of each portion of the receiver's circuitry, including both component layout and schematic drawings.

continued on page 104

Modular Components... The Soldering Choice is Yours

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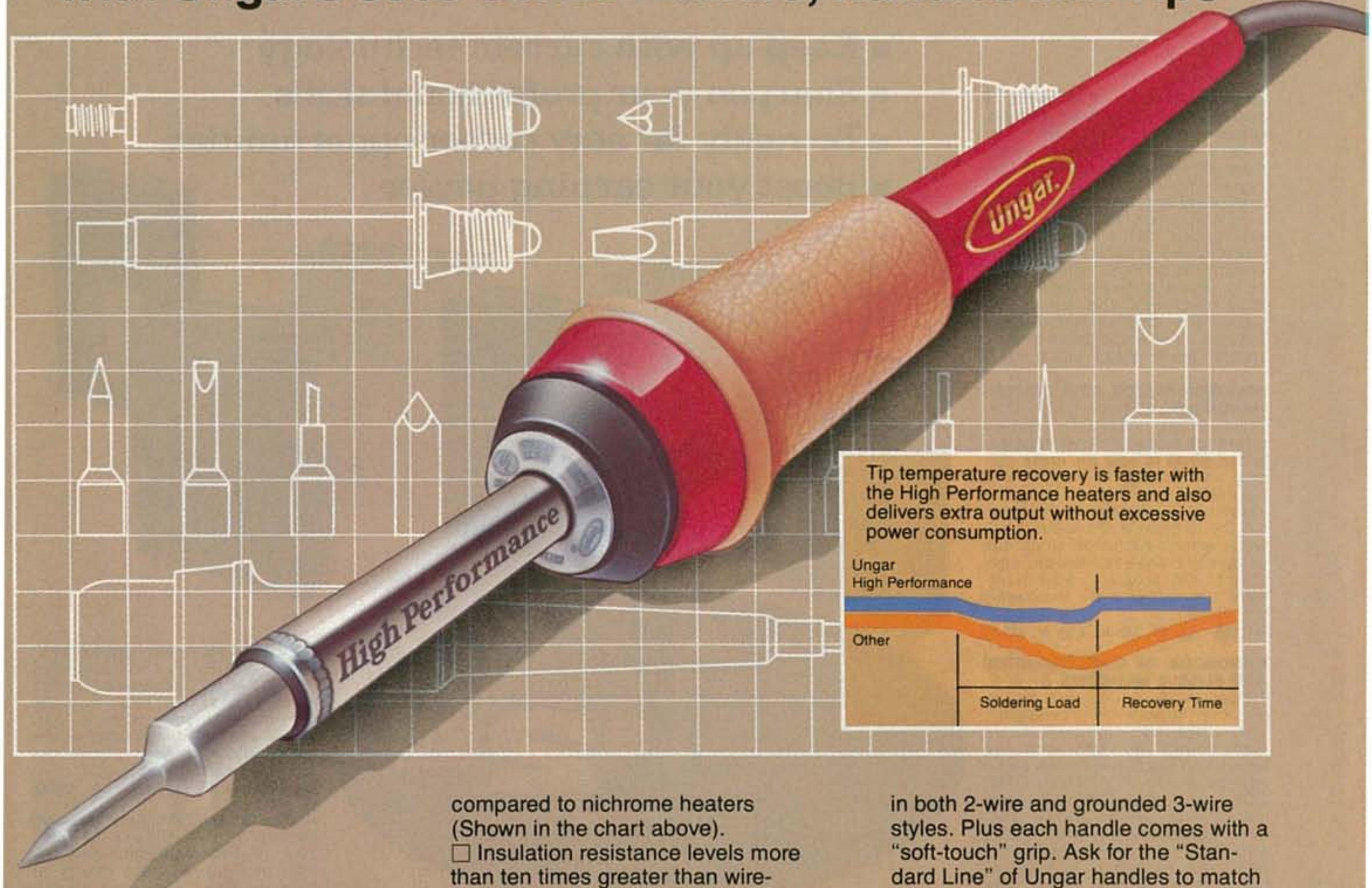

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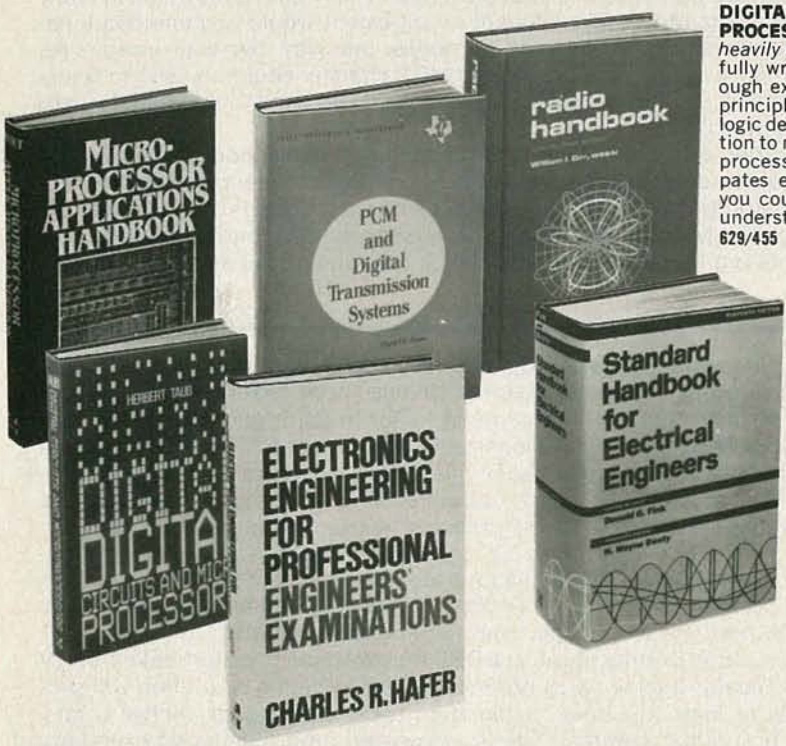

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SATELLITE/TELETEXT NEWS

GARY ARLEN
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WIRELESS CABLE PLAN

Urbanet, a multi-channel microwave hybrid service that can be used for teletext, data transmission, pay-TV, and other entertainment services, is being proposed by Microband Corp. of America, the nation's largest operator of Multipoint Distribution Service (MDS) stations. Microband's proposal for "wireless cable" would create up to 14 video channels in the top 50 U.S. cities. The channels would operate in the 2500 MHz band, and would be first cousins of the MDS pay-TV services now offered in many markets in the 2160 MHz range. The *Urbanet* arrangement would accommodate national and local transmissions in a variety of modes: one-way, two-way, interactive, and asymmetrical. For example, the broadband MDS channel could be used to transmit video programming; an asymmetrical variation could be used to download videogames or for electronic mail.

For services requiring two-way or interactive capability, the telephone will be used in conjunction with value-added data communications networks. By augmenting current software and data-storage capabilities, services can be developed to handle teletext and home banking. The Microband plan comes in response to a long-simmering FCC study about reallocating the 2500 MHz band that is now underused as an educational TV band.

HIGH-DEFINITION TV

High-definition television (HDTV), with 1125-line video resolution, stereo sound, wide-screen pictures, and other enhanced features, seems to be moving ever closer to reality—and satellite distribution will be a major factor in its development. CBS and Japanese-TV network NHK recently demonstrated their latest refinements of HDTV, along with a hint that the service could begin in less than five years on a limited basis. Because of its sizeable spectrum demands—about 30 MHz-per-channel (five times the bandwidth of conventional TV)—HDTV will probably be used for special purposes. Direct-broadcasting satellites (DBS), cable-TV, and home-videocassette/disc distribution are possible, because bandwidth limitations are not a problem as they are on current broadcast-TV systems. However, engineers are now working on bandwidth-compression systems to bring down the spectrum requirements for HDTV.

Satellite service is a high priority because a DBS transmission of a high-definition TV signal would offer theater-quality video projection. The 1125-line resolution will provide picture quality at least five times better than today's TV signal—richer colors, higher resolution, and better contrast. The 3×5 screen ratio (compared to today's 3×4 ratio) provides wide-screen capabilities. HDTV also offers Hollywood studios a new opportunity to produce movies directly as electronic cinema, rather than shoot on film and then transfer to videotape.

TEXT VIA SATELLITE

Text and data services will be transmitted nationwide via subcarriers on National Public Radio's transponders aboard Westar starting late this year. The project is part of public radio's effort to find new financial sources to support its non-commercial audio programming. According to this plan, the national satellite feed will be transmitted in hundreds of communities by local public radio stations, again using subcarriers on their standard broadcast signals. In many cases, the local stations will also insert additional data aimed solely at receivers in their communities.

Data will be transmitted using an SCA (*S*ubsidiary *C*hannel *A*uthorization) that is piggy-backed to an audio circuit. Each signal will carry an identifying code, and customers will be equipped with an addressable receiver to pick up the data. Customers would only be permitted to receive material designated for their specific decoder. Initially, most receiver locations would plug their decoders into hard-copy printers, but the data could also be displayed on a video screen.

A new organization, Information Network Corp. (INC) has been set up by NPR and a Washington-area company called National Information Utilities Corp. that will develop databases and services for the network, including videogames, shopping information, computer information, and business information. INC expects to deliver services almost entirely to business customers. The plan, however, is one of a growing number of projects seeking to piggy-back auxiliary services into the scarce satellite circuits. **R-E**

NEW IDEAS

Electronic Thermometer

HERE IS AN INEXPENSIVE ELECTRONIC thermometer than can be built in just one evening. It is capable of measuring temperatures over a range of from $-30°F$ to $+120°F$.

The circuit is shown in Fig. 1; its operation is fairly straightforward. A diode-connected 2N3904 transistor forms a voltage divider with R1. The transistor is used as the temperature sensor and, for best results, should be connected to the rest of the circuit using twisted wire as shown. As temperature increases, the voltage drop across the transistor changes by approximately -1.166 millivolts-per-°F. As a result, the current at pin 3 of IC1, a 741 op-amp with a gain of 5, decreases as the temperature measured by the sensor increases.

A second 741 op-amp, IC2, is configured as an inverting amplifier. Since pin 3 of that IC is grounded, pin 2 is at a virtual ground and the sum of all currents into that pin must be zero. Resistors R5 and R6 are used to calibrate the circuit. Once R6 is adjusted (more on that later), the current flow through those resistors will be constant. At a temperature of about $-30°F$, the current through R4 (that resistor is formed by connecting a 910- and a 1600-ohm resistor in parallel) should equal the current through R5 and R6.

At higher temperatures, the current through R4 will be less than the current through R5 and R6. Since the sum of the currents at pin 2 of IC2 should be zero, current will be drawn from the output (pin 6) of that IC to offset the difference. That current must pass through M1, and the amount of current drawn is, of course, measured by the meter. As the relationship between the amount of current drawn and the measured temperature is linear, it is relatively easy to calibrate the meter to indicate measured temperature.

If the temperature goes below $-30°F$ a reverse current will be generated. As that reverse current is undesirable, its flow is prevented by inserting D1 into the circuit as shown.

Calibration is also straightforward. When properly done, a temperature of $-30°F$ will result in a meter reading of 0 milliamps, while a temperature of 120°F will result in a meter reading of 1 milliamp. Divide the scale between those points into equal segments and mark the divisions with the appropriate corresponding temperatures. Note that dividing the scale into more parts will result in greater accuracy; if you divide it into 150 equal segments, for instance, each division will equal one degree. The calibration is completed by placing the sensor in an environment with a known temperature, such as an ice-point bath. The ice point of water is approximately 32°F. That is the temperature at which water and ice can co-exist in the same container. To prepare the bath, place water and ice in a large glass beaker or similar container, wait a few minutes for the temperature of the bath to stablize, and verify that the temperature is indeed 32°F using another thermometer that is known to be accurate. Then, simply place the sensor in the bath and adjust R6 until you get the correct meter reading.

—David McNeill **R-E**

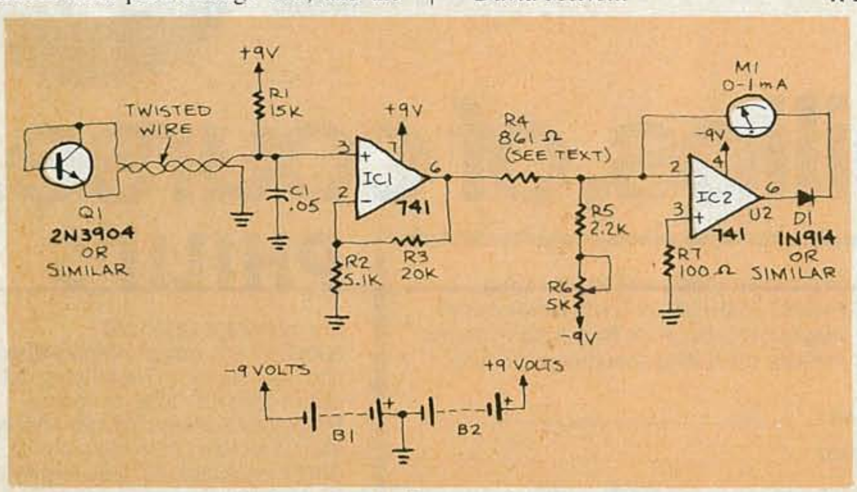

FIG. 1

NEW IDEAS

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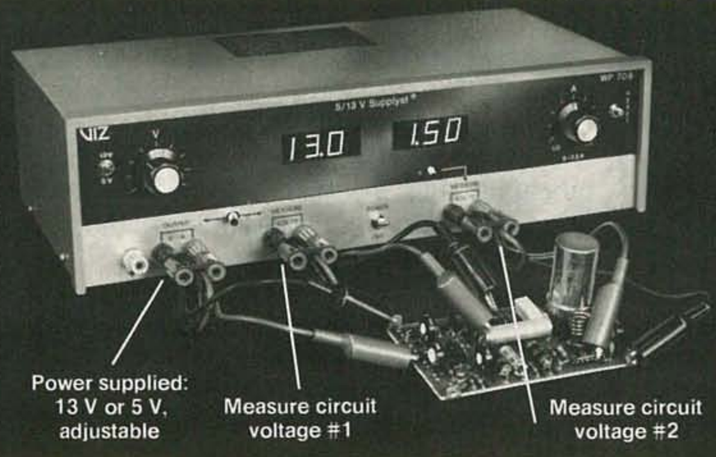

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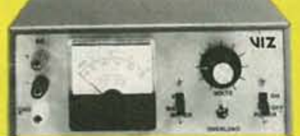

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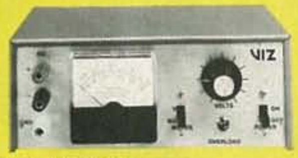

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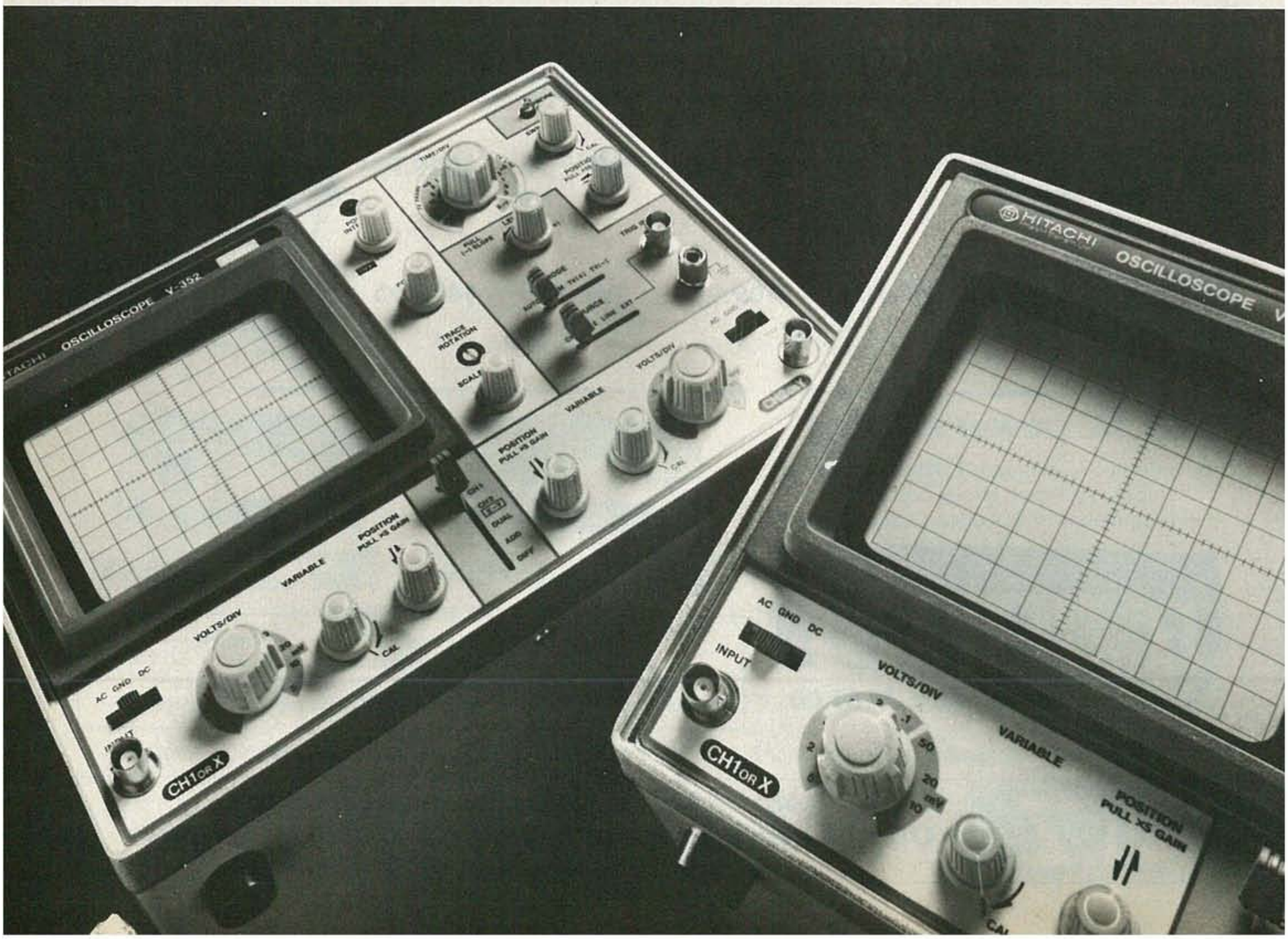
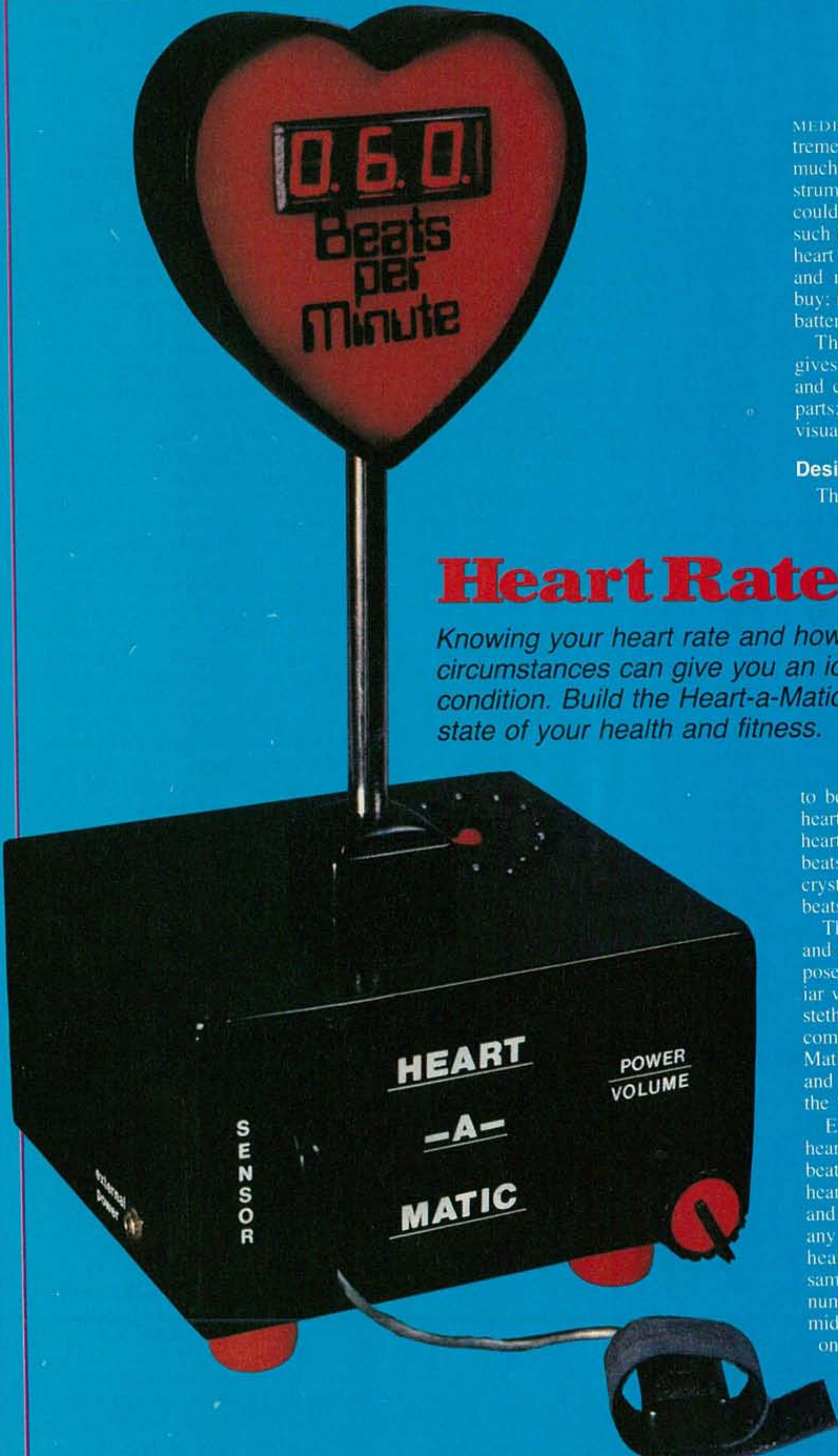




Heart Rate Monitor

Knowing your heart rate and how it varies under different circumstances can give you an idea of your physical condition. Build the Heart-a-Matic and keep track of the state of your health and fitness.

ROBERT GROSSBLATT

MEDICAL TECHNOLOGY HAS GROWN tremendously over the past 20 years. So much so that the consumer now has instruments available to him that at one time could only be found in hospitals. One such instrument, a machine to monitor a heart rate, used to occupy an entire room and required a sizeable endowment to buy; now you can build one that runs on batteries for under a hundred dollars.

The Heart-a-Matic described here gives a digital readout of your heart rate and can be built from readily available parts; it features both an audible and a visual heart-rate indication.

Design considerations

There are two basic problems that have to be overcome in designing a reliable heart-rate monitor. The first is that each heartbeat is actually made up of several beats; the second is that the heart is not crystal-controlled—even a healthy heart beats somewhat irregularly.

The heart is a four-chambered pump and consequently each heartbeat is composed of several parts (everyone is familiar with the "lub-dub" heard through a stethoscope). Figure 1 shows the various components of a heartbeat. The Heart-a-Matic is designed to integrate the "P" and "T" portions of the waveform with the "R" portion.

Even during rest, the rate at which the heart beats varies; irregularity between beats is a natural characteristic of the heart. Several beats have to be sampled and averaged to provide a result that has any useful meaning. The Heart-a-Matic heart-rate monitor uses an eight-beat sample to obtain an average reading. That number of beats was chosen as a good middle ground to minimize irregularity, on the one hand, and to provide reasonable response-time, on the other. Commercially available machines use multi-beat samples and update at the end of each sampling period. The Heart-a-Matic, however, gives a running average. In other words, whenever it adds a new beat to its sample,

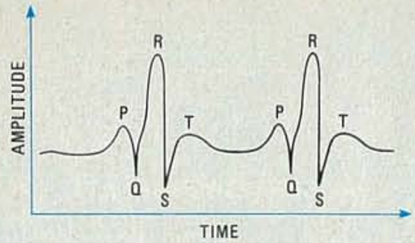


FIG. 1—THE PARTS OF A HEARTBEAT. The Heart-a-Matic integrates the P and T portions with the R portion.

it drops the first beat of the sample. Consequently, it's able to update with each beat and still give a meaningful readout.

How it works

As shown in Fig. 2, the Heart-a-Matic is composed of eight sections. A complete schematic of the device is shown in Fig. 3. The sensor, IC24, is an FPA104 infrared emitter-sensor combination in one housing. The two elements are side by side and there is no direct way for the radiation from the emitter to be seen by the detector, because they are separated by part of the case. The sensor is designed to be placed against a person's finger. The IR (*I*nfra*R*ed) radiation emitted by the LED in IC24 penetrates the outer skin-layer and is reflected back to the detector. As the heart beats, a new volume of blood is pumped into the finger and changes the amount of infrared light reflected back to the photo-transistor. That change in blood density (and, consequently, in reflected IR) is used by the Heart-a-Matic to determine the heart rate.

The input amplifier, composed of Q1 and IC1, has two main jobs. It amplifies the weak signal from the detector, and integrates the several components of the heartbeat into one pulse. The waveform emerging from the output of IC1, however, is far from being a clean single pulse. Even though the peaks and valleys of the heartbeat have been smoothed out, the pulse still has to be conditioned before it can meet the somewhat snobbish square-wave requirements of the digital circuitry that will process it later. That is a problem with *any* system that combines digital and analog techniques. While digital systems require strictly "yes" or "no" answers, the analog world usually provides just "maybes."

The conditioning circuit, consisting of Q2 and IC2, squares the wave presented to it by IC1 and raises its voltage level so it can be reliably detected by IC2, a 555 configured as a monostable multivibrator, or pulse generator. Capacitor C8 and resistor R9 give the output pulse of the 555 a width of about 100 milliseconds. That serves two purposes. First, it insures that the high level of the pulse will be seen as a logic one by the digital circuitry that follows and, second, it helps eliminate the "maybes" of the analog world. Once the 555 is triggered, it ignores all other signals for 100 milliseconds.

Should some signal ambiguity still manage to emerge from the analog portion of the heart-rate monitor, the first part of the digital portion should take care of it. Integrated circuit IC3-a is a Schmitt trigger set up as a half monostable with an output-pulse width of about 20 milliseconds. That signal is one of the two that control the interlock portion of the circuit made up of the three other NAND gates of IC3 and IC5. A set-reset latch formed by IC3-b and IC3-c controls the calculation of the heart rate started by each heartbeat detected.

When a positive pulse appears at the output of IC3-a it causes the output of the latch to go—and remain—high. That output is inverted by IC3-d and presented, through inverter IC22-f, to the clock input of IC21, a 4017 decade counter. Each pulse will make one of that IC's outputs go high in sequence.

We are sure of starting with number one because C18 performs a power-on-reset function. That means that IC21 will start with its first output at a logic-high and will then clock along with incoming heartbeats for eight beats, at which point it will reset back to one. That happens because the ninth output (which, coincidentally, is also pin 9) is also connected to the RESET pin. The outputs of the IC21 are connected in successive pairs to IC20's 2-input NOR gates. As a result, we have repeating sequential logic ones that are used in the section of the heart-rate meter that measures the period and calculates the heart-rate frequency.

Integrated circuit IC23 and its associated components provide an extremely accurate source of 60-Hz square waves that are counted by IC16-IC19, 4040 binary ripple counters. Each of the 4040's is connected to the "D" inputs of a 4508 (IC12-IC15) configured as 3-state eight-bit hold-and-follow latch.

When a heartbeat is detected, one of the outputs of IC20 goes high and causes two things to happen. The first is that its associated 4508 is enabled, and the data present at that moment at its "D" inputs is stored in the latch and presented at its "Q" outputs. The second thing that happens is that an inverter (a section of IC22) set up as a half-monostable outputs a positive pulse, lasting about 70 microseconds, that resets the 4040 to zero. The counter immediately starts counting again; but the latch is now disabled and it ignores the changing data at its inputs. The period of each heartbeat is counted at a 60-Hz rate and appears on the data bus.

Next comes a bit of arithmetic. Since the device knows the period of the heartbeat, it now has to calculate its frequency. Those are reciprocals of each other and the form of the calculation that has to be performed is also simple. Sixty Hz (cycles-per-second) times 60 (seconds-per-minute) equals 3600 cycles-per-minute. The number of beats per minute is therefore the number of cycles per minute divided by the number of cycles per beat. Since we are using a period of eight heartbeats, the magic number becomes 28,800 (8×3600). The division is carried out in two ways. The first way is sneaky and the second is interesting.

The sneaky way is to ignore the two least-significant outputs of the 4040's. By doing that we immediately divide the count by four. That also gives us the advantage of smoothing out any "bobble" in the circuitry by dropping the two least-significant figures, which is where it would show up. All we have to do now is divide by 7200 ($28,800 \div 4$), and the way that is done is one of the most interesting features of the Heart-a-Matic. The secret lies in an often overlooked, frequently misunderstood, and extremely useful type of IC—the rate multiplier.

There are two types of rate multipliers—binary and decimal. The difference between them is much the same as

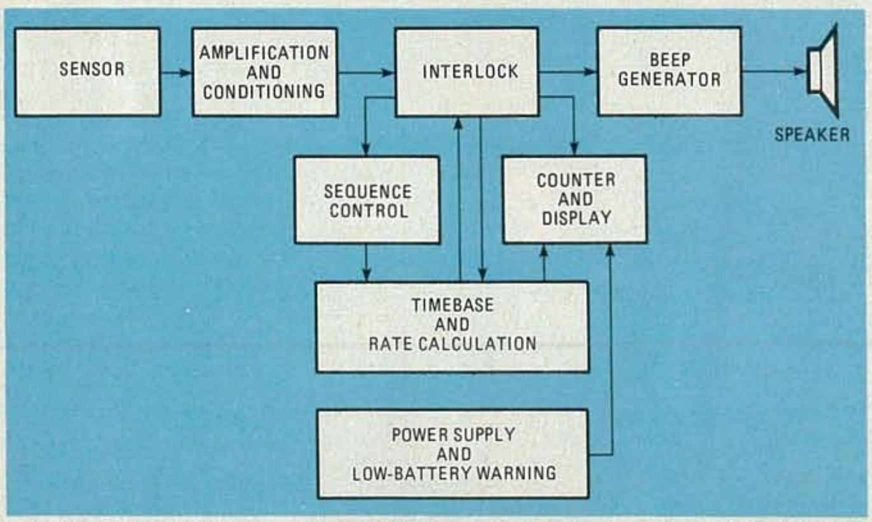


FIG. 2—THE HEART-A-MATIC is made up of eight main sections as shown in this block diagram of the device.

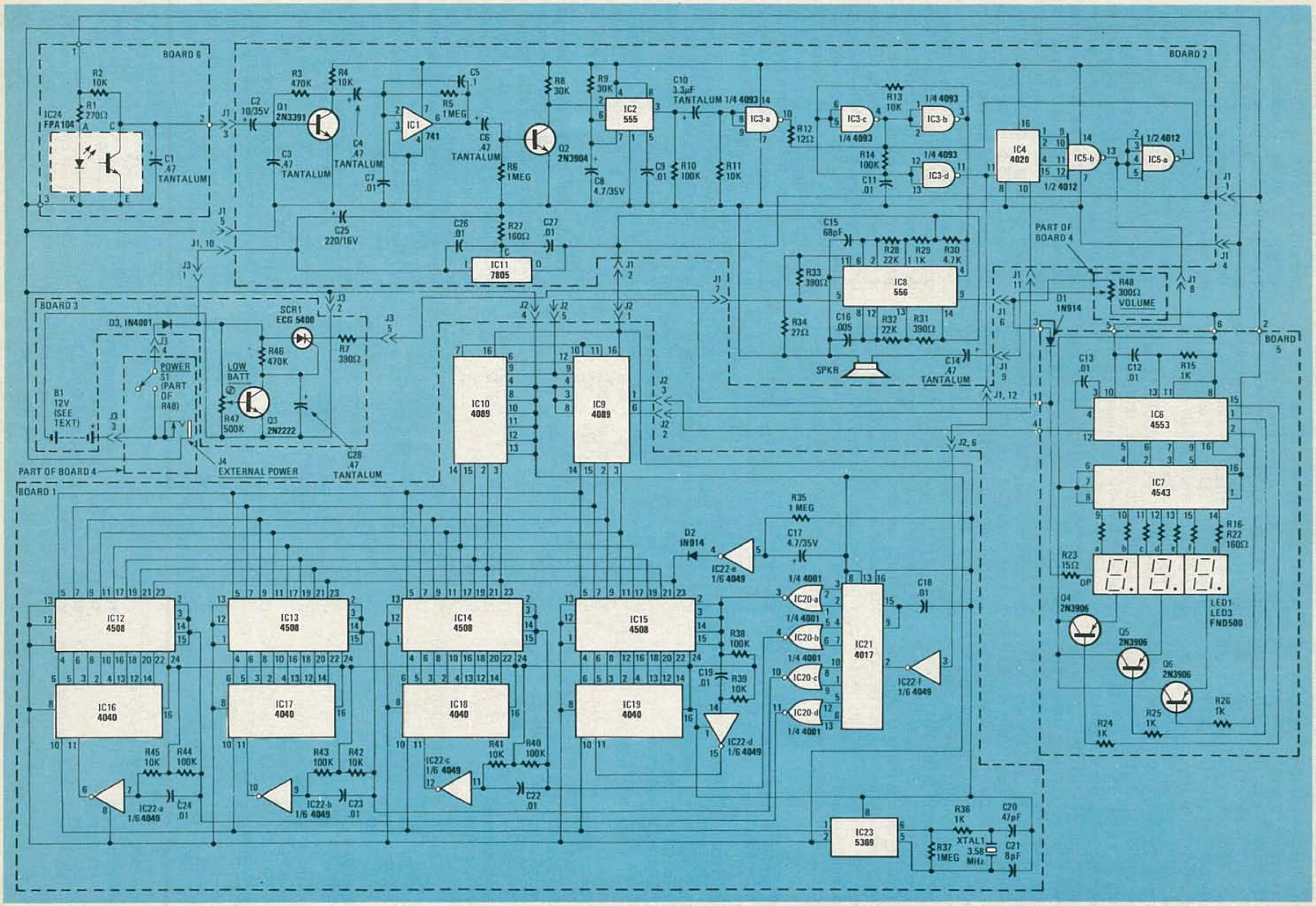


FIG. 3SCHEMATIC DIAGRAM of the Heart-a-Matic. The device is built on six separate PC boards.

the difference between a counter such as the 4520 that counts strictly in binary and its companion, the 4518, that counts in BCD (*B*inary-*C*oded *D*ecimal). Since BCD isn't needed by this part of the Heart-a-Matic, the choice is the 4089, a binary rate-multiplier (IC9 and IC10).

The 4089 has two types of outputs. The first, which we'll discuss shortly, is 1/16 the input frequency; if a 16-kHz signal were applied to the input, the output would be 1 kHz. The second output is "programmable" and is equal to 1/16 the frequency applied to its clock input *multiplied by* whatever number is applied to its binary inputs. For example, if the input frequency is 16 kHz, and a binary four is presented to the binary inputs, the 4089 will output a frequency of 4 kHz. Unfortunately, a rate multiplier will not always do exactly what you expect it to—output a number of pulses that is *always* an *average* of 1/16 the input frequency multiplied by the input number. While the example presented above works out very nicely, the rate multiplier may have to work with a frequency of 17 kHz as well. Since that figure is not evenly divisible by 2 (or multiples of two), the output pulse will be unevenly spaced and of uneven width. Fortunately for the Heart-a-Matic, however, that is unimportant because we are only interested in the number of pulses and not in a particularly smooth waveform. Rate-multipliers IC9 and IC10 are cascaded so they can handle division by an eight-bit number.

Half of IC8, a 556 dual timer, is used as an astable multivibrator, or frequency generator. With the component values indicated, the free-running frequency is about 400 kHz, although the actual figure is not critical. That's because the signal is fed to the cascaded 4089's and all we're interested in is the *ratio* of their base rate to their multiplied rate. The multiplied rate is output at pin 6 of IC9 and routed to the clock input of IC4, a 4020 binary ripple-counter. The base rate, output at pin 1 of IC9, is sent to IC6, a 4553 three-digit binary counter. The outputs of the 4020 that are decoded all go high when the counter reaches a number you should remember from earlier—7200. With all that behind us, we can now explain the device's operation much more simply.

The controlling key is the interlock section of IC3 and IC5, and the heart of the device is the 4089's. When the output of the IC3 latch goes high following a detected heartbeat, one of the octal-latch 4508's puts a number on the data bus. At the same time, two other things happen. A high is applied to pin 4 of the 400-kHz frequency generator, setting it in operation, and a low is applied to the RESET pin of IC4, the 4020 counter, enabling it. The rate multipliers begin outputting pulses to the 4020 at the rate of 1/16 the 556's frequency multiplied by the number on the data bus, and sending the base-rate frequency to IC6, the three-digit counter. When the count at the 4020 reaches 7200, the output of IC5-b, a four-input NAND gate, goes low and transfers the count present at IC6 into its internal latch.

The same signal also travels to the RESET pin, pin 13, of IC6 via C12 and clears the counter to zero in preparation for the next count. The output of IC5-b is inverted by IC5-a and returns to the latch formed by IC3-a and IC3-b, causing its output to go low. That disables the 400-kHz frequency generator, causes the 4020, via inverter IC3-d, to reset to zero and hold there for the next heart-rate calculation, and returns the clock input of the 4017 decade counter to a low state until the next heartbeat.

The sequence of events resembles those of the classic "do-nothing box." The Heart-a-Matic gets turned on, does its thing, and then turns itself off. In this case, however, the device performs a complex series of operations and then waits for the next incoming signal to retrigger it.

The other half of IC8 is also configured as a frequency generator and is frequency-modulated by the output of the 400-kHz generator. The result is a tone of about 1 kHz, that lasts as long as the other oscillator is running. That tone is fed to the speaker via volume-control R48. An unusual side-effect of that is that the duration of the beep changes with the heart rate. The reason is that the lower the heart rate, the less time it takes to do the internal arithmetic and the less time the 400-kHz oscillator operates and enables the beep generator. The beep generator also supplies power to the decimal points of the displays for a visual as well as audible indication of the heartbeat.

The counter section, IC6 and IC7, is fairly straightforward. The latter is a decoder that feeds the three multiplexed common-cathode displays. The actual multiplexing is done by an internal oscillator in IC6 whose frequency is determined by the capacitor connected between pins 3 and 4. Resistor R15 holds the RESET pin of IC6 low until it receives a positive reset-pulse from IC5-b via C12.

Inverter IC22-e is present because of a basic law of mathematics that says that

continued on page 109

PARTS LIST

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

R1—270 ohms
R2, R4, R11, R13, R39, R41, R43, R45—10,000 ohms
R3, R46—470,000 ohms
R5, R6, R35—1 megohm
R7, R31, R33—390 ohms
R8, R9—30,000 ohms
R10, R14, R38, R40, R42, R44—100,000 ohms
R12—12 ohms
R15, R24-R26, R29, R36—1000 ohms
R16-R22, R27—160 ohms
R16-R22, R27—160 ohms
R23—15 ohms
R28, R32—22,000 ohms
R30—4700 ohms
R34—27 ohms
R37—10 megohms
R47—500,000 ohms, multiturn potentiometer, PC-mount
R48—300 ohms, potentiometer, panel-mount with switch (commonly used in TV receivers)

Capacitors

C1, C3, C4, C6, C14, C28—0.47 µF, 35 volts, tantalum
C2—10 µF, 35 volts, electrolytic
C5—0.1 µF, ceramic disc
C7, C9, C11-C13, C18, C19, C22-C24, C26, C27—0.01 µF, ceramic disc
C8, C17—4.7 µF, 35 volts, electrolytic
C10—3.3 µF, 35 volts, tantalum
C15—68 pF, ceramic disc
C16—.005 µF, ceramic disc
C20—47 pF, ceramic disc
C21—8 pF, ceramic disc
C25—2200 µF, 16 volts, electrolytic

Semiconductors

IC1—741 op-amp
IC2—555 timer
IC3—4093 quad 2-input NAND Schmitt trigger
IC4—4020 14-stage binary ripple counter
IC5—4012 dual 4-input NAND gate
IC6—4553 3-digit binary counter
IC7—4543 BCD-to-7-segment latch/decoder/driver
IC8—556 dual timer
IC9, IC10—4089 binary rate multiplier
IC11—7805 5-volt regulator
IC12-IC15—4508 dual 3-state 4-bit latch
IC16-IC19—4040 12-stage binary ripple counter
IC20—4001 quad 2-input NOR gate
IC21—4017 decade counter
IC22—4049 hex inverter
IC23—5369 60-Hz timebase
IC24—FPA104 infra-red emitter/sensor array
Q1—2N3391
Q2—2N3904
Q3—2N2222
Q4-Q6—2N3906
SCR1—ECG 5400
LED1-LED3—FND500 0.5-inch common-cathode 7-segment display
D1, D2—1N914 or 1N4148
D3—1N4001
XTAL1—3.579545 MHz color-burst reference crystal
SPKR—8 ohms, 2-inch diameter
S1—SPST switch (part of R48)
J1—12-contact edge connector
J2, J36-contact edge connector
J4—subminiature N.C., chassis-mount
B1-B8—1.5-volt "AA" cell

Miscellaneous: PC boards, two "AA" side-by-side battery holders, Velcro strip, plastic for cases, wire, shielded cable, solder, etc.

The following are available from Hal-Tronix, P.O. Box 1101, Southgate, MI 48195: Set of six etched and drilled PC boards, $29.95; Board 1 (double-sided), $19.95. Add $2.00 for shipping & handling; MI residents add 4% tax.

Picture Phone

Before you build your Picture Phone, you should know how the device works. We'll conclude our discussion of that topic in this part.

JOSEF BERNARD,
TECHNICAL EDITOR

Part 2 THE FIRST PART OF THIS article discussed the theory of operation of a good portion of the main board of the Picture Phone. We'll now complete that discussion; it will be helpful if you have Part 1 handy.

Fast-scan counters

The fast-scan counters are IC6, IC8, IC23 and IC39. Each IC is a four-stage binary counter that is cleared to all zeroes when pin 1 is taken to a logic-low state. When pin 9 is low, the counter stages are preset to the value hard-wired at pins 3-6. Pin 2 receives the clock pulses, and responds to their positive-going edges. Both clear and load operations are synchronous—that is, they take place only on the positive-going edge of the clock pulse. When the LOAD or CLEAR pin is taken low, the counter stops and retains its value. If a clock pulse occurs while the appropriate pin is low, the counter will load or clear.

The fast-scan dot counters are IC6 and IC8 (dots are the pixels along a line of video). The dot counter is analogous to the horizontal sweep in the camera and display. The dot counters have two modes, one for the camera and one for all other operations.

Let's consider non-camera operation first. The crystal oscillator supplies clock pulses to pin 2 of the dot counters. Note that pin 15 of IC6 is connected to pin 10 of IC8. That is the "carry" from the first IC to the second, and provides synchronous operation of both IC's.

Figure 5 shows the timing of the dot counters. The counter CLEAR pulse is provided by IC10 at a count of 215. That means that the counter advances to 215, is reset to zero, and begins to count again. The internal horizontal-sync pulse (IFH) is produced by counter inputs applied to IC42. The clock frequency, divided by 216 (the count from zero to 215), generates the correct horizontal-sync frequency.

Signal "J," which is low between the counts of zero and 127, serves several purposes. It is delayed by one clock pulse to form IFHB, the internal fast-scan blanking signal, which blanks the display in all modes. That signal is also applied to IC28 to control when data can be written to memory. Memory-write takes place, and the display is unblanked, when the counter is between zero and 127.

Now let's look at the operation of the dot counter in the "snatch" and camera-display modes. The clocking signal is derived from the synchronous oscillator; and IC10, which supplies the CLEAR pulse, is disabled. The counter advances until a horizontal-sync pulse from the camera (EFH) takes the LOAD pin low. The counter is preset to a value of 217, as determined by the fixed inputs to pins 3-6 of IC6 and IC8. The counter resumes counting at a preset value of 217 when EFH is no longer present. When it reaches its maximum count of 255, it resets to zero and starts counting again. The time spent counting from 217 to 255 represents blanking of the left-hand edge of the picture; the time between 128 and EFH is used for right-hand blanking.

The LOAD pin is controlled by an RS flip-flop made from IC15-c and IC15-d. That flip-flop insures that the LOAD pin remains low until a clock pulse to load the counter has arrived.

The EFH signal is applied to the CLEAR pin of IC32 to insure that the clock always starts with the same polarity.

The fast-scan *line* counters are IC23 and IC39. Let's first look at how they work during the non-camera mode. Dot-counter signal "J" is used as the clock pulse, making the line counter advance one step for each line. Nine count-stages are needed; the extra stage is supplied by IC32 and is the least significant bit.

Figure 6 shows that the counter advances to a count of 262, is cleared, and starts again at zero. The clear pulse is supplied by IC47, which is hard-wired with the eight most-significant bits of the line counter. The CLEAR pin is held inactive when the camera is in use by connecting it to the logic-1 present at pin 10 of IC48.

The internal fast-scan vertical sync (IFV) comes from IC31.

When the camera display is viewed, the CLEAR function is disabled and the line counter is preset whenever a vertical-sync pulse occurs. When the counter is preset and the sync pulse from the camera is completed, the counter starts counting. When the count reaches 511, the next count, zero, allows display and writing to memory to begin. The time that is spent in counting from the preset value to zero is used to allow the camera's blanking-function to be completed.

The line counter advances two counts for each slow-scan line to allow each line to be displayed twice for an easier-to-view picture. There are 128 slow-scan lines, which means that 256 lines-per-field (or 512 lines-per-frame) will be displayed. Since NTSC standards call for 525 lines per frame, a small portion of the picture at the top and bottom is blanked.

Slow-scan clocks

There are two slow-scan clocks. One is derived from the master crystal oscillator and is used for all functions except slow-scan reception. The second clock is free-running, and is synchronized to the slow-scan horizontal-sync pulses. The clocks are selected by IC13, a 4PDT multiplexer.

PARTS LIST

All resistors ¼-watt, 5% unless otherwise noted

R1-R3, R43, R78, R139, R202—22,000 ohms
R4, R201—10 megohms
R5, R6, R8, R9, R50, R80—15,000 ohms
R7—620 ohms
R10, R12, R15, R54, R93-R95, R102, R110, R209, R211, R714-R716—4700 ohms
R11, R13, R14, R16-R18, R86, R99—10,000 ohms, 1%
R19, R20, R27, R147—39,000 ohms
R21—20,000 ohms
R22, R23—18,000 ohms
R24—8200 ohms
R25, R26, R145, R146—82,000 ohms
R28, R42, R51, R136, R140, R142, R204, R205, R710, R711—10,000 ohms
R29—470,000 ohms
R30, R47-R49, R53—2200 ohms
R31, R79, R148—100,000 ohms
R32, R108—2700 ohms
R33—150,000 ohms
R34, R40, R52, R96, R109, R137, R144, R704, R717—1000 ohms
R35-R39—not used
R41—680,000 ohms
R44—47,000 ohms
R46—33,000 ohms
R55, R76, R112, R707—100 ohms
R56—100 ohms, trimmer potentiometer
R57—3300 ohms
R58, R77, R111—330 ohms
R59, R703, R712, R713—470 ohms
R60—100 ohms, 1%
R61-R75—26.1 ohms, 1%
R81-R84—not used
R85, R98—20,000 ohms, 1%
R87, R100—4990 ohms, 1%
R88, R101—2490 ohms, 1%
R89-R91—not used
R92, R200—680 ohms
R97—47 ohms
R103—820 ohms
R104—2000 ohms, trimmer potentiometer
R105—1200 ohms
R106, R107, R138, R141, R143, R203—1000 ohms, trimmer potentiometer
F113-R116, R125-R135—33 ohms
R117-R123—not used
R144—68,000 ohms
R149-R199—not used
R206, R207—220 ohms
R210—560 ohms
R212, R213—33.2 ohms, 1%
R314, R315, R317, R318—0.33 ohms, 2 watts
R316—220 ohms, 2 watts
R601—130 ohms, 2 watts
R701—1000 ohms, panel-mount potentiometer
R702—10,000 ohms, panel-mount potentiometer
R706—1 megohm
R708, R709—1800 ohms, 1 watt

All capacitors Mylar or mica unless otherwise specified

C1-C6—.022μF
C7, C24, C25, C38, C200, C240-C243—.01 μF ceramic disc
C8, C10, C12, C17—.0047 μF
C9—.0068 μF
C11, C207—.018 μF
C13, C15, C18, C19, C23, C263-C266—22 μF, tantalum
C14—10 μF, tantalum
C16, C22, C206, C703—.001 μF, monolithic or ceramic disc
C20, C201—27 pF, monolithic or ceramic disc
C21, C28-C31—470 pF
C26—not used
C27—33 pF, monolithic or ceramic disc
C32, C220-C227—0.1 μF, ceramic disc
C33, C41, C208, C317-C320—2.2 μF, tantalum
C34, C230-C237, C250-C262, C702—0.1 μF, ceramic disc
C35, C202-C205—100 pF
C37, C39—not used
C40—.047 μF
C309—500 μF, 12 volts, electrolytic
C310—9200 μF, 15 volts, electrolytic
C311—450 μF, 25 volts, electrolytic
C312—5800 μF, 25 volts, electrolytic
C601—500 μF, 25 volts, electrolytic
C701—2 μF, tantalum

Semiconductors

IC1-IC4, IC17-IC20, IC33-IC36, IC49-IC52—μPD411 (MM5280) 4K × 1 dynamic RAM
IC5, IC13, IC21, IC37, IC46, IC48, IC55—74LS157 quad 2-1 multiplexer
IC6, IC8, IC9, IC23, IC24, IC39-IC41—74LS163 presettable binary counter W/ clear
IC7, IC26, IC57, IC58, IC61—75LS04 hex inverter
IC10, IC31, IC47—74LS30 8-input NAND gate
IC11, IC32—74LS107 dual JK negative-edge-trigger flip-flop
IC12—4046 CMOS phase-locked loop
IC14, IC15, IC45—74LS00 quad 2-input NAND gate
IC16, IC29, IC65—74LS74 dual D flip-flop
IC22, IC38, IC71, IC72—74LS153 dual 4-input multiplexer
IC25, IC42, IC88—74LS20 dual 4-input NAND gate
IC27, IC67, IC68—74LS10 triple 3-unit NAND gate
IC28, IC43, IC66—74LS25 dual 4-input NOR gate
IC30—74LS221 dual one-shot
IC44, IC62—74LS32 quad 2-input positive OR gate
IC54, IC56—74LS175 quad D flip-flop
IC59—74LS08 quad 2-input AND gate
IC60, IC63, IC64—74LS13 dual Schmitt trigger
IC66—3245 quad TTL-to-NMOS memory driver
IC69, IC70—74LS02 quad 2-input NOR gate
IC73-IC80—LM711 dual difference-comparator
IC81-IC84—not used
IC85, IC86—74LS86 quad EXCLUSIVE-OR gate
IC87—4066 CMOS quad bilateral switch
IC89—566 function generator
IC90-IC94, IC105—1458 dual 741 op-amp
IC95-IC104—not used
Q1, Q2, Q4, Q5, Q8-Q13—2N4124 or equivalent
Q3, Q6—not used
Q7—2N4126 or equivalent
LED1-LED3—jumbo red LED
D1-D11, D13-D18, D27-D33—1N914 or 1N4148
D12—not used
D19-D26, D601, D602—1N4007
DT601—gas discharge tube (Joslyn Electronics type 2022-44 or equivalent)
CB1—0.6-amp circuit breaker
T1—dual-secondary type: 1st secondary: 25VCT, 1 amp; 2nd secondary: 12.6VCT, 1.5 amps (see text and below)
T601—phone-line matching transformer (Microtran type 6112 or equivalent)
S1—4P5T rotary switch
S2-S4—N.O. momentary pushbutton switch
S5—SPDT toggle switch
S6—SPST toggle switch
J1-J2—not used
J3—36/72-pin PC-board edge connector (36 contacts for *each side* of board, two contacts per pin)
J4—socket for modular telephone connector, panel-mount
J5—DB25-S 25-pin female "date-type" socket, panel-mount
J6, J7—RCA-type phone jack, panel-mount
J8, J9—female coaxial connector, panel-mount (BNC- or SO230-type)
TB601—miniature 8-terminal barrier strip, PC-mount
RY601, RY602—4P2T 12-volts, PC-mount (Potter & Brumfield T10-E2-Z4-12VDC or equivalent)

Miscellaneous: PC boards, perforated construction board, IC sockets, RG59 cable, shielded audio cable, 4-conductor telephone cable w/modular plug, 3-conductor line cord w/plug, enclosure, hardware, etc.

The following are available from Robot Research Inc., 7591 Convoy Court, San Diego, CA 92111, (714) 279-9430: Assembled & tested Model 535 Picture Phone, FCC registered for direct connection to telephone line (KIT-1) (14 lbs.), $1195.00; assembled and tested No. 400929C main PC board (KIT-2) (4 lbs.), $495.00; assembled and tested Picture Phone chassis, including telephone adaptor board, but *less main board,* (KIT-3) (12 lbs.), $695.00; kit of No. 400929C main PC board with all main-board parts (KIT-4) (5 lbs.), $295.00; kit including chassis and chassis parts, and telephone adaptor board and parts, but *less main board,* (KIT-5) (12 lbs.), $445.00; telephone adaptor board kit including board and parts (KIT-6) (3 lbs.), $79.50; etched, drilled, and plated-through main board (KIT-7) (3 lbs.), $59.00; etched, drilled, and plated-through telephone adaptor board (KIT-8) (2 lbs.), $19.95; T1 (KIT-9) (4 lbs.), $29.50; T601 (KIT-10) (2 lbs.), $24.50; DT1 (KIT-11) (1 lb.), $8.50; kit of 32 1% resistors for main board (KIT-12) (1 lb.), $12.00; individual 1% resistor (KIT-13) (1 lb.), $0.35; Model 535 Picture Phone enclosure kit with mounting rails for main board and back plate for controls (KIT-14) (6 lbs.), $99.50; kit of *front panel parts only,* (KIT-15) (2 lbs.), $59.50; assembled & tested RF modulator, less power supply and enclosure (KIT-16) (1 lb.), $29.00; RF-modulator kit, less power supply and enclosure (KIT-17) (1 lb.), $19.50. For information on other parts, write to Robot Research.

CA residents please add 6% sales tax. All prices F.O.B. San Diego—check with UPS for shipping charges; please add $0.50 per $100.00 of value above first $100.00 for insurance. MC and Visa accepted.

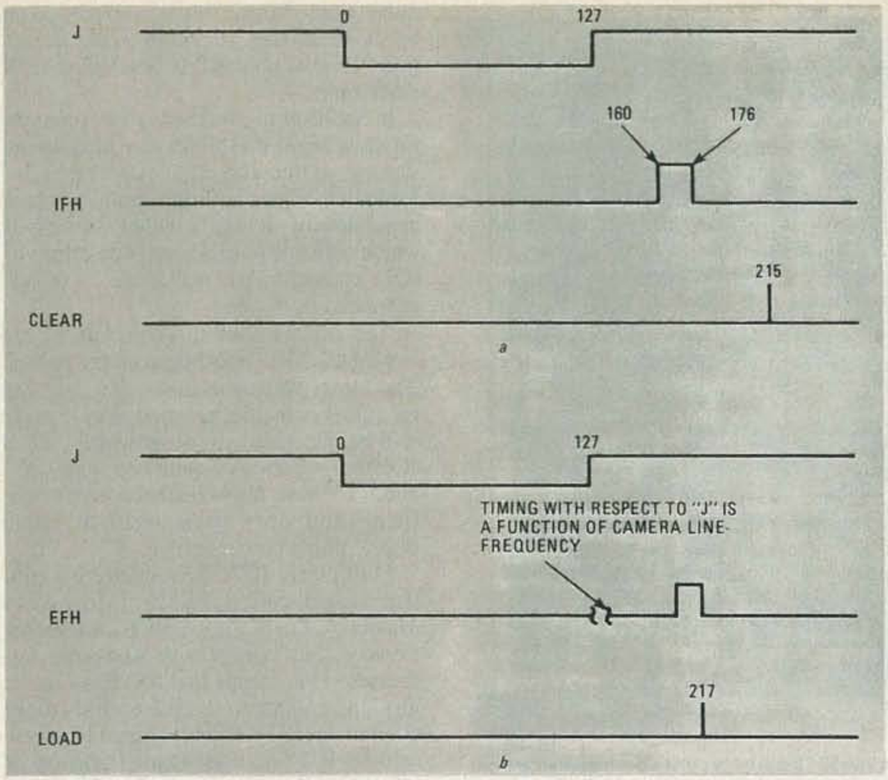


FIG. 5—FAST-SCAN dot counter has two modes—*a* is used for memory display, *b* for frame grabbing and camera display.

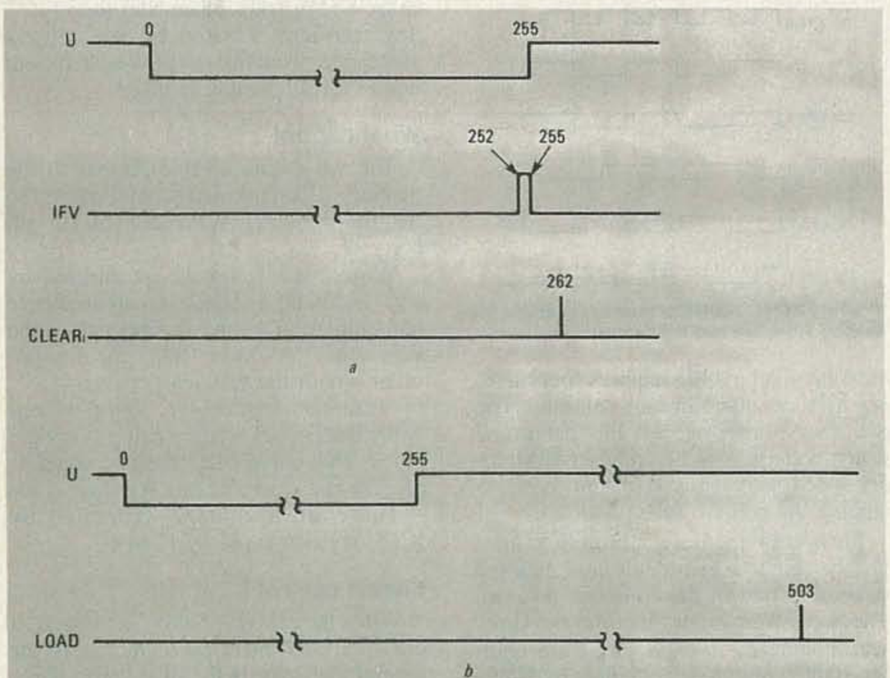


FIG. 6—FAST-SCAN line counter timing for memory display (*a*), and camera display (*b*).

The crystal-derived clock pulses begin with the 60-Hz "U" output of the fast-scan counter. It is divided by four by IC11. The resulting 15-Hz pulse train is applied to one input of PLL (*P*hase-*L*ocked *L*oop) IC12. The other input to that IC is the clock oscillator's output divided by 139, making the output of the PLL 15 × 139, or 2085 Hz. That becomes the slow-scan clock. It allows for 128 pixels and 11 sync counts per slow-scan line.

The synchronized clock pulses are generated by IC60. Its free-running frequency is controlled by R143. As the frequency is increased, the counter takes less time to address 128 memory "cells" and a shorter line is displayed. The clock is synchronized with the incoming signal by having the incoming slow-scan sync pulses cause the oscillator to stop and restart in phase with them.

The slow-scan clock is aligned with the fast-scan system by retiming the leading and training edges of the clock pulses with a section of IC16. A control signal,

CAUTION:
FCC regulations prohibit the connection of this device to telephone lines without the use of an approved coupling device. The *only* exception to this is the assembled and tested unit available from the suppliers indicated in the Parts List. A coupler that meets FCC requirements will be described in the next part of this article. *Do not attempt to connect the Picture Phone you build without it—it's illegal to do so.*

"Z," controls all the slow-scan functions. It is in operation only for the duration of the slow-scan memory-write cycle. Its use for retiming the slow-scan insures that the clock will not change during a slow-scan read or write memory access.

Slow-scan counters

The slow-scan counter is made up of IC9, IC24, IC40 and IC41. They function the same way as their counterparts in the fast-scan circuit.

The slow-scan dot counter uses IC9 and IC24. It has two modes of operation—one to write slow scan to memory, and one to read it. Let's look at the read-mode first. The clock signal is derived from the crystal oscillator. The CLEAR signal is derived from IC25; the LOAD function is inactive. The counter is cleared at a count of 139 to provide 128 memory "cells" per line and 11 sync counts.

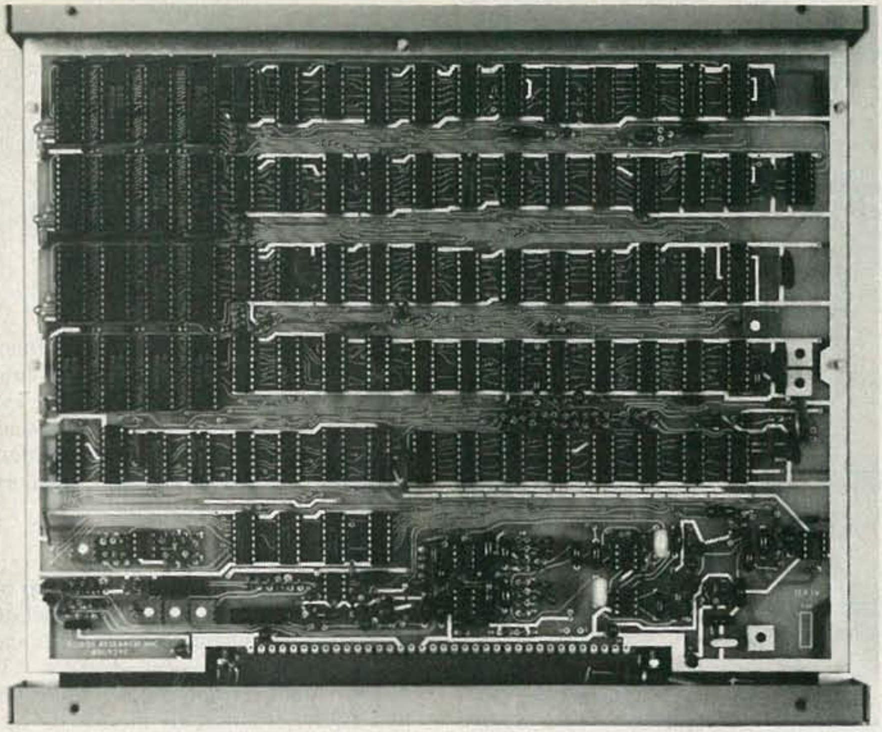
When slow scan information is to be written to memory, the free-running clock is used. The CLEAR signal is derived from a flip-flop formed from IC14-a and IC14-b. The flip-flop is set by an incoming sync pulse, and reset by a clock pulse. That is done to make sure that a clock pulse to clear the counter occurs while the CLEAR pin is low. The slow-scan sync pulse is allowed to reset the counter only after 128 counts (the end of a line) to insure noise immunity. In other words, false pulses can't interrupt a line as it is being written.

The line counter uses IC40 and IC41. A clock pulse occurs when each slow-scan line has been completed. The counter is reset to zero in the "read" mode at a count of 127 by the "U" signal. In the "write" mode it is cleared by the external vertical-sync signal applied to an RS flip-flop made from IC14-c and IC14-d. The flip-flop is reset by IC43 and IC45-a.

When a picture is grabbed from the camera, the line counter is set to all ones, and on the next clock pulse to all zeroes. That one-line time generates a slow-scan vertical-sync pulse.

Address selector

The memory address-lines are driven by the fast-scan counter to generate a video signal for fast-scan display, and also by the slow-scan counter to generate a slow-scan signal. The memory address-



COMPLETED MAIN BOARD of the Picture Phone plugs into 36/72-pin edge connector mounted at front of enclosure.

lines are connected to the appropriate counter by an address multiplexer made up of IC5, IC21 and IC37—4PDT switches, each of which switches four address lines. Resistors on the leads to the memory IC's damp reflections so that the address voltages will not ring.

The address lines are in the "slow scan" mode during time "Z," which takes place for 16 dots following the right-hand edge of the fast-scan picture. In other words, slow-scan memory access takes place just after fast-scan access for the current line is completed. When "Z" becomes active, the address multiplexer switches to slow scan, and the slow-scan counter is inhibited from changing state. The "Z" signal is generated by IC25-b.

Fast-scan memory multiplex

To obtain the speed required for fast-scan operation, memory operation is multiplexed. The multiplexing is done with the memory CE (*C*hip *E*nable) pulse. Figure 7 shows the CE pattern. Note that successive memory columns are overlapped by 50%.

The CE signal is formed by a delay flip-flop, IC65, that uses "B" as data and "A" (delayed) as a clock signal. Signal "A" is delayed by an RC circuit that feeds Schmitt trigger IC60. The delay is provided to insure that memory address-lines are stable before CE goes high.

The CE signal is a zero-to-+12-volt pulse translated from 5-volts by IC66.

Slow-scan memory multiplex

Memory multiplexing is performed by the two lowest-order bits on the memory address-lines. In other words, each bit of

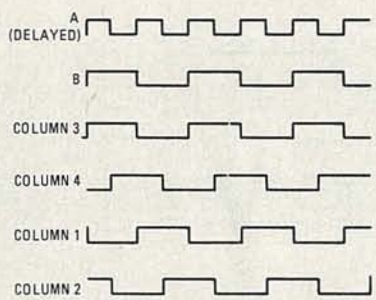


FIG. 7—EACH COLUMN of memory overlaps the next by 50%. See text for details.

the 4-bit pixel nybble requires four memory IC's, arranged in four columns. The two lowest-order address bits determine which column is to be addressed. Memory-speed increase is achieved by overlapping the column-select address.

Slow-scan memory addressing must also be able to select the desired memory column as part of the complete address. The two lowest-order bits from the slow-scan counter, "a" and "b," are combined into column-select pulses by IC69.

Each of the 16 memory IC's has a CS (*C*hip *S*elect) pin that is used for slow-scan memory column selections. The CS

REAR PANEL of Picture Phone. Circuit-breaker reset is located above line cord at left.

pulses come from IC69 and are passed on by IC70 during the slow-scan access time. That IC holds all IC's selected at all other times.

In addition to addressing the memory for slow scan, it is necessary to time the storage of the incoming slow-scan information. The required timing signal is generated by IC71, a DP4T switch of which only one pole is used. The inputs of IC71 consist of the slow-scan CS pulses generated by IC69.

The signals used to control IC71 are "X" and "Y," the fast-scan CS pulses. Therefore, when the slow- and fast-scan CS pulses coincide, a "read store" pulse will be generated. In other words, when IC69 has selected column one, and "X" and "Y" have also selected column one, then—and only then—will a "read store" pulse be generated.

Multiplexer IC71 is enabled by a control signal called SSME (*S*low-*S*can *M*emeory *E*nable), which is active for exactly four consecutive fast-scan addresses. That means that SSME is active just long enough to sample each memory column once. The SSME signal is generated by IC27-b. It is a small portion of "Z," which is the time for slow-scan address to be applied to the memory. Since SSME takes place later than "Z," any transients created by the address switchover from fast- to slow-scan die out before a read sample is taken.

Write control

The WE (*W*rite *E*nable) signal to the memory IC's must also be multiplexed so that the write and CE inputs to an IC will coincide.

Write-control signals are formed by IC67 and IC68-b. Those signals are active one column at a time in response to the values of "A" and "B," the lowest-order bits of the fast-scan counter.

A common control-line to the WE encoder determines when writing is to take place. That control line has two sourses, one for fast scan and one for slow scan.

The control signals, generated by IC28, are combined by IC44-b.

Snatch control

When the SNATCH button is pressed, a one-shot puts out a pulse that lasts for several fast-scan fields. The pulse is retimed by a section of delay flip-flop IC29 so that the useful SNATCH command starts and ends at the bottom of a TV picture. That prevents any errors that might result from the SNATCH pulse ending in the middle of a picture. Another section of IC29 retimes display selection so that the changeover between display memory and the camera takes place when the picture is blanked.

In the next part of this article we'll discuss the telephone interface and power-supply circuits. We will also begin to look at the construction and alignment of the device. **R-E**

The INS and OUTS of BUYING MAILORDER COMPONENTS

Often, the hardest task in building a project is obtaining the various parts that you need. Keeping a well-stocked junk box can save you a considerable amount of time, effort, and money!

KARL T. THURBER, JR., W8FX

ONE OF THE MOST REWARDING WAYS TO GAIN EXPERIENCE IN ELECTRONICS IS to build electronics projects. Besides the satisfaction of accomplishment, you learn a great deal in the process involved.

Today, it isn't an easy matter to obtain the right parts, at the right time, and at the right price. The search for and selection of electronic components for projects can be a very disheartening job, particularly when it's seemingly impossible to obtain certain parts, or the price you must pay for them is excessive. You *can* get the parts you need, when you need them, and at a reasonable price, if you are willing to take an organized approach to parts procurement and do a good deal of preparatory spade work before picking up soldering iron and pliers.

In this article, we will examine the need to get organized for the task; look at parts-selection criteria and the question of substitutions; review various sources of parts; and discuss details of component identification and testing.

As you'll see, once you have a clear view of the process, shopping for parts is no longer the formidable challenge it might otherwise be.

Catalogs and reference material

Before buying parts, it pays to be organized—to have done some preplanning before you start looking for specific parts for a given project. Some of the things you can do in advance include laying in a good store of catalogs, reference sheets, and reference books; buying-in-advance "staple" and bargain-priced parts; and setting up a well-stocked junk box.

It surely pays to accumulate a broad range of catalogs. No builder's library is complete without them. With a little effort, you will find that virtually any desired part, or a usable substitute, will be listed in *someone's* catalog or cross-reference. You may also find that a single firm may have all, or almost all, of the parts required for a given project, eliminating the need for repeated shopping forays or inefficient orders to a number of mail-order firms. Having a number of catalogs at hand also allows ready price comparisons between firms.

Having a good reference file, or recent issues of major electronics publications such as **Radio-Electronics;** amateur magazines such as *CQ, Ham Radio,* and *QST;* and a variety of computer-oriented magazines, *Byte, Microcomputing,* and *Popular Computing* will provide a good background. The magazines also list the addresses of the major suppliers, along with their ordering policies. Of course, single-page magazine ads can't include a supplier's full stock, and are no substitute for the catalogs themselves.

Another reason for obtaining the larger catalogs is that those serve as excellent reference files for various components, and often provide good sources of cross-reference data, particularly for solid-state components. Note that many of the distributors offer two or more catalogs, such as a consumer-type catalog oriented to hi-fi or CB, and an industrial catalog that would normally be more suitable.

In addition, you should acquire the factory service manual, schematic diagram, and component parts list for any item of electronics gear you buy. A surprising quantity of semi-professional and professional-electronics equipment is sold today with no more than a *user's manual,* which is of little help in servicing and parts replacement. Obtaining the proper manuals and parts lists while equipment is currently being manufactured is much easier than trying to obtain such materials later on, when needed information may no longer be readily available.

To facilitate original construction, it's worthwhile to have on hand a selection of standard reference books and manuals, as well. The publications required, of course, will depend upon the particular type of project work undertaken. Some of the more important, all-round useful reference texts include the Editors and Engineers' *Radio Handbook,* the *Master Tube Substitution Handbook, Transistor Substitution Handbook, TTL Data Book, Transistor Specifications Manual,* and *Reference Data for Radio Engineers;* the ARRL *Electronics Data Book* and *Radio Amateur's Handbook,* and several others. A handy cross-reference manual is the *Archer Semiconductor Reference Handbook,* a useful guide to Radio Shack's semiconductors that's also a substitution and cross-reference guide for more than 100,000 solid state devices. Another Radio Shack reference is Forrest Mims' *Engineers Notebook,* which contains tried-and-tested applications for most popular linear and digital IC's. Other helpful parts information sources are Motorola's *Semiconductor Cross-Reference Guide* and *Discrete Hybrid Components Handbook,* Sylvania's *ECG Semiconductor Replacement Guide;* and RCA's *SK Replacement Guide.*

Photos courtesy of Radio Shack and GC Electronics.

Buying in advance of needs

Is stocking parts in advance of specific project needs a good idea? It's true that with a few judicious purchases, you can stockpile many of the components needed for future projects. On the other hand, an apparent bargain isn't one, unless there's a real prospect of the part or parts ultimately being used.

BUYING LARGE ASSORTMENTS of components and hardware can result in savings, but only if the parts are likely to be used.

Mail-order dealers offer all kinds of special deals—hardware assortments, resistors, knobs, transistors, IC's, potentiometers, transformers, diodes, capacitors, and various surplus components and assemblies. Many of those offerings are indeed bargains, if carefully surveyed and even more carefully purchased. It's generally worthwhile to take advantage of quantity offerings and specialized assortments, tempering one's enthusiasm for a "good deal" with a realistic expectation of when, and if, the contemplated bulk purchase will likely be put to use. A small investment in component assortments usually represents money well spent; however, there is usually little that can be done about a poor choice—you take what you get and hope to be able to use most of it.

For initial stock-up, some useful components include poly-bag assortments of disc ceramic, mica, and small electrolytic capacitors; low-wattage resistors; diodes, and hardware. On the other hand, assortments of precision resistors, large electrolytic capacitors, IC's, and transistors are probably *too* specialized and may not represent good value. The key to selecting true bargains lies in choosing components that you are most likely to use in your projects.

There are some cautions to keep in mind. Buying in advance of your needs is intended to build an inventory of common parts, not to produce specific parts for an intended project. It's unusual to find just what you need for a particular project from a grab-bag assortment. Whenever you need a *specific* part, order *that* part.

Carefully note the makeup of parts assortments. Are the parts offered all of one (possibly oddball) value, or are they of different values? What are the tolerances and power ratings? Are the leads full-length or too-short PC-board length? Are the components new, used, or surplus; tested or untested; firsts or seconds; marked or unmarked; old or fresh; usable or dubious?

All of those considerations play an important part in determining whether buying in advance of needs is a worthwhile approach or a waste of money.

Acquiring a junk box

Most builders have a junk box that can be a handy and money-saving device for both construction projects and repair jobs. Not only does the well stocked junk box satisfy convenience and economic needs, but it can also provide a valuable educational experience in component identification and substitution practices for the beginner.

Assembling a useful junk box is a prime objective of most electronics hobbyists. The accumulation gives you the parts you need for projects, when you need them, at reasonable prices—sometimes even at *no* cost. While you may have to spend some money to acquire a foundation, it's possible to accumulate a large assortment of components inexpensively, if you aggressively search for bargains.

ELECTRONICS FLEA MARKETS often are a good place to acquire parts at a reasonable cost.

The sources for junk box parts are myriad, and they include local purchases, surplus/salvage, mail order, flea markets, auctions, and other sources. Probably the best, lowest-cost way to build an initial parts inventory is to salvage usable components from junked electronics gear. Components such as switches, potentiometers, coils, diodes, transformers, resistors, and capacitors are often salvaged from such equipment. In earlier days many of those components could be obtained from old radios, defective TV sets, discarded amateur equipment, and government surplus gear—components large and small being saved with the expectation that they could be used again in some future project.

Those were the good old days, and by and large, junked gear—particularly that of the tube-type variety—provides a shrinking source of junk box parts. With the advent of solid-state equipment, printed circuits and specialized transistors, and IC's, it's harder to "recycle" those components into useful junk box parts than it was 15 or 20 years ago. The trend in junk box acquisition is toward judicious buying of discrete components in advance. We've already discussed parts-selection tips and cautions, and they apply equally to purchases for the junk box.

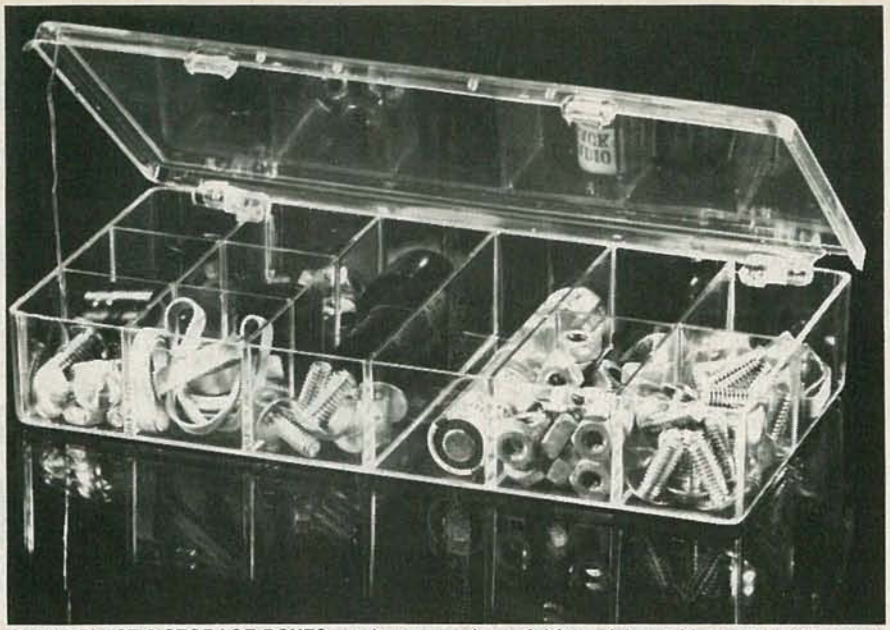
Regardless of what methods are used to procure for the junk box, the components—particularly the smaller, easily damaged ones—should be carefully segregated by type and value, and placed in labeled jars, plastic drawers, or even small boxes—whichever suits your particular style. The key is that the storage procedures used should allow fast and positive recovery of the parts when needed. Components that can be tested should not be used without first checking their electrical condition, regardless of how good they may look physically. We'll delve into component identification and testing later; suffice it to say at this point that a multimeter and grid-dip oscillator are two very important testing devices for builders.

A final point on junk boxes: After you've developed a respectable junk box, don't hesitate to *use* it for your projects or repairs. You will save money using "pre-owned" parts, and the risk of improper substitution of a part in a circuit is *usually* not too great (except to that particular part). Even if a substituted junk box part fails, a good deal of learning has taken place!

Developing the parts lists

Most published projects include an itemized parts list that identifies the various components' size, value, and nomenclature, as well as required voltage, current, and power-handling capability. Some parts lists even state brand names and recommend sources for hard-to-find and critical components.

Even when a clear and definitive parts list is provided, you should carefully review the construction project, looking closely at the schematic diagram, photos, and explanations of special circuitry and parts requirements. In many cases, the author will point out critical components that should not be changed. Based on your judgment, other parts may be substituted, possibly from existing junk box stocks. We'll talk more later on the question of parts substitution and how far one can deviate from specified values without



CLEAR PLASTIC STORAGE BOXES can be extremely useful for quick, positive part identification.

affecting performance.

The author's parts list should trigger you to work up additional subsidiary parts lists. Those may logically take the form of lists showing which parts are best procured from your junk box; which are best procured by mail-order; which are best acquired from surplus or salvage sources, and which can be purchased locally. After checking your junk box, look over the local purchase and surplus lists next, with unavailable items added to the mail-order list. In large, complicated projects, it may also be useful to have each list further divided by type of component for convenience in searching for the required parts.

From practical and economic standpoints, it's often wise—even necessary—to make appropriate component substitutions. We'll turn to those next.

Parts selection and substitution

As the prices of individual components increase, it's important to "make do" with the parts you have on hand. It's possible to substitute components within limits, and yet have a device function as intended. Besides the financial advantages of using existing stocks, it's a real time saver to be able to use on-hand components rather than having to shop for new ones. Also, it's worthwhile to get a feel for the range and types of substitutions that can be made so as to develop flexibility when shopping for components—since local suppliers and mail-order houses will not always have exact specified components in stock.

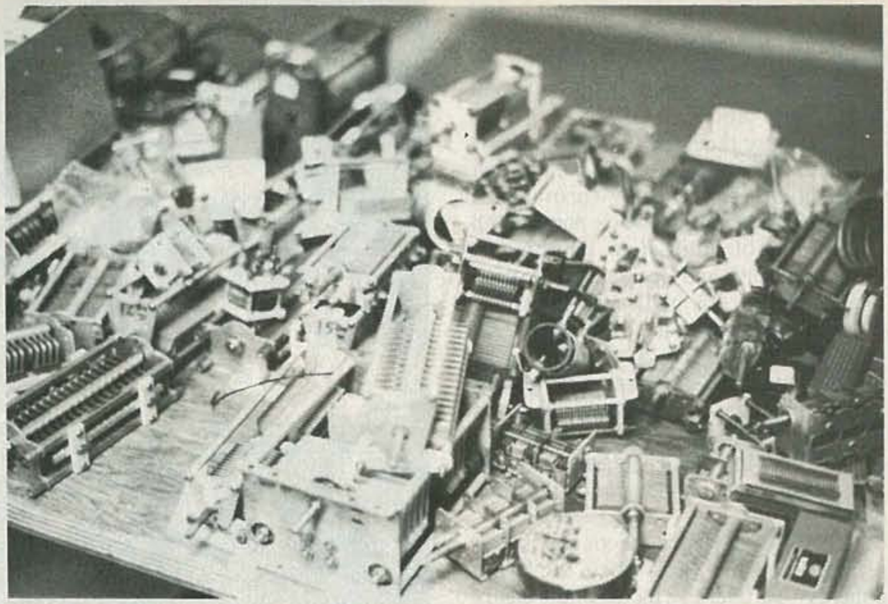
Many inexperienced electronics enthusiasts have an unnecessary fixation on obtaining the exact parts and values indicated in a construction piece, fearing that the finished equipment will not function correctly if any liberties are taken with the stated parts list. Usually such fears are exaggerated. Unless a "mirror image" of the item is required, *identical* parts are not needed. In most cases, parts substitutions can be made, within reasonable bounds. Component specifications are not "graven in stone," as the saying goes. There is usually a tolerance range within which the hobbyist may work. Sometimes those are stated, though mostly they are not. The trick to intelligent parts substitution, of course, lies in knowing just what the boundaries of wise substitution are.

Obviously, if the construction article's author or circuit designer has highlighted critical components, you shouldn't change them. Special-purpose or close-tolerance IC's, transistors, tubes, capacitors, resistors, and other parts are best not substituted. But in many cases the component specified is what the designer had on hand, and represents an arbitrary specification. So, bearing in mind that most hobbyists are also experimenters, when you have trouble finding components with the exact specifications, try some substitutions of your own, using a combination of good judgment and close attention to available reference guides, catalogs, and substitution manuals. You may not have the experience to ascertain whether or not you'll be successful in making the substitution, but you'll never know unless you try!

Most components, such as resistors, capacitors, inductors, transformers, and transistors, have *ratings* that are important. Those include power and maximum voltage and current ratings. The ratings of substituted components should be equal to or greater than those specified for the project. Generally speaking, over-rated components *can* be used in electronics projects. For example, a 1-watt resistor can be substituted for a ½-watt resistor of the same value without concern, unless the larger physical size of the 1-watt unit causes a space problem.

Active devices, such as transistors, are more difficult to substitute on a "rating" basis, due to the multiplicity of rating parameters involved. Still, similar guidelines hold for those components, as long as the substitute has equivalent design parameters. One must be cautious in trying to substitute components with overrated ones when the device is to perform a specific function at a particular value of current or voltage. In such a case, a "larger" unit would not be satisfactory. Zener diodes and other current- and voltage-regulating devices, for example, would fit into that category.

Making a proper "ratings" substitution is a great deal easier than making a "value" substitution. Each type of component is affected by different rules and guidelines, so it's worthwhile to look at each individually:



APPROPRIATE SUBSTITUTES can be found for most electronic components, including variable capacitors. Flea markets are a good source for those components.

1. Resistors. Fixed resistors are often easily substituted. Unless specified otherwise, fixed resistors commonly have a tolerance of ± 10 or 20%. Knowing that, you can usually safely substitute any resistor. If no tolerance is specified, working in the ± 10% or 20% range is usually safe. One general exception is high-voltage power-supply bleeder resistors—those can be as much as 25% lower or 50% higher than specified.

In some applications, metal-film precision resistors, manufactured to tolerances of ± 1% or better, are required. That type of resistor is frequently specified for high-stability/ultra-low-noise circuits in computers, voltage dividers, test equipment, and active filters. The stated tolerance must be maintained when substituting those types of resistors.

Frequently, you can find resistors in your junk box that can be adapted for a substitution, using series and parallel combinations whose net resistance is close to the desired value. Resistors connected in series have the total resistance of the sum of the resistors—two 2000-ohm resistors in series have a total resistance of 4000 ohms. To find the effective resistance (R_t) for resistors in series use the formula:

$$R_t = R1 + R2 + R3 + \ldots$$

Two or more resistors can be connected in parallel to obtain the desired circuit resistance. When you do that, total resistance is always less than the lowest value used in the combination. Use the following simple formula to calculate the value of two resistors connected in parallel:

$$R_t = \frac{R1 \times R2}{R1 + R2}$$

There are two major kinds of fixed resistors: composition or carbon, and wire-wound. Normally, do not use wire-wound resistors in circuits carrying RF since they have a certain amount of inductance that can upset the associated RF circuit. However, carbon-type resistors of the appropriate power rating can be used to substitute for wire-wound types.

2. Potentiometers. Substitutes can usually be made having somewhat higher or lower values than those specified. Surplus pots can be bargains, but physical characteristics such as shaft length and type of shaft are important. Consider: Is the unit for screwdriver adjustment, or is the shaft designed to accept a knob? What about the pot's electrical characteristics, such as the "taper"—is it usable? Pots with "linear" or "audio" tapers are the types most frequently called for in construction projects. And is an on-off switch required on the control?

One caution: Wire-wound pots are frequently found in surplus. Those pots are most suitable for low-frequency, high-power applications, not for delicate solid-state circuitry. They are not for circuits that require high precision (resolution). Thus, for most work, standard carbon-composition pots represent the best selection.

When shopping for new pots, quality is paramount; cheap materials are synonymous with inferior performance, often evidenced by a pot that is hard to turn because of high-friction bearings. Cheap imports should be avoided; stick to top-quality pots in all construction projects.

3. Capacitors. Fixed capacitors come in a surprising variety. There are mica, Mylar, silver-mica, ceramic, oil-filled, paper, and electrolytic types. Each has specific applications. Mica types (especially silver-micas) and zero-temperature-coefficient ceramics are usually specified where low losses and high stability are essential; normally, you should not substitute other types for them. Probably the best all-round capacitor for general purpose use is the Mylar polystyrene type—also one of the cheapest, and typically available for values between 5 pF and 0.5 μF.

Standard tolerance ratings for most project-grade capacitors is ± 10 to 20%, though for some inexpensive general-purpose ceramic capacitors (including disc types)it's as wide as − 30% to + 100%. Exact capacitance is relatively unimportant in typical bypassing/filtering and coupling applications, and you can easily deviate as much as 50% from the spec value without trouble, sometimes much more (except at VHF and UHF). Mylar polystyrene capacitors also run in the 10–20% tolerance range, with 5% Mylars readily available, and 2.5% and 1% units available at somewhat higher prices.

As with resistors, capacitors can be substituted in series or parallel to yield different equivalent values, though the combining effects are the opposite to those of resistors: capacitors in series act like resistors in parallel, while capacitors in parallel act like resistors in series.

When two capacitors are placed in series, the total capacitance is less than that of either one, as determined by the simplified formula:

$$C_t = \frac{C1 \times C2}{C1 + C2}$$

Capacitors are additive when placed in parallel:

$$C_t = C1 + C2 + C3 + \ldots$$

Another handy formula is one to use when you need a lower value of capacitance and want to find the value needed to place in series with an available unit to obtain the desired value. That value is given by the formula:

$$C1 = \frac{C2}{(C2/C_t)-1}$$

The voltage-handling capability of the resulting capacitor chain should be considered, as should power-handling capability of series/parallel resistors. A standard electronics text should be consulted for more on that.

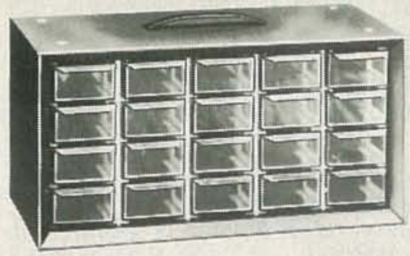
Most capacitors above 1 μF are aluminum electrolytics and are polarized. Tolerances tend to be fairly loose because filtering and coupling applications usually don't call for precise values. Those types are often available with capacitances of 100,000 μF or more, though usually at very low voltage ratings at those high capacitances. A related though more expensive capacitor is the tantalum type. The tantalum capacitor is generally superior to the standard electrolytic, and boasts tighter tolerance, smaller size (for equivalent capacitance), and lower leakage.

Except in specialized applications, such as in timing circuits where tantalums are generally preferred over aluminum electrolytics, exact capacitance isn't terribly important. When substituting, it's generally wise to err on the side of too-high capacitance rather than too-low. Surplus oil-filled types can normally be substituted for electrolytics having equivalent characteristics.

Substitutions are also possible with variable capacitors. The main considerations here relate to minimum and maximum capacitance. As a general rule, you can substitute a capacitor having a greater capacitance than the value specified. It may also be possible to substitute a variable capacitor that has somewhat less range than that specified, if you can determine the actual tuning range required in the circuit. That involves figuring the amount of circuit inductance and amount of capacitance required for a given tuning range, and is best done with the aid of a device such as the ARRL *LCF Calculator*, or using a computer. Note that junk box variables can be modified to become lower-value capacitors simply by removing rotor plates, and multi-section receiving variables can be paralleled to get higher capacitance.

In high-voltage circuits, be sure you observe maximum operating voltages that depend on plate spacing. Plate spacing should be equal to or greater than that specified by the designer, or you can refer to a catalog to convert spacings to voltage-handling capacities. Knowing the voltages in the circuit, you can easily check to see if your particular substitute is adequate for your purpose.

4. Diodes. Besides resistors and capacitors, you'll often be faced with making substitutions for diodes of various kinds, both rectifier and small-signal types. The former are generally specified according to their maximum current and reverse breakdown ratings. It's possible, in many instances, to come up with a suitable replacement without having to resort to checking a data book. The 1N4148 is a good all-around small-signal type diode to have in the junk box as it is able to meet a wide range of substitution needs.



A 20-DRAWER CABINET such as this is ideal for maintaining a well-organized junk box.

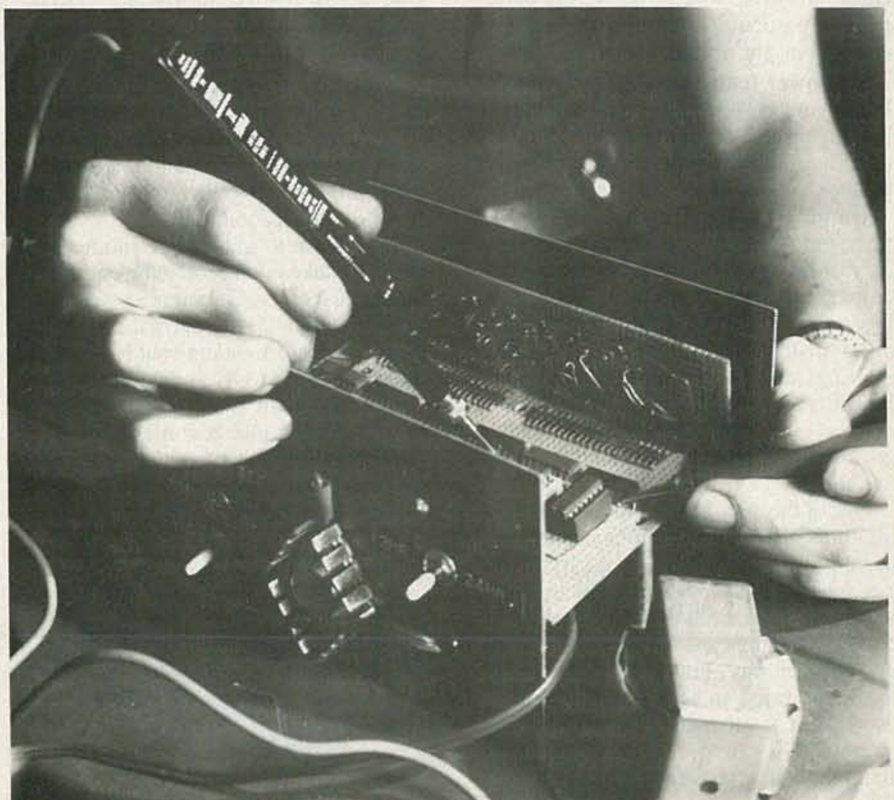
5. Transistors. Besides diodes, other types of discrete semiconductors that present substitution questions include bipolar transistors, FET's, SCR's, and UJT's. As with diodes, practically everyone sells some transistors, but few distributors stock each and every part number, particularly highly specialized and Japanese types.

Many transistor suppliers and manufacturers overly emphasize the difficulty of transistor substitution. From a practical standpoint, the many different types of transistors and related economic considerations make it imperative that some substitutions be attempted. You'll need a transistor data book to determine proper specifications; once those numbers are available, you can apply them to select appropriate substitutes. Even using abbreviated substitution guides such as found in the Radio Shack catalogue can make the purchase of bargain-priced blister-pack replacement transistors practical and useful.

6. Integrated Circuits. The silicon chemistry of integrated circuitry constitutes a key element of most sophisticated electronics construction projects. Because of their importance and widespread use, those devices are sold by most electronics suppliers. The devices range over a wide spectrum, and include linear, CMOS, TTL, DTL, ECL, LSI, and other types. The variety encountered precludes stocking up on any but the most common types.

There is little latitude in substituting IC types. A circuit specifying a particular IC usually requires *that* particular IC. In fact, it's usually not worthwhile to salvage IC's from scrap equipment unless the IC's can be clearly identified and there is some prospect of actual use for that particular device.

However, it's important to point out that IC designations often include alphabetical prefixes that simply indicate the device's manufacturer. There is no need to use an IC made by a particular manufacturer if the same basic device is available from other firms. You'll find that IC suffix letters aren't terribly critic-



A MULTI-FUNCTION TEST PROBE, such as the one shown here, is handy for finding good components in surplus or salvaged equipment.

TABLE I—COMPONENT SUBSTITUTION GUIDELINES

The following constitute *general* guidelines for substitution of the most-used components: resistors, capacitors, inductors, rectifier diodes, and transistors. Refer to the text for discussion of other factors that should be considered in making parts substitutions, and for guidelines for other components.

RESISTORS
Resistance value: within ±20% of that specified.
Resistance tolerance: equal to or better than specified, but usually not critical.
Power rating: equal to or greater than specified.

CAPACITORS
Capacitance value: within ±20% of that specified, except in critical timing and tuning circuits.
Capacitance tolerance: equal to or better than specified, but usually not critical.
Voltage rating: equal to or greater than specified, or twice the maximum supply voltage.
Type: generally not important except in critical timing and tuning circuits.

COILS/INDUCTORS
Inductance value: within ± 20% of that specified.
Current rating: equal to or greater than specified.

RECTIFIER DIODES AND BRIDGE ASSEMBLIES
Current rating: equal to or greater than specified.
Reverse breakdown voltage: equal to or greater than specified.

TRANSISTORS
Type: as specified (PNP or NPN, etc.).
Collector current rating (I_c): equal to or greater than specified.
Reverse breakdown voltage: equal to or greater than specified.
Gain (Beta or hf_e): equal to or greater than specified.
Power rating: equal to or greater than specified.
Cutoff frequency: equal to or greater than specified.
Case style: usually not important.

NOTE: *A transistor data book must be consulted for determining most of the specifications necessary for making substitutions.*

al, either. They usually indicate a change in the internal IC configuration that does not alter the basic function, though the suffix letter may indicate the package style. But, if you find a letter (or two) inserted between some of the numbers, it may indicate a significant modification that precludes easy substitution. In such cases, it's wise to consult a data book, paying particular attention to possible changes in pin numbering.

7. Power transformers and chokes. When your project requires a very specific transformer, it may be best to order it directly from the manufacturer or his distributor.

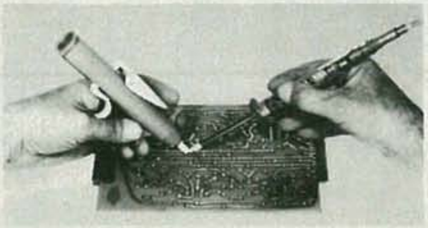
On the other hand, if specs aren't too tight, or it's possible to connect windings in various configurations to obtain required voltages, it may pay to take advantage of specials and closeouts by mail-order distributors—though transformer offerings are usually limited in variety. Industrial surplus dealers generally have the best selection; transformers with the most unusual characteristics can turn up in surplus.

One of the main considerations in making transformer substitutions is adequate current/power handling capacity. You can substitute if the transformer in question has the same voltage rating with more current-carrying capacity, but it's risky to go the other way. However, if the transformer is rated in terms of continuous duty, and its intended use will be intermittent, a rating reduction of up to about 25% may prove to be quite acceptable.

Minor primary and secondary voltage substitutions can be made without adverse effect. If you have a transformer that delivers a higher voltage than you want, you can drop the voltage with a series resistor or a voltage-divider system.

As for power-supply chokes, substitutions are usually easy. The specified value of a filter choke can usually be regarded as a minimum value. The inductance of chokes in series is additive; conversely, chokes in parallel function like resistors in parallel. The amount of capacitance required in a power supply is affected by the power-supply choke inductance—the choke and electrolytic capacitor work together to bring ripple down to an acceptable level.

In addition to inductance ratings, you must also take into account the current the choke must carry. Of course, you can use a choke with a higher current rating than specified. Using a somewhat lesser-rated choke is probably OK, unless the choke is rated at less than 75 % of expected current. The inductance becomes less if more current is drawn through the choke than the unit is rated for, thus reducing the choke's filtering effectiveness.



A DESOLDERING TOOL makes removing parts from a surplus or salvaged piece of equipment simple.

8. Switches. Substituting switches can be tricky because of the numerous possible switching configurations and applications. You can always use a switch that has more contacts or sections than are required for a given circuit, as long as it has an adequate voltage rating. Often that information can be obtained from manufacturers' and distributors' catalogs. Similar considerations apply to relays, but selection criteria are complicated by relay coil voltage and current, and other operating characteristics.

9. Tubes. Most contemporary circuitry has abandoned the once-common vacuum tube, though a few tube designs survive, and there is still demand for tubes for replacement purposes. Tubes are becoming extremely expensive and difficult to find, and few are still manufactured in the United States. One good, low-cost source of once-common receiving tubes is *Cornell Electronics Company*, 4217 University Avenue, San Diego, CA 92105; the firm stocks a wide variety of bargain-priced receiving tubes. *Radio Shack* also provides a special-order service that includes about 2000 different types. If you don't have the tube you need, of course, you'll have to buy it. But a quick check of a tube-substitution manual, or the ARRL's *Radio Amateur's Handbook* (it lists different tube types and possible substitutions if available) may prove worthwhile.

10. Other components. There are many other components that the project builder will find useful to keep in his junk box or bench stock for the purpose of convenient substitution in construction projects.

We can't treat all of them here. But some that come to mind include plugs, jacks, audio and IF transformers, transistor and IC sockets, battery clips, terminals, hardware, alligator and crocodile clips, meters, connectors, chassis, PC boards, and cabinets.

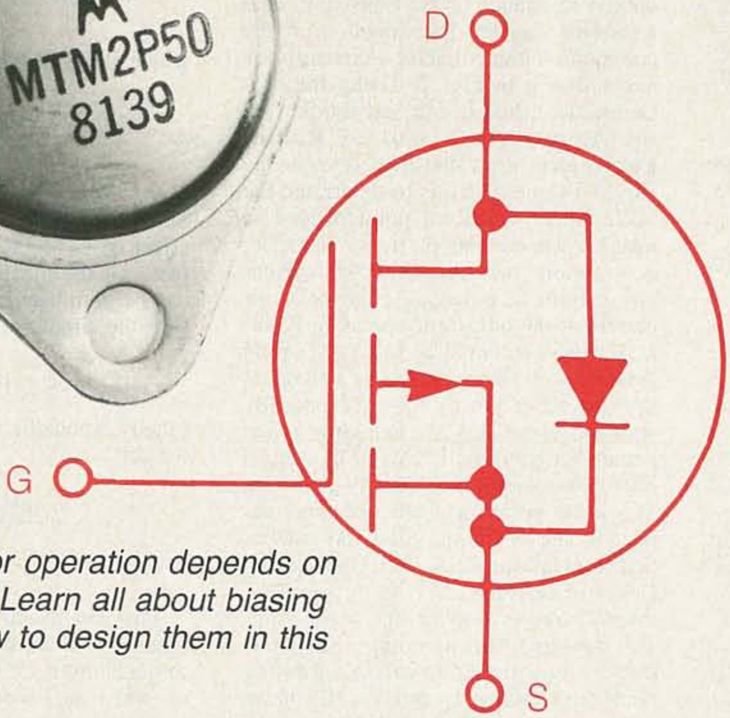
In many instances your best guide to making intelligent substitutions is simple, ordinary common sense, as well as an understanding of when not to use substitute parts but to go out and acquire a specified part.

Getting into the practice of breadboarding project circuitry will not only help refine a circuit before commitment to a final design, but will make substitutions easier because it gives you a chance to double-check your choices. Solderless breadboards eliminate a great deal of the trouble involved in circuit development and make desk-top experimentation—and substitution—much easier.

Table 1 lists popular component substitution considerations in tabular form.

When we continue this article, we'll take a closer look at where you can obtain your parts for projects. Among the topics we'll cover will be how to successfully use surplus and salvaged parts, including how to test and identify them **R-E**

How to Design Analog Circuits - Biasing Transistors



Proper transistor operation depends on proper biasing. Learn all about biasing circuits and how to design them in this month's article.

MANNY HOROWITZ

Part 5 LAST MONTH, WE BEGAN our discussion of bipolar and FET transistors by looking at the structure of those devices and at some basic transistor circuits. One of the things we mentioned was that if a bipolar device were used in a Class A common-emitter circuit, for linear operation the collector voltage (with no input signal present), should be set at one half the supply voltage. The no-input-signal condition is commonly referred to as the quiescent operating point. (Similarly, in the case of an FET in a common-source circuit, the drain voltage should be one half the supply voltage). That, however, is merely an approximation; the actual operating point varies with the specific requirements of the circuit. In any event, once the proper operating point has been selected, the device must be *biased* for that point. Just how that is done is the topic of this month's article.

Bipolar transistors

There are essentially two types of bias circuits that are used with bipolar devices. Although there may appear to be many more, the others are simply variations of those two circuits. And even the two circuits are variations of each other.

But why do we need many bias circuits? They arose mainly because of the high leakage current, I_{CBO}, that flowed from the collector to the base in early germanium transistors. If that leakage current also flowed through the base-emitter junctions (as it normally did), it was multiplied by beta (β) to make it into a large undesirable leakage current, I_{CEO}, that flowed in the collector and emitter circuits. And to compound the problem, I_{CBO} and I_{CEO} doubled every time the temperature of the transistor increased by 10°C. Although those factors are still important in modern silicon transistors, the effect on the collector current is reduced considerably because the leakage current in silicon transistors is frequently low enough to be ignored.

In addition to leakage current, variations in the operating parameters from device to device, as well as with temperature, can cause problems. The value of β, for instance, will vary from device-to-device of the same type, as well as with temperature and collector current, I_C. In addition, the value of I_C at the operating point will vary with several parameters. Among those are V_{BE}, the voltage drop across the base-emitter junction, which itself varies with temperature; V_{BB}, the base supply-voltage; r_c, the collector-to-base resistance in a common-base circuit, and r_d the collector-to-base resistance in either a common-emitter or common-collector circuit.

But, once the operating point has been established for a circuit, ideally it should not be effected by differences in parameters from device-to-device, or by any external factors such as temperature. That is the reason for all of the bias-circuit variations—they are designed to help stabilize the operating point. In theory, if the proper bias circuit is used, the operating point will not change regardless of any change in any of the factors mentioned. However, theory and what really happens are not always the same. But even so, using the proper bias circuit will minimize any variations of the operating point sufficiently so that the circuit will still operate as intended.

To design a bias circuit properly, it is important to know how a variation in one variable will effect the other variables in the circuit. Because of that, three *stability factors* that relate the change of one factor to the change in another have been derived. They are:

$$S = \frac{\Delta I_C}{\Delta I_{CBO}} \qquad (1)$$

which relates the change of collector current to the change in leakage current. The stability factor relating the change of collector current to the change in V_{BB} is:

$$S_E = \frac{\Delta I_C}{\Delta V_{BB}} \qquad (2)$$

while the equation relating the collector current change to the change in β is:

$$S_\beta = \frac{\Delta I_C}{\Delta \beta} \qquad (3)$$

Equations used to relate the various components in the circuit to the various stability factors, will be noted as each bias circuit is described. In each case, it is desirable that stability factors be as close to 1 (the perfect stability factor) as possible. Should more than one stability factor differ from 1, the effects of all variations must be taken into account when evaluating the design.

Bipolar transistor bias circuits

The simplest bias circuit to be described here is shown in Fig. 1. The base current, I_B, originates at V_{BB} and is delivered to the base through R_B. However, V_{BB} often does not exist as an independent supply; instead V_{CC} is used to supply both base and collector current. In that case, R_B is connected to V_{CC}, and that supply serves as both V_{CC} and V_{BB}.

In Fig. 1, all base current from V_{BB} flows through the base-emitter junction. If we consider the voltage across that junction, V_{BE}, as negligible when compared to V_{BB}, the base current due to the supply is V_{BB}/R_B. Collector current due to that base current is approximately equal to βI_B.

Next, let us add the effect of I_{CBO}, the leakage current that flows from the collector to the base. After flowing through the base-emitter junction, it is multiplied by beta. That βI_{CBO} flows in the collector and emitter circuits and substantially effects the collector and emitter currents. Collector current due to I_{CBO} is thus $\beta I_{CBO} = I_{CEO}$. (Note that in our discussions beta has been assumed to be much greater than 1. Thus only β is shown in formulas rather than β + 1.)

Finally, we have some collector current flowing due to r_d, the collector-to-emitter resistance of the transistor. That resistance can be determined from the common-emitter collector-characteristics curve shown in Fig. 2. Using the procedure described in our last article (see the August 1982 issue of **Radio-Electronics**, draw the load line on the curve. The next step is to determine the operating or quiescent point needed to insure linear operation. If, for instance, you require that the collector current swing from 0 to $I_{C(MAX)}$, the collector current at the quiescent operating point, I_{CQ}, would be equal to $I_{C(MAX)}/2$. Find that point on the I_C axis. The voltage at the quiescent point, V_{CEQ}, is usually equal to about $V_{CC}/2$. Drawing a line perpendicular to the I_C axis at I_{CQ}, and a line perpendicular to the V_{CE} axis at V_{CEQ}, the point at which the two lines cross is the operating point. As drawn, that point falls on the $I_B = 100\ \mu A$ curve. Collector resistance, r_d, is the slope of that I_B curve around the operating point. The slope is found by noting two points that are equidistant from the operating point, and finding I_C and V_{CE} for those points. Assuming that the collector voltage and current at one point are V_{CE1} and I_{CE1}, and V_{CE2} and I_{CE2} at the other, then:

$$r_d = \frac{V_{CE2} - V_{CE1}}{I_{CE2} - I_{CE1}} \qquad (4)$$

As indicated, r_d is the collector-emitter resistance of the transistor when it is used in a common-emitter or common-collector circuit. In a common-base circuit, that collector-emitter resistance is much higher and equal to βr_d; that quantity is called r_c.

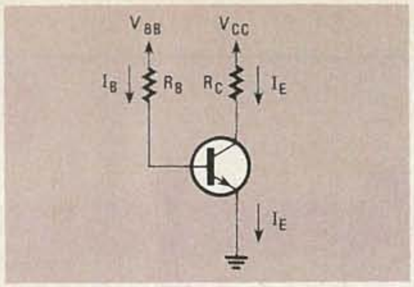


FIG. 1—A SIMPLE CIRCUIT for biasing bipolar transistors. Often there is no separate V_{BB} supply; instead V_{CC} is used to supply both the collector and base.

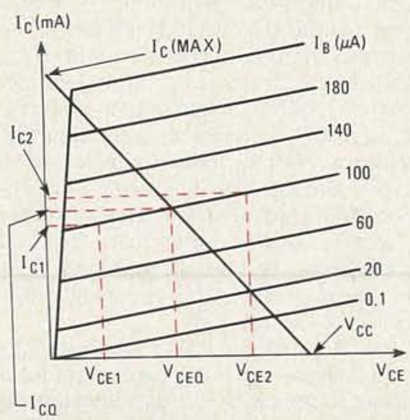


FIG. 2—ONCE THE QUIESCENT POINT has been found, the value of r_d is equal to the slope of the I_B curve around that point.

A portion of the total collector current is due to the presence of r_d in the circuit. It is equal to the collector-emitter voltage, V_{CE}, divided by r_d. Obviously, V_{CE} is equal to the supply voltage less the voltage drop across the collector resistor, R_D, or $V_{CC} - I_C R_C$. Consequently, the total quiescent collector current flowing in the circuit of Fig. 1 is:

$$I_C = \beta I_B + I_{CEO} + \frac{V_{CC} - I_C R_C}{r_d}$$

which simplifies to:

$$I_C = \frac{\beta I_B + I_{CEO} + V_{CC}/r_d}{R_C/r_d + 1} \qquad (5)$$

Should R_C be less than 10% of r_d, the effect of r_d becomes negligible, and all factors in the equation involving that term can be eliminated. We will then end up with the simple relationship:

$$I_C = \beta I_B + I_{CEO}$$

Finally, remembering that $I_B = V_{BB}/R_B$, we get:

$$I_C = \frac{\beta(V_{BB} + R_B I_{CBO})}{R_B} \qquad (6)$$

You can usually use equation 6 and ignore r_d in most designs. But do not forget about r_d. It will be important later on when we discuss AC gain and the output impedance of transistor circuits.

The various stability factors for the circuit shown in Fig. 1 are:

$$S = \beta \qquad (7)$$

$$S_E = \beta/R_B \qquad (8)$$

$$S_\beta = \frac{I_{CBO}R_B + V_{BB}}{R_B} \qquad (9)$$

Equation 9 indicates by how much the collector current will change for a specific change in β. Thus if a transistor with a β of 80 is substituted for one with a β of 40, the quiescent collector-current will double. To see how we came to that conclusion, let's digress a bit. First, as we saw in equation 3, $S_\beta = \Delta I_C/\Delta\beta$. Expanding further, equation 3 can be rewritten as $\Delta I_C = \Delta\beta(I_B)$. Secondly, since I_{CBO} is generally small enough to be ignored, and since V_{BB}/R_B is equal to I_B, in this case, the stability factor, Sβ, defined by equation 9 is approximately equal to I_B. Thus $\Delta I_C = \Delta\beta(I_B)$. Originally, I_C was equal to the inital β of 40 multiplied by I_B, or $40I_B$. If $\Delta\beta = 40$, and $\Delta I_C = \Delta\beta I_B$, then

$\Delta I_C = 40I_B$. Finally, the total collector current when β is increased from 40 to 80 is $I_C + \Delta I_C$, or $40I_B + 40I_B = 80I_B$.

Improving stability

Stability can be improved by adding an emitter resistor, R_E, to the circuit in Fig. 1. If that is done, equations 7, 8, and 9 are modified to become:

$$S = \frac{\beta(R_E + R_B)}{\beta R_E + R_B} \qquad (10)$$

$$S_E = \frac{\beta}{\beta R_E + R_B} \qquad (11)$$

$$S_\beta = \frac{(R_E + R_B)\,V_{BB} + I_{CBO}\,R_B\,(R_E + R_B)}{(\beta R_E + R_B)^2} \qquad (12)$$

In this arrangement, base current is less than it was when there was no emitter resistor. It is reduced because the emitter resistor, R_E, is reflected into the base circuit as a resistor equal to βR_E. Because of that, the base current becomes $(V_{BB}/(R_B + \beta R_E)) + I_{CBO}$. In addition, I_C becomes equal to βI_B.

The bias circuit shown in Fig. 3 is used when stability is a very important consideration. The circuit in Fig. 1, and the variation we created by adding an emitter resistor, are simplified versions of that circuit. In it, V_{BB} has been eliminated; instead, V_{CC} is used as both the collector and base supply.

Thevenin's theorem must be used in order to determine the base current in the circuit in Fig. 3. That theorem states, in part, that any network of voltage sources and resistances can be simplified to a single voltage source in series with a single resistance. Use the following steps to apply that theorem to the circuit. Those steps are shown in Fig. 4.

First, as shown in Fig. 4-a, separate the bias resistor circuit from the rest of the circuit.

The second step, as shown in Fig. 4-b, is to determine the voltage at the junction of R_B and R_X. That voltage is called the *Thevenin voltage*, V_{TH}, and, since R_B and R_X make up a simple voltage divider, is equal to $V_{CC}(R_X/(R_B + R_X))$.

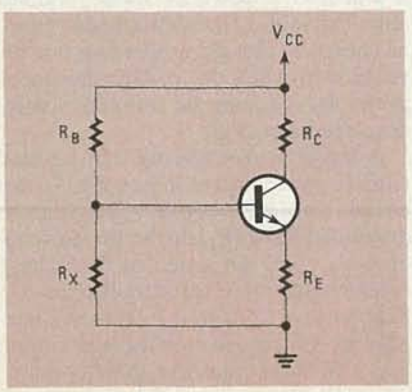


FIG. 3—IF BETTER STABILITY IS REQUIRED, the bias circuit shown here can be used.

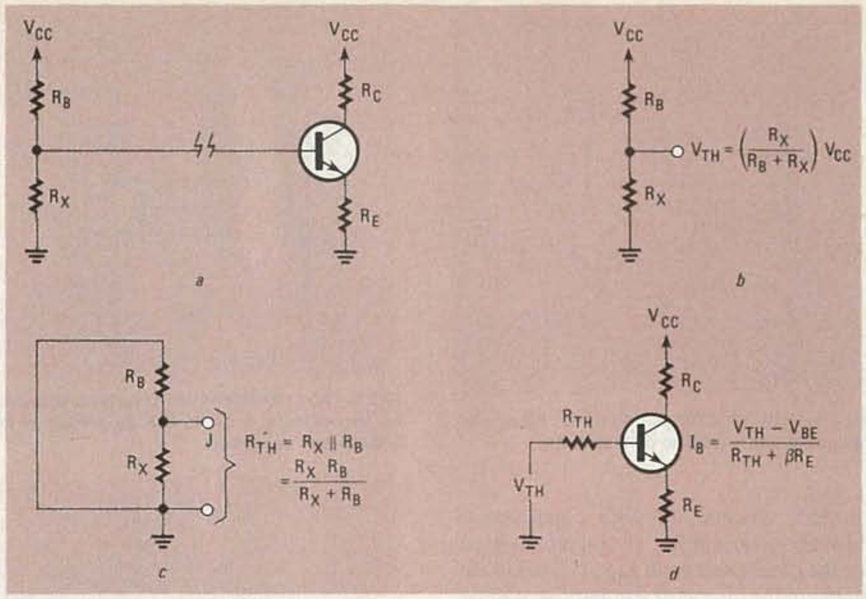


FIG. 4—TO EVALUATE THE BASE CURRENT of the circuit shown in Fig. 3, Thevenin's theorem must be used. The steps followed in applying that theorem are shown here.

The third step, as shown in Fig. 4-c, is to short the supply to ground and determine the *Thevenin resistance,* R_{TH}. That is the resistance seen when looking back toward R_X; in other words, the resistance between the junction "J" and ground. In this case, it is the parallel combination of R_X and R_B, which, of course, is equal to $R_XR_B/(R_X + R_B)$.

The fourth, and final step, shown in Fig. 4-d, is to reconstruct the original circuit, substituting V_{TH} for V_{CC}, and R_{TH} for R_B and R_X. The Thevenin voltage, V_{TH} and the Thevenin resistance, R_{TH}, are connected in series with the base of the transistor as shown. The base current can now be calculated from the formula:

$$I_B = \frac{V_{TH} - V_{BE}}{R_{TH} - \beta R_E}$$

The value of V_{BE} is usually .017-volt for a silicon transistor, and 0.2- to 0.3-volt for a germanium device. Once you've calculated I_B, the collector current is simply βI_B.

In this type of circuit, the effect of leakage current, I_{CBO}, is reduced because some of it is diverted from the base-emitter junction to R_X. A good rule of thumb to use when designing this type of circuit is to make R_X equal to less than ten times the size of R_E.

As we mentioned earlier, there are two basic types of bias circuits. So far, all of the circuits we've examined were variations of one type. Let's now turn our attention to the second type. It is shown in Fig. 5. Here, R_B is connected to the collector of the transistor being biased instead of to V_{CC}. In that circuit, negative feedback from the collector to the base acts to reduce the value of the stability factors, a desirable result. In determining the operating point, the simplest approach is to again use Thevenin's theorem. Just adapt the method described for the circuit in Fig. 3 to this circuit, using the value of V_{CE} that you are designing for instead of V_{CC}. A reasonably accurate formula for determining collector current is shown as equation 13. Note that R_C and I_{CBO} are included in the equation. Stability factors for this circuit are shown in equations 14, 15, and 16.

$$I_C = \frac{\beta[R_XV_{CC} + I_{CBO}(A + R_XR_B)]}{\beta A + R_XR_B} \qquad (13)$$

$$S = \frac{\beta(A + R_XR_B)}{\beta A + R_XR_B} \qquad (14)$$

$$S_E = \frac{\beta R_X}{\beta A + R_XR_B} \qquad (15)$$

$$S_\beta = \frac{(R_XV_{CC} + R_XR_BI_{CBO})(A + R_XR_B)}{(\beta A + R_BR_X)^2} \qquad (16)$$

Where $A = R_ER_C + R_ER_B + R_ER_X + R_XR_C$).

Those current and stability equations can be applied easily, with just slight modifications, to the circuit in Fig. 3. In equations 13 through 16, R_C is an important factor in determining the bias. It plays no part, however, in determining the stability and quiescent current for the circuit in Fig. 3. When applying those equations to that circuit, let R_C equal 0. That eliminates all terms containing R_C. If, in addition to setting R_C equal to 0, R_X was made infinite by removing it from the circuit and R_E was made equal to 0, or

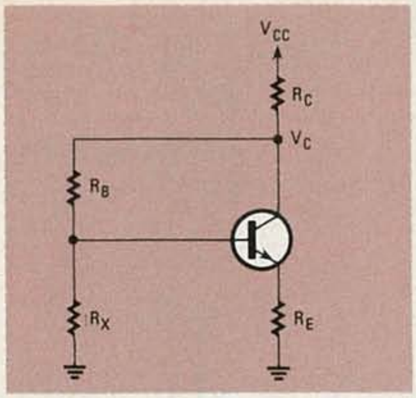


FIG. 5—THIS CIRCUIT is one of the many variations of the two basic bias circuits.

shorted, we end up with equations 6 through 9; those were, as you recall, used for the circuit shown in Fig. 1. Should R_E be left in the circuit, the equations will be identical to equations 10, 11, and 12, Thus, equations 6 through 12 are simply variations of equations 14, 15, and 16.

There are many variations of the simple circuits we have presented thus far. One of those is to remove R_X from the circuit of Fig. 5. That does reduce stability somewhat, however. Equations 13 through 16 still apply, but are modified by removing all terms containing the expression R_X.

Temperature compensation

Base-emitter voltage variation with temperature is an important consideration, especially in power circuits, because in those the temperature of the transistors tends to increase by a considerable amount. The circuit most-commonly used to compensate for that is shown in Fig. 6.

Diode D is placed into the circuit as shown so that it is always on. The diode used should have the same voltage/temperature characteristic as the forward biased base-emitter junction of the transistor. It should also be placed close to the transistor so that both of their temperatures will vary in a similar manner. With this configuration, the voltages across the diode and the base-emitter junction are always identical. Because of that, the voltage across R_E and R_X are also always identical, regardless of any changes in V_{BE} caused by temperature. Thus stability is improved.

The final variation we'll discuss here, is the one shown in Fig. 7. In most bias circuits, R_E is connected between the emitter and ground. Here, however, a battery or other voltage source, V_{EE}, is inserted between the emitter and ground. As a result, the base current, I_B is approximately equal to $V_{EE}/(R_X + \beta R_E)$; the collector current, as usual, is equal to βI_B. The stability factors for that circuit are essentially the same as those calculated using equations 10 through 12. When applying the equations here,

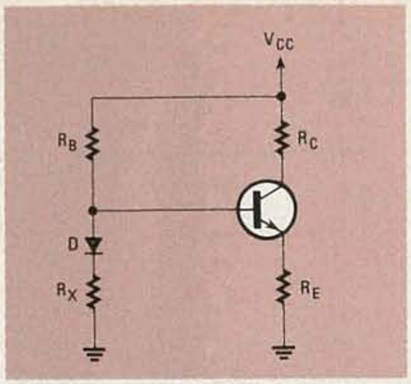


FIG. 6—TO COMPENSATE for variations caused by temperature, a diode can be placed in the base circuit as shown.

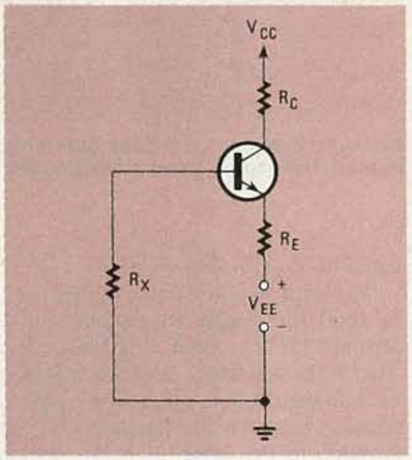


FIG. 7—IN THIS VARIATION, a battery or other voltage source is inserted between the emitter and ground.

however, substitute V_{EE} for V_{CC}, and R_X for R_B.

In summary, as a general procedure when designing bias circuits, first determine the ideal quiescent collector voltage and current. Divide the collector current by β to find approximately what the base current should be. Next design a base circuit to establish those conditions. Remember that those conditions should be relatively insensitive to temperature changes, as well as parameter variations from device to device. To make certain that they are, you must check the stability factors. Any of the circuits we've discussed, as well as many other variations, can be used when biasing bipolar transistors. You must determine how much operating point instability your design can tolerate. Start with the simplest circuit and calculate the stability factors. If collector current variations due to these factors are too great, increase the complexity one step at a time. Never go beyond the simplest circuit you can use to satisfy your requirements.

Biasing JFET's

Gates of n-channel JFET's are usually made negative with respect to the source. But, as no gate current flows if the gate is made just slightly positive with respect to the source of a JFET, up to +0.5 volt may be placed at the gate. Two arrangements used for establishing the proper bias voltage are shown in Fig. 8.

In Fig. 8-a, drain current, I_D, flows through R_D and R_S. Thus, the source current, I_S, and I_D are equal to each other. A voltage equal to $I_D R_S$ is developed across R_S. That voltage is called V_{RS} and has the polarity shown.

A leakage current, I_{GSS}, flows from the gate to the source. The value of I_{GSS} at 25°C is often found on the specification sheets of the device. That leakage current, however, increases with temperature—usually doubling with each increase of 10°C. The leakage current flows through R_G, developing a voltage, V_{RG} equal to $I_{GSS}R_G$. The polarity of that voltage is also shown in Fig. 8-a.

Voltage between the gate and source is equal to $V_{RS} - V_{RG}$. The value of V_{RS} is usually adjusted to be larger than the value of V_{RG} so that the gate will be biased negative with respect to the source. That's how the bias for the circuit shown in Fig. 8-a is established.

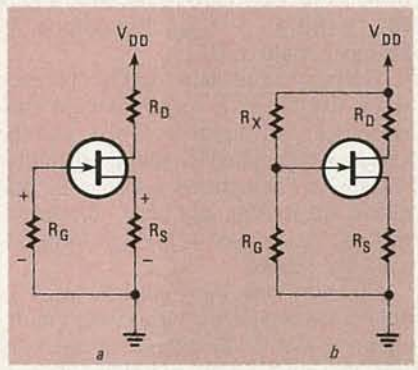


FIG. 8—EITHER OF THESE CIRCUITS can be used when biasing either JFET's or MOSFET's.

The source resistor is an important factor in enhancing the stability of the circuit as it is used to counteract any increase of I_{GSS} caused by a change in temperature. Circuit stability can be improved by increasing the size of R_S. But there is a limit to this. Should R_S be increased too much, the voltage developed across it can be high enough to bias the transistor near or at pinch-off. That is, of course, undesirable. The value of the source resistor must be chosen so that the proper bias point is established when the voltage developed across R_G is subtracted from the voltage developed across R_S.

A larger source resistor can be used with the circuit shown in Fig. 8-b. In that circuit, a sizable positive voltage can be developed across R_G due to the presence of $+V_{DD}$ and the action of the voltage divider made up of resistors R_X and R_G. That positive voltage is increased somewhat by the presence of leakage current I_{GSS}. To determine the gate-to-source bias voltage, subtract the voltage de-

continued on page 102

STEREO IMAGE EXPANDER

Add an extra dimension to your recorded music with this Stereo Image Expander. Build it and hear what you've been missing.

JOEL COHEN

Part 2 IN THE FIRST PART OF this article, we looked at the theory behind the Stereo Image Expander. This time we'll apply what we've learned and build our own.

Assembly

A foil pattern for the expander PC-board is shown in Fig. 11, and a parts placement diagram in Fig. 12. Figure 13 will also help you in completing the board. Some of the instructions here pertain specifically to the parts supplied with the kit available from the supplier indicated in the Parts List, but may also be applicable to you if you're building from scratch.

Pin 1 of each IC is indicated by an indented dot and all but IC5 are mounted with pin 1 facing towards the rear of the board. The bucket-brigade device, IC6, is subject to damage from static charge—it's a good idea to be sure that you are grounded before handling it. The use of IC sockets is recommended.

The BBD, incidentally, can be either an SAD512 *or* SAD1024—the pinouts are identical. The SAD1024 contains two SAD512's, and one of them will simply not be used.

Be sure to observe the polarities of the electrolytic capacitors and diodes. Note that regulators IC1 and IC2 are mounted with their center leads bent back toward the curved part of the package, while the transistors they resemble have their center leads bent slightly forward, toward the flat sides of the packages. Don't forget the two jumpers shown in the parts placement diagram.

The transformer must be installed with pins 1 and 2 toward the rear of the board. Bend the two mounting tabs away from the transformer and solder them to the foil side of the board. If you are using the phono jacks provided by the supplier shown in the Part List, cut off the plastic tabs at their rear corners before attaching them and be sure they are firmly seated parallel to the board before soldering. The switch bodies must be spaced .093-inch above the top of the board if the cabinet supplied with the kit is used. If the switches do not have shoulders on their mounting pins, use three plastic spacers over the pins at the front of S3 and the rear of S1 and S2. Be sure the switches and IMAGE control are seated parallel to the board so they will fit into the holes in the chassis.

To mount the LED, bend its leads at a 90° angle while holding it towards you with the anode lead on your right. Solder it in so that the bend is ½-inch above the top of the board. Install the completed board in its enclosure, and attach the line cord. Be careful of stray strands of wire, especially near the grounded board-mounting screw at the rear corner.

Alignment

Only one adjustment is required; the BBD bias which is set by R7. There is about a 2-volt window for signals to pass through the BBD and the bias is set for the center of that range so that the maximum peak-to-peak signal can pass through without clipping. There is enough headroom in the design of the expander to allow for individual IC variations if the bias is simply set to +3.5 volts.

If you want to "fine tune" the expander, apply about 1.5-volts RMS at 1 kHz to just the left input and observe the waveform present at jumper J1. If the bias is too high, the top of the sinewave will be clipped; if it's too low, the bottom will be clipped. At the optimum setting the waveform will be just slightly clipped at both top and bottom.

Rooms and loudspeakers

While most of us would find it difficult to tell the difference between one amplifier and another by ear, we all know that different speaker-systems have different qualities and that the sound from a particular system can vary depending on where it is located in a room. Most of the sound energy reaching our ears comes not

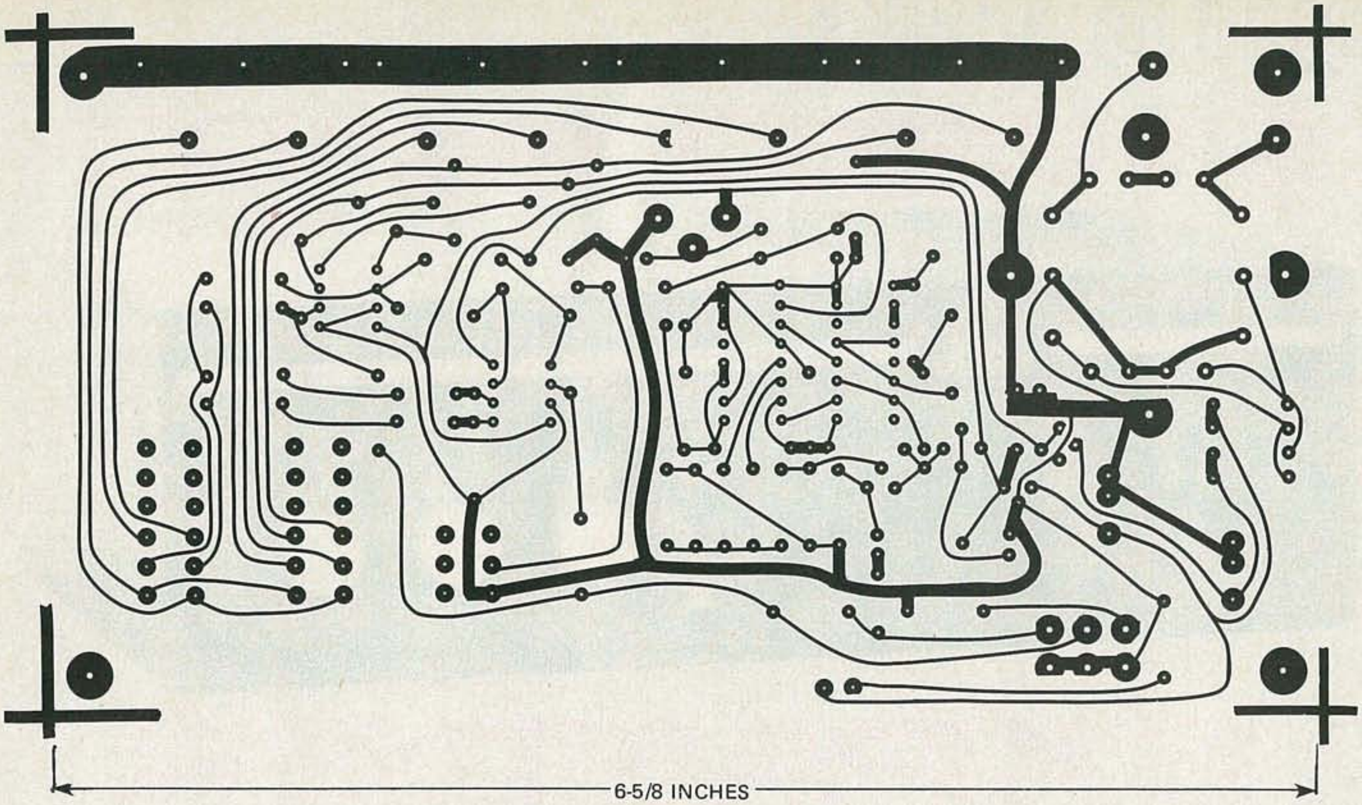


FIG. 11—STEREO IMAGE EXPANDER is constructed on single-sided PC board. The use of IC sockets is recommended.

directly from the speakers, but from secondary reflections of the sound from the walls, floor, and ceiling. The frequency response of that sound energy is shaped by the absorption characteristics of the surface it reflects from. The stereo image, however, is formed entirely by the first-arrival sound traveling directly from the loudspeakers to our ears.

Several conditions are needed for a good stereo image, and they are the same whether that image is expanded or not. First, the listening position must be the same distance from each speaker so that each ear hears its own speaker first. It is also helpful to point the speakers in toward the listening position. Second, the first-arrival sound from the speakers should precede the arrival of the first *reflected* sound by as long a time as practical, with one or two milliseconds being the minimum. That usually requires that the speakers be two feet or more from any wall or large piece of furniture and no more than 10 or 12 feet from the listening position. Third, the two speakers should be separated by an angle of 40°; that is, an imaginery line drawn to each speaker should form a 20° angle with one drawn from the listener to a point directly between them. That means that the distance between the centers of the two speakers should be 7/10 of the distance from each speaker to the listening position. Fourth, the speakers must be connected in phase. The easiest way to test that once they are positioned is to tune in some FM interstation hiss or a monophonic program. If the speakers are in phase the sound will appear to come from a point directly between them. If they are out of phase, it will seem to come from the sides, or from each speaker individually. If the apparent source is diffuse, the speakers should be repositioned as described above and again checked for phasing.

Finally, the speakers themselves must produce a sharp coherent wavefront.

PARTS LIST

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

R1, R6, R14, R16, R17—1000 ohms
R2, R4, R25, R26, R30, R31—100,000 ohms
R3, R5—47,000 ohms
R7, R15, R23, R24, R27-R29—20,000 ohms
R3, R5—47,000 ohms
R7, R15, R23, R24, R27-R29—20,000 ohms
R8—100,000 ohms, PC-mount potentiometer
R9, R13—4.7 ohms
R10, R20, R22, R34—4700 ohms
R11—100 ohms
R12—2000 ohms
R18, R19—10,000 ohms
R21—100,000 ohms, potentiometer, audio taper
R32, R33—390 ohms

Capacitors

C1, C2—470 μF, 35 volts, electrolytic
C3, C4, C6-C8, C12—0.1 μF, ceramic disc
C5—47 μF, 16 volts, electrolytic
C9, C17, C18—0.01 μF, axial ceramic or ceramic disc
C10, C13, C16—10 μF, 16 volts, electrolytic
C11—100 pF, axial ceramic or ceramic disc
C14—390 pF, axial ceramic or ceramic disc
C15—1500 pF, axial ceramic or ceramic disc

Semiconductors

IC1—LM340L15, 15-volt positive regulator
IC2—LM320L15, 15-volt negative regulator
IC3, IC4—MC4558 dual op-amp
IC5—CD4049 CMOS hex inverter
IC6—SAD512 or SAD1024 N-channel bucket-brigade device (Reticon. Also Radio Shack 276-1761.) (See text.)
Q1, Q2—2N2222, 2N3904 or similar
D1-D4—1N4002 or 1N4003
LED1—jumbo red LED
T1—35 volts, center-tapped, PC-mount (Dale PL-12-09 or similar)
S1-S3—pushbutton switch assembly: 3 DPDT or 1 DPDT, 2 4PDT (Schadow F-series or Centralab PB20-series)
J1-J8—RCA-type phono jack, right-angle PC-mount

Miscellaneous: PC board, IC sockets, enclosure, line cord, strain relief, hardware, etc.

The following are available from Sound Concepts, Inc., P.O. Box 135, Brookline, MA 02146: assembled and tested IR2200 stereo image expander, $169.00; kit of all parts (KIR-1), $95.00; PC board (KIR-2), $16.00; T1 (KIR-3), $7.50; all pots, knobs, switches and jacks (KIR-4), $12.50; all semiconductors and sockets for them (KIR-5), $19.00. Please add $2.00 for shipping and handling; MA residents add 5% sales tax. If at all possible give street address for UPS delivery. Please add 10% ($5.00 minimum) for parcel post outside continental U.S.A.

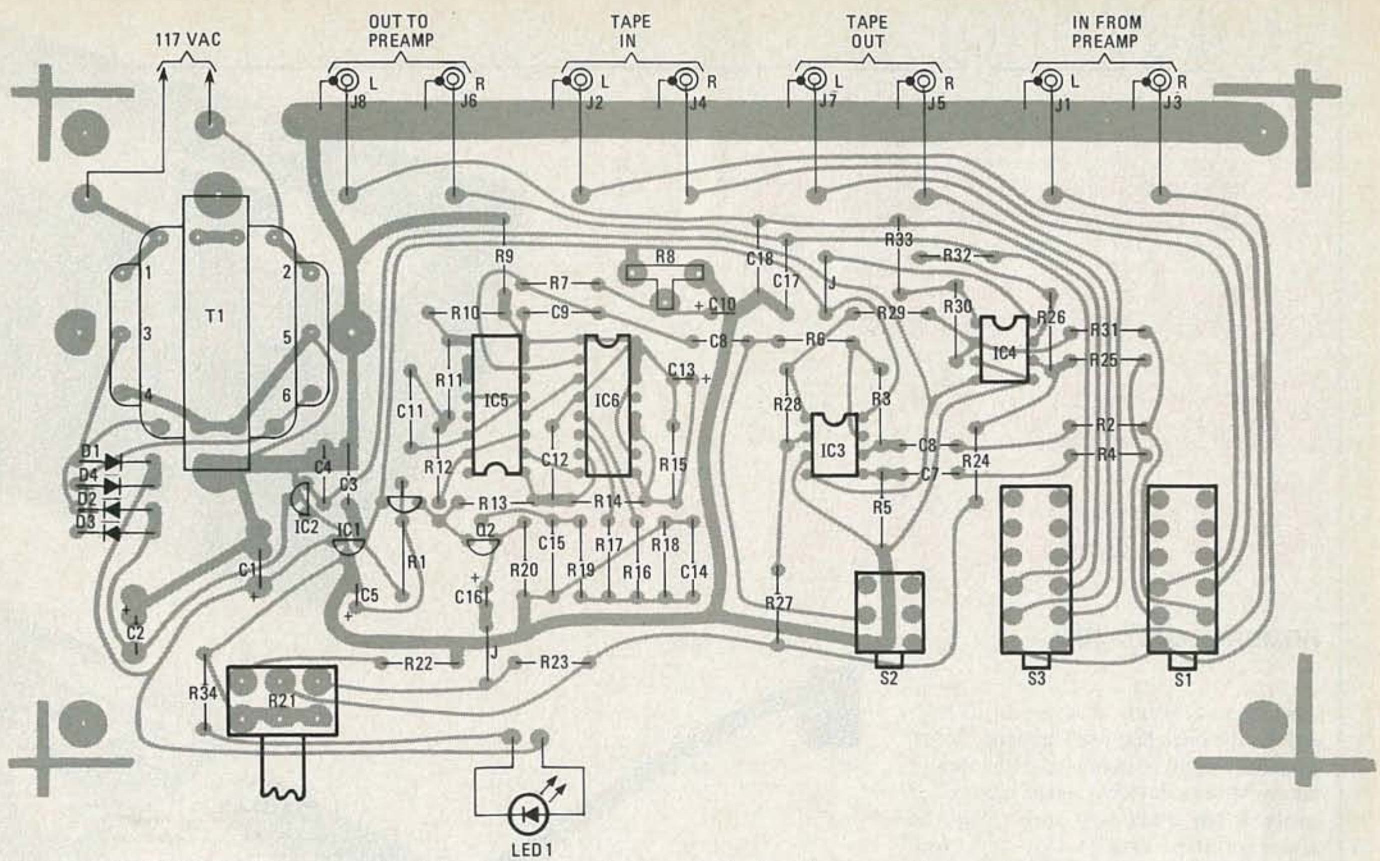


FIG. 12—PROVISION IS MADE for mounting right-angle input and output jacks directly on board.

Two- and three-way speaker systems with a single in-line vertical array of drivers usually work best. Omnidirectional speakers, or those with multiple drivers covering the same frequency range, cannot create as sharply focused an image.

You can actually check all this out before trying an image enhancer. Using a mono signal to get a tightly focused single sound-source located between the speakers is the best and easiest way to judge the imaging capability of your speakers in your listening room. Once you are set up correctly, you will probably be impressed with how much better your stereo system sounds—even without expansion.

Installation and use

The stereo image expander is intended to be connected in the tape-monitor loop of your preamplifier or receiver. Provision is made in the expander for connecting a tape recorder. The recorder can be used in the normal manner when the preamp's tape-monitor switch is on and S1 of the expander is in the TAPE position. Image-enhanced tapes that can be played back *without* the expander can be made when S3 is in the REC position. You should never have S1 and S3 pushed in at the same time since that effectively connects the recorder's output back to its input.

The recorder-output jacks from your receiver or preamp should be connected to the INPUT FROM PREAMP jacks, J1 and J3, on the expander and the OUTPUT TO PREAMP jacks, J6 and J8, to your tape-input or tape-monitor jacks. The expander's TAPE OUTPUT jacks, J5 and J7, are connected to the line-input jacks on the recorder and its line-output jacks connected back to the TAPE INPUT jacks, J2 and J4, on the expander.

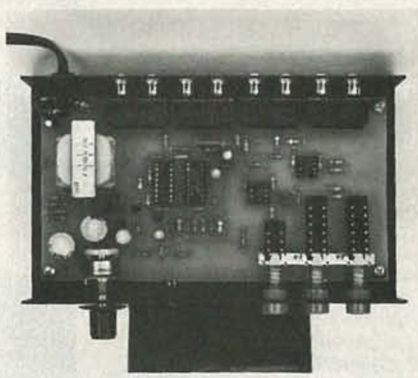


FIG. 13—NOTE HOW LED is mounted *above* the board, not flush with it. All components including transformer and switches, are soldered to board.

If you are using two tape-loops and two recorders, place the expander in loop 2. To play unenhanced tapes through the expander, use the tape-monitor switch corresponding to the loop the recorder is in. With S1 in the TAPE position, the signal comes directly from the recorder connected to the expander, and in the SOURCE position the signal is supplied by the receiver or preamp. If the expander is in loop 2 and you want to listen to the recorder in loop 1, either engage both tape monitor switches or—if you have them—the TAPE MONITOR 2 and DUB 1 TO 2 switches on the preamp or receiver.

If you have other signal processors in your system the expander should be the last one in the chain so that there is a minimum loss of phase integrity. If, for example, you already have an equalizer in your tape loop with a recorder plugged into it, plug the expander into the equalizer's tape jacks and the recorder into the expander's tape jacks. The expander can also be connected to the external-processor loop or between the preamp and power amp if you don't wish to use it for recording.

Listening

Before you make a critical evaluation of the stereo image expander's capabilities, make sure your system is set up as described earlier. Start with a record or tape of a good live or concert hall performance, preferably of a large orchestral work so you have a realistic frame of reference. (Most of the recent Telarc records have excellent imaging.) You may want to turn up the image level slightly with some other records, particularly those that were originally recorded using multiple-mike techniques and whose

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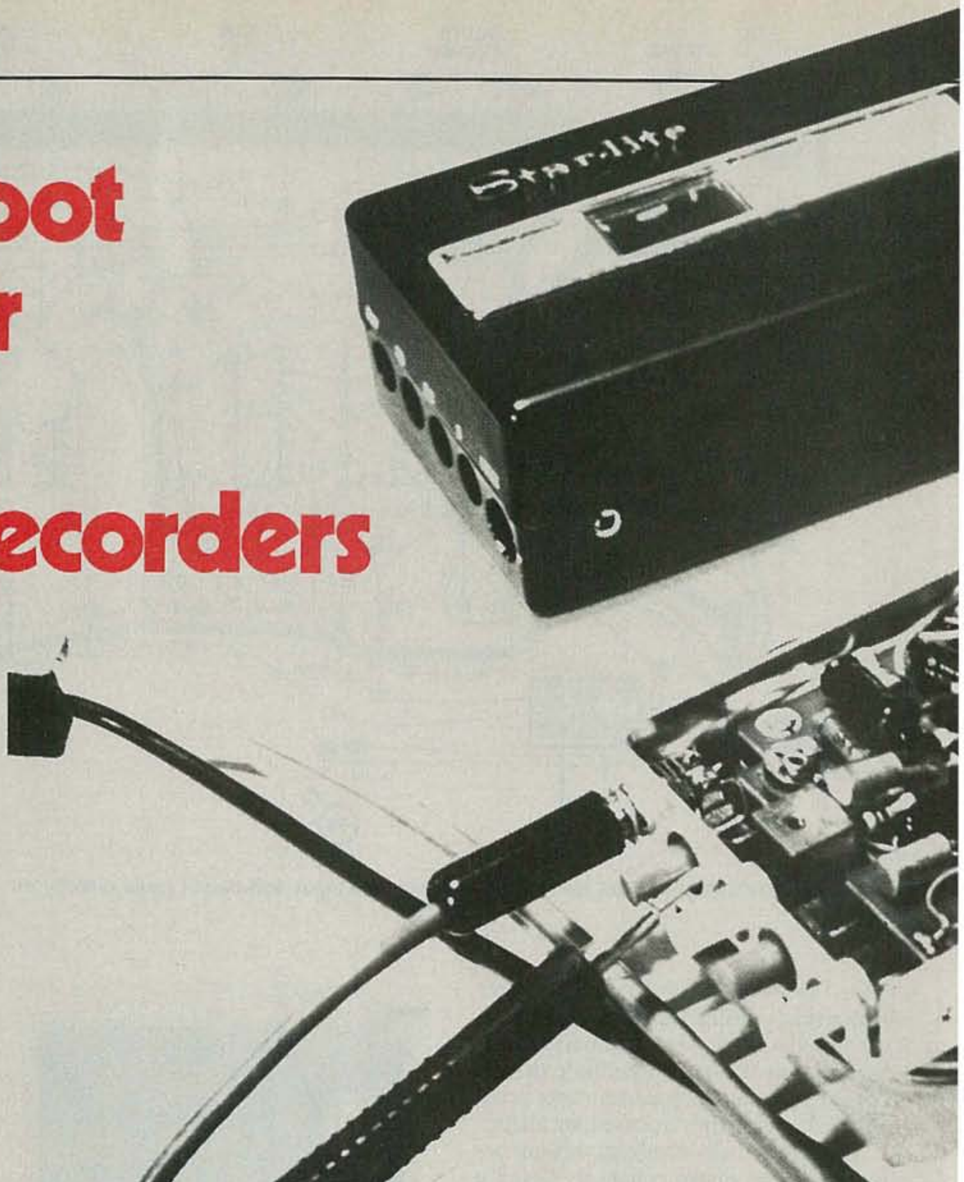
Troubleshoot and Repair Portable Cassette Recorders

HOMER L. DAVIDSON



PORTABLE CASSETTE PLAYERS AND RECorders (the ones that use standard Philips cassettes, not to be confused with mini- or micro-cassette devices) can be repaired as easily as any other tape units. Don't be afraid of their small size—the components may be a little closer together and you may have to work in a tighter space, but that's all. Servicing them can be easy when you follow the tips and information here.

If you have a well-equipped workbench you shouldn't need much in the way of additional equipment. If you don't have one, a take-up torque gauge may be needed for mechanical components. A VTVM (*V*acuum *Tube* *V*olt-*M*eter) will do nicely for making head-azimuth adjustments, and for troubleshooting the amplifier section, you can use your signal generator, signal tracer, and scope.

Cleaning and lubrication

Most sound and speed problems can be solved by a good clean-up and "lube job." A dirty record/playback head may be responsible for weak and distorted sound, and under- (or over-) lubrication can cause tape-speed to vary erratically.

When a recorder develops speed or sound problems, it's time for a cleanup and lubrication. Start at the erase and record/playback heads and clean them with alcohol and a soft-tipped cleaning stick. Critical points for cleaning are shown in Fig. 1. *Do not* use rubbing alcohol—it contains an additive that may leave a gummy deposit. Use pure isopropyl alcohol (available at your drugstore's prescription counter). If some oxide is packed into the gap area of the record/playback head, gently use the round end of the cleaning stick to remove it. You can get at the heads easily by putting the recorder in the RECORD mode; that moves them out into the open.

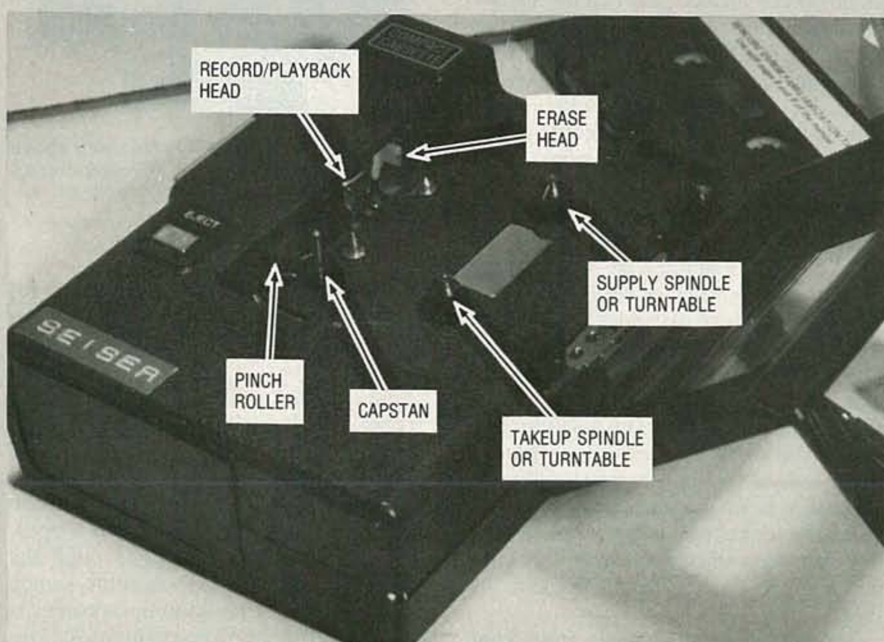
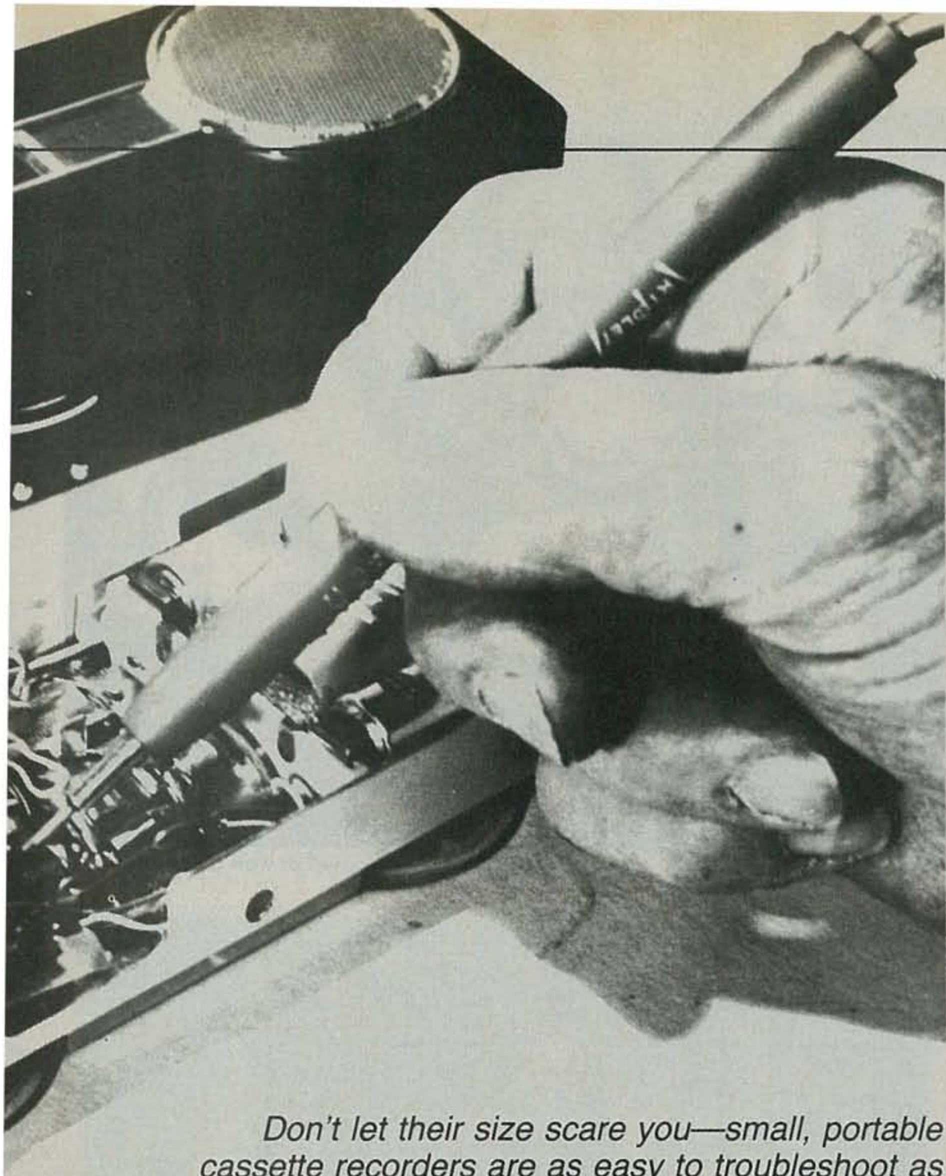


FIG. 1—CRITICAL POINTS FOR CLEANING are indicated above. A good cleaning can be all that's needed to solve many problems.



Don't let their size scare you—small, portable cassette recorders are as easy to troubleshoot as their larger brothers. Here are a number of hints and kinks to help you out.

You may find more oxide on the pinch roller and capstan than on the tape heads. Remove it with alcohol. Apply a drop of light oil to the pinch-roller bearing and wipe off any excess. Also, always dry off parts that have been cleaned with alcohol since it can damage many rubber and plastic components if it remains on them too long.

If the capstan flywheel appears sluggish, remove it and clean it with alcohol. Also clean around the flywheel-bearing area using a cleaning stick dipped in alcohol. Place a drop of oil upon the capstan bearing and replace the capstan. Wipe off any excess oil with a paper towel or cloth. Clean the capstan-drive area well to remove any remaining oil.

A dry capstan-bearing may be responsible for erratic or slow tape motion, and noisy and squeaky sounds may be caused by dry motor or pulley bearings. Excess oxide on the pinch roller can also be the cause of slow speed or tape pulling. Oil on any drive surface may produce slow—or no—motion in the parts it contacts. Erratic bunching of tape from the cassette may be caused by a drop of oil on the drive surface of the take-up turntable.

All rubber or plastic drive-pulley surfaces should be cleaned with a cleaning stick, and a drop of light oil placed on the pulley bearings. Any excess oil should be wiped off. All sliding parts should receive a thin coat of light grease. Finally, most motors have sealed bearings and never needed lubricating.

After cleanup and lubrication, it's always a good idea to demagnetize the record/playback head to insure best frequency-response, and then to check the unit out to see how it performs.

Now we'll discuss some commonly encountered problems, and their causes and remedies.

No play or fast-forward

When the recorder's in the PLAY or RECORD mode, the capstan and pinch roller pull the tape across the record/playback head, with the takeup turntable causing the tape to be wound on the cassette's takeup hub. In FAST FORWARD, the tape moves in the same direction, but the takeup turntable runs at a faster rate of speed; the capstan and pinch roller are disengaged. It's possible for one defective component to affect *all* of those functions.

If the capstan or tape will not move with the PLAY switch engaged, check for a defective ON/OFF switch. Hold the unit close to your ear and see if you can hear the motor running. If the motor is dead, check the power switch and see whether the voltage is being applied to the motor. If the motor is operating, check for a loose or broken drive belt. If the unit works on AC, but not from its batteries, make sure that batteries are not weak or dead.

Erratic fast-forward action can be caused by a dirty, worn, or binding turntable. Check for oil on the idler wheel or drive pulley (see Fig. 2).

Sometimes the fast-forward lever may bend and not permit the drive pulley to engage the capstan. Check for a weak spring or an out-of-position lever mechanism. A good cleanup of the take-up turntable and a drop of oil on the drive pulley bearing may cure erratic fast-forward motion.

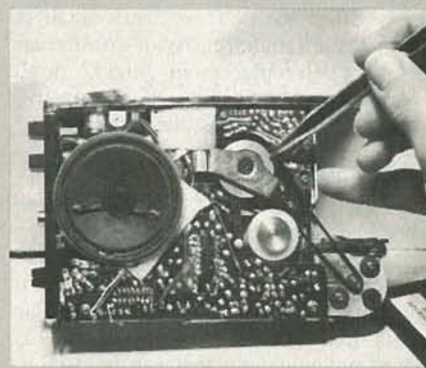


FIG. 2—FAST-FORWARD problems may be caused by oil on the idler pulley or capstan/flywheel.

No rewind

If a recorder/player operates normally in the PLAY and FAST FORWARD modes, but not in REWIND, suspect that the idler or drive pulley is not engaging the supply turntable. In some units the idler pulley gets shifted to the left and rotates the supply spindle in the opposite direction. A dry or worn supply turntable may be the cause of erratic rewind, as well as of slow speeds.

To remedy erratic rewind, remove the supply turntable and clean it with a cloth dampened with alcohol. Don't forget to dry it off afterwards. Place a drop of light oil on the turntable bearing, and then replace the turntable. Clean the rubber or plastic drive area with alcohol and use a cleaning stick to clean off the idler or drive-pulley surface area. Also check for a worn or binding idler-pulley.

If a loud chattering noise is heard when the cassette is almost rewound, suspect dry hub areas in the cassette itself. A tiny drop of oil in the plastic hub area may help, but be careful; you don't want to ruin the tape.

Slow speed and wow

Slow-speed problems may be caused by a dry-capstan-bearing or by oil on the drive surface. A dry or worn pinch roller can also be responsible for slow speeds or wow. Replace the pinch roller if you find it's out of round after cleanup. (A defective pinch roller can also cause the tape to ride high or to pull from the cassette.)

Check for a loose drive belt, or oil on it, when wow or slow-speed symptoms are noted. You may find that the motor belt slips right at the drive-motor pulley. Some of the important points to check are shown in Fig. 3.

Also, look for a black area or small particle of rubber on the motor pulley; those signs indicate that the belt is slipping. Since the belts are very small in diameter and stretch easily, it's best to use an exact belt replacement. Finally, don't overlook the possibility of a defective cassette being responsible for wow.

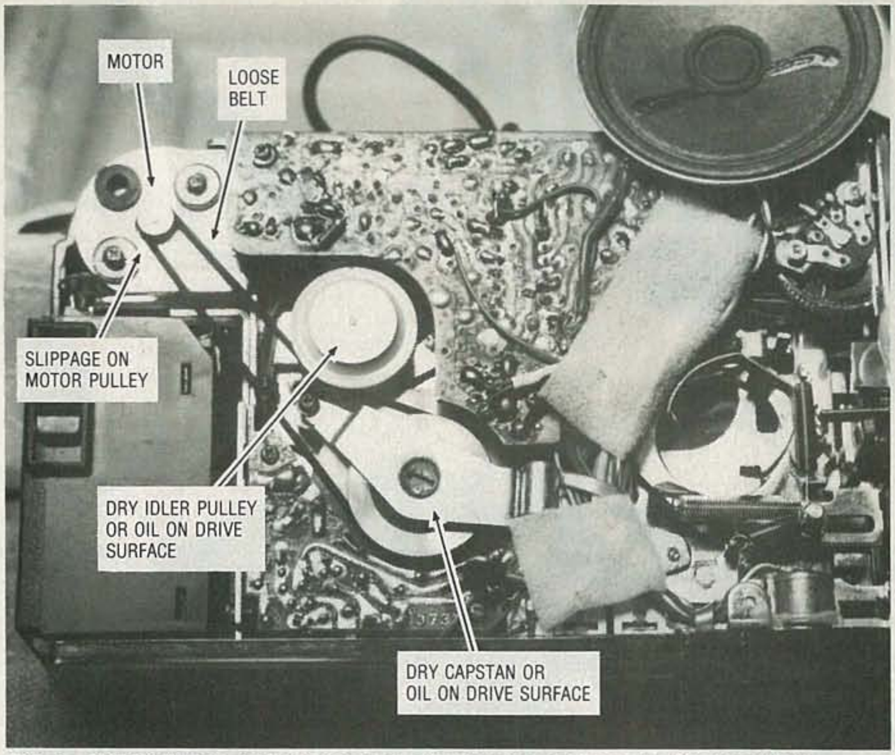


FIG. 3—CHECK THESE AREAS if you are experiencing slow-speed or wow problems.

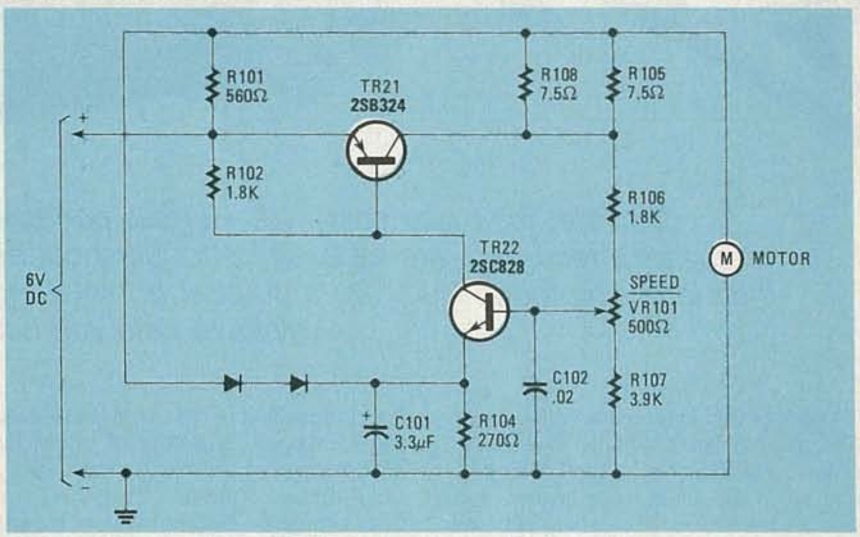


FIG. 4—MOTOR-SPEED CONTROL circuit used by J.C. Penny *model 6541*. Circuits in other recorders should be similar.

Check the motor

A defective motor can cause slow speed and wow conditions. Generally, a defective motor will start at normal speed, and then slow down. Sometimes if you tap the motor housing, it will speed up again. In most units you will find a motor-speed potentiometer that can be used to adjust the speed over a certain range. If the speed adjustment has no effect, check the speed-control circuit and motor. (A typical circuit is shown in Fig. 4.)

In some cases you may find that the motor is running too fast. Adjust the speed control, using a piano or music selection as a reference. You can also use a frequency counter to determine the correct speed.

If the motor is still running too fast, see whether the belt is riding too high on the motor pulley. If none of the above adjustments help, install a new motor, using an exact replacement.

Pulling and bunching tape

Bunching and unraveling of tape in a cassette player may be caused by an erratic or inoperative take-up turntable. The take-up turntable or spindle winds the tape coming from the capstan into the cassette. When the take-up spindle becomes dirty or starts to bind, the excess tape will bunch up and pull out of the cassette. Remove the take-up turntable and clean it with alcohol. Apply a drop of oil to the bearing area. Also, clean the turntable-drive area. Check the idler and drive pulleys for oil or dirty drive-surfaces.

Sometimes the pressure roller may become worn or out of round, and cause the tape to ride high and pull out of its proper path. In that case, try cleaning the pinch roller and capstan with alcohol. A bent capstan may also cause tape pulling.

If the take-up turntable, pinch roller, and capstan appear to be normal and the player is still pulling tape, check the take-up torque with a torque gauge. Finally, remember that a defective cassette can cause tape to unravel or bunch up.

No sound

If the tape is moving but there's no sound, suspect the record/playback head or the amplifier section. Quickly rotate the volume control up and down and listen for a scratchy sound from the speaker. If you can hear some noise, it's an indication that the amplifier is working, so suspect the record/playback head. If you hear a loud hum with the volume wide open, check for a broken wire at the record/playback head. Since the head assembly moves forward every time the PLAY or RECORD buttons are pushed, the wires leading to it have a tendency to break with time.

To determine whether the record/playback head is defective, pass a small screwdriver-blade rapidly across the head area. You should hear a flutter from the speaker. If you don't, dismantle the player by removing both the top and bottom covers. Check the head connections for broken wires. Touch the screwdriver blade to the ungrounded side of the tape head. With volume wide open you should hear a loud hum; a loud noise would indicate that the tape head may be defective. Remove the cable-leads and measure the resistance of the head. Normally, that resistance will be between 50 and 800 ohms.

Defective components in the audio stages can be located with an audio-generator/signal tracer and through voltage measurements. Start at the first AF transistor and inject a 1-kHz signal to the base of each transistor. Step by step, check each stage. When the signal appears, you have located the defective stage. Check each transistor in the problem area for out-of-line voltages. (A schematic is a must when servicing cassette-recorder amplifier circuits.)

In some earlier units you may find five or more small transistors in the amplifier stages, while in present-day ones only one or two transistors may precede a power-IC output circuit. Such a circuit is shown in Fig. 5. To signal-trace the IC circuits, inject an audio signal at the IC's input pin and use the speaker as the indicator. To make sure the IC really is defective, measure the voltages at each pin. With correct voltages, but no signal from the IC, you can safely assume that the IC is defective. If the IC is leaky, even the supply voltage may be affected.

Weak and distorted sound

Weak and distorted sound may be caused by a dirty record/playback head. Clean the head with alcohol and a cleaning stick, as described earlier, before tearing into the amplifier. A weak battery or insufficient operating voltage can also affect the quality of the sound.

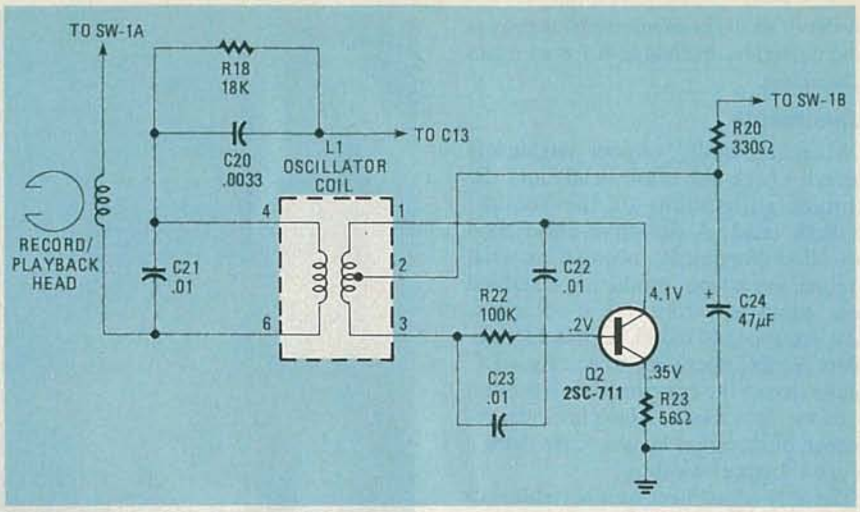


FIG. 6—RECORD OSCILLATOR CIRCUIT used by Sharp *model RD-428UA*. Use a scope on L1 to determine whether the oscillator is working.

The best method for locating a weak audio-stage is to inject an audio signal, with a scope connected to the output of the recorder/player so that you can observe the audio waveform. Start at the record/play-head connections. The signal should be the same on both sides of the electrolytic coupling-capacitor. (Most weak-sound problems are caused by small coupling-capacitors and transistors in the amplifier section.) If it is not, shunt a new capacitor across the suspected one and see whether the sound returns. Each transistor in the amplifier section should have a large gain from its base to collector terminals.

Excessive distortion may accompany a weak-signal condition. Most distortion in small amplifiers takes place in the output stages. In push-pull transistor output-circuits, an open or leaky transistor can produce weak and distorted sound. Since most circuits of that type are DC-coupled, check the driver or AF transistor for incorrect bias on the output transistors.

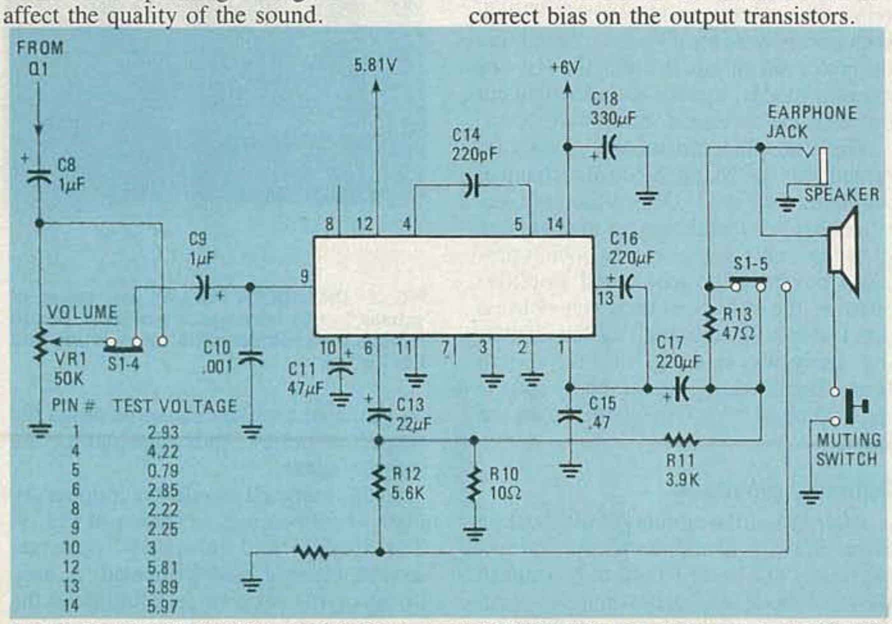


FIG. 5—IC OUTPUT CIRCUIT used in Sanyo *model M1000*. Voltages shown are typical for this unit but may be different in others.

Remove both transistors when distortion is located in a push-pull output circuit—it's best to check each transistor for leakage out-of-circuit. Before replacing the output transistors, check the emitter and bias resistors for correct values. Generally, a burnt emitter-resistor will be found along with a shorted or leaky output-transistor.

A leaky IC can also produce weak and distorted audio. Replace the suspected IC when no signal will pass through it or if incorrect voltages are measured at its pins. Use a wick-type solder absorber (like *Solder-Wik*) to remove the excessive solder from the IC pins to make removing the part easy. Then use a low-wattage pencil iron to install the new IC.

No record function

If the unit will play but not record, suspect a dirty PLAY/RECORD switch or defective record circuits. First, make sure the record/playback head is clean. Then spray the PLAY/RECORD switch with contact-cleaner. Work the switch back and forth to clean the contacts and then try to record once again.

Although most portable recorders do not have an oscillator stage to excite the record tape-head, you may run across one that does. A representative circuit is shown in Fig. 6. To determine whether the oscillator is operating, use the scope and check the waveforms at the primary and secondary windings of L1. Transistor testing of Q2 and voltage measurements can indicate whether the transistor is functioning properly.

Check for poor connections to the built-in microphone. Most built-in mikes are electret-capacitor types and require a DC-voltage to work, so test for that voltage at one of the microphone terminals. A defective microphone may be responsible for weak or erratic recordings. Substitute a dynamic microphone across the shielded wires to the built-in mike terminals (but do not connect it to the DC source). If the built-in microphone proves to be defective, exchange it for an exact replacement.

Adjustments

When "crosstalk" or poor playback is noticed, check the erase head, and the azimuth adjustment of the record/playback head. A defective erase head may allow previously-recorded material to remain on a tape, producing a garbled mess when new material is recorded. Most erase heads found in portable recorders are DC-operated. Check for a DC voltage across the erase head with the unit in the RECORD mode. Also check the resistance of the erase head in case there's an open internal winding.

The only adjustment on a portable recorder's record/playback head is for azimuth (elevation). The azimuth-adjustment screw is usually located on one side of the head, with a coiled spring underneath it. Connect a VTVM with an eight-ohm dummy load to the earphone jack. Insert a 3-kHz or 6.3-kHz test tape and start it playing. Adjust the azimuth screw for the highest reading on the VTVM. After that has been done, you may want to dab the adjustment screw with paint or glue to secure it in place.

The only other mechanical adjustments are for take-up torque and adjustment of the pressure roller. (You may find that either one or both adjustments are fixed in some models.) The pressure-roller adjustment can be made using a spring scale and changing the position of the pressure-roller spring to vary the tension it puts on the mechanism.

Take-up torque should be measured on the take-up turntable with a torque gauge while in PLAYBACK mode. Most take-up torque readings should be between 35-60 gr-cm. For greater tension, bend the tension spring and, if necessary, replace the take-up pulley. It's best to follow the manufacturer's service literature for correct tension adjustment.

Now let's take a look at some typical case histories.

Weak and distorted output

A GE *NBR-35311C* had weak and distorted sound. Although the symptoms indicated possible output-transistor problems, the tape head, pinch roller, and capstan were cleaned with alcohol as a matter of routine. The weak condition still remained, as expected.

When the back cover was removed we noticed that new batteries had been installed. Only 2.7-volts was measured at the adjustment transistors. Either the transistors were defective or something in the circuit was loading down the voltage source. A bench supply was connected to the player for servicing and everything worked normally. It turns out that one of the new batteries was practically dead, and the battery terminals were corroded. A good cleanup of the battery terminals and a set of fresh batteries solved the weak-audio/distortion condition.

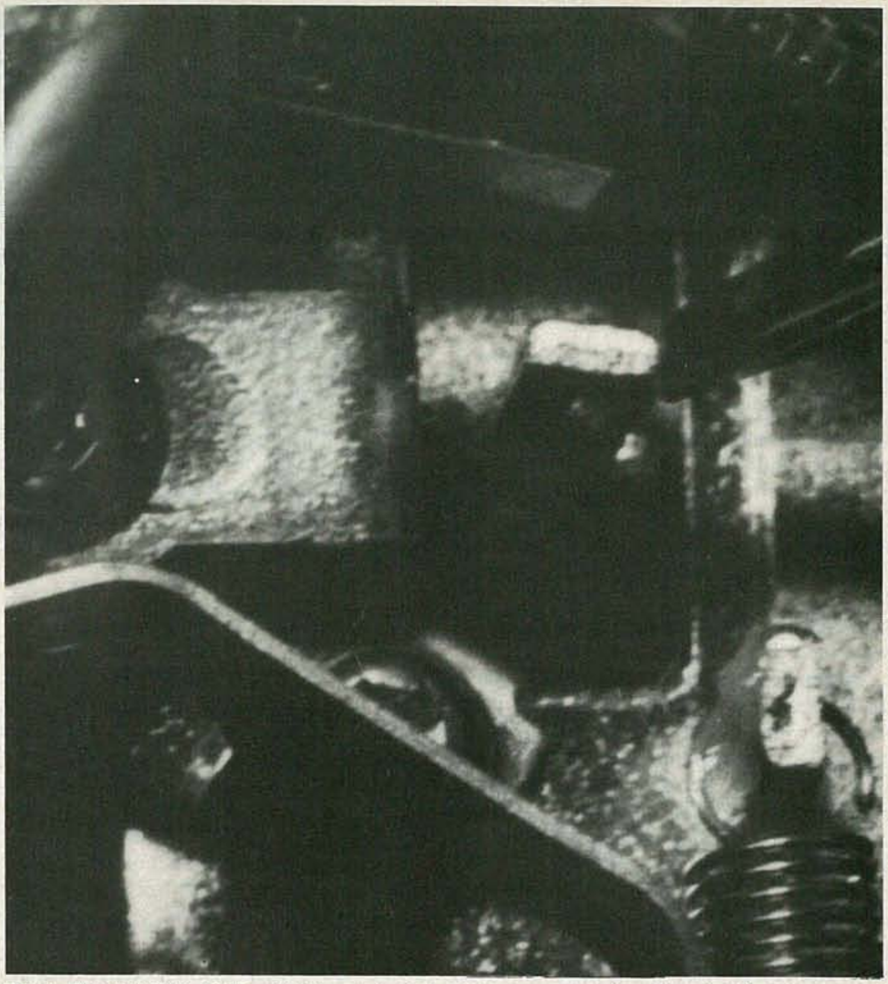


FIG. 7—THe UNINSULATED switch lever shorted out the power-supply voltage in this Sharp *model RD-428UA*.

No play, no record

In a Sharp *RD-428UA*, we found that the motor was turning, but we couldn't play or record. Both REWIND and FAST FORWARD modes were normal. When both covers were removed, we found that the motor did not run in either the PLAY or RECORD modes, and the sound would cut out with the volume control wide open.

The "no play, no record" symptom turned out to be an electromechanical problem (see Fig. 7). When the RECORD/PLAY switch's metal plunger touched one of the switch's leaf contacts, which provided power to the motor and amplifier circuits, the voltage source was shorted out. It seems that the small rubber insulating sleeve was missing from the switch lever. The problem was solved by epoxying a piece of large "spaghetti" over the lever.

Squeaky playback

After about five minutes of playback, a Sharp *RD-428* would develop a squeaking noise. The noise would only occur in the PLAY mode, and only when the wheel or pulley came around to a certain position. Sometimes by probing around with an insulated tool you can slow down the suspected pulley, thus eliminating the squeaky noise.

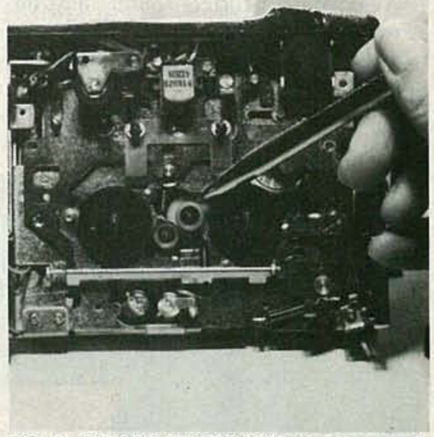


FIG. 8—DRY IDLER PULLEY was cause of squeak in this recorder. It's a good idea to remove the problem parts for cleaning and lubrication.

In this particular model we found a dry idler-wheel bearing, as shown in Fig. 8. The spindle and turntables were removed, cleaned, and lubricated. A drop of oil on the idler wheel eliminated the squeaking noise.

continued on page 107

ALL ABOUT PULSE GENERATORS

This month we'll look at another pulse-generator application, testing analog circuits, as well as some problems that you might run into when you use that device.

CHARLES GILMORE

Part 4 SO FAR WE HAVE CONfined our discussion to using the pulse generator in logic-circuit analysis. While that is one of the prime functions of the pulse generator, it is not its only one. Let's begin this month by looking at another area where the pulse generator is useful—testing and analyzing analog circuitry.

Analog circuits

Using a pulse generator as a signal source can simplify many of the measurements that are often made when testing analog circuits. That's because, generally speaking, pulse generators are useful over a very wide frequency range, which can come in handy when working with broadband amplifiers, etc.

For instance, a single, conventional, pulse generator is the only signal source you need to test an amplifier whose frequency response extends from below 1 Hz to considerably more than 10 MHz. Otherwise, testing that amplifier would require using an audio generator for the low end and an RF generator for the upper end, or perhaps a very wide-range function generator.

The reason for that becomes apparent if the nature of a pulse is analyzed. Such analysis would reveal that the pulse's fast rise and fall times are caused by the pulse's high-frequency components, while the interval between the rise and fall times (i.e. the top of the pulse) is caused by the low-frequency components; in some cases, the frequency of those components is so low that it is approaching DC. Those high- and low-frequency components are what gives the pulse generator its wide frequency range.

Frequency-response measurements on an amplifier are usually made at the 3-dB points; that is, the point at which amplifier delivers half its rated power output, or 70 percent of its rated voltage output. That 3-dB point is considered the upper and lower cutoff frequency of an amplifier. The simplest method to measure the low-frequency 3-dB cutoff is by adjusting the pulse generator so that the pulse *droop* is 25 percent. Pulse droop (the difference between the amplitude immediately following the leading edge and the amplitude at which the trailing edge begins) is expressed as a percentage of the amplitude at the leading edge (see Fig. 11).

When the pulse droop is adjusted to 25 percent, the width of the pulse is related to the frequency (in Hz) of the lower 3-dB point through the formula:

$$f_{low} \approx \frac{0.0456}{t}$$

where t is the width of the pulse. The constant (0.0456) is derived from a Fourier analysis of the pulse.

To measure the frequency of the upper 3-dB cutoff, the following formula is used:

$$f_{upper} = \frac{0.35}{t_r}$$

where f_{upper} is the upper 3-dB cutoff frequency (MHz), and t_r is the pulse risetime in nanoseconds.

While that formula has been idealized and is for a circuit where the product of the capacitance and inductance is 0, the formula will hold until that product exceeds 0.25. After that point, some overshoot begins to occur at the end of the leading edge, lowering the value of the constant, 0.35, in the formula. With overshoot of 25 percent, for instance, that constant would be lowered to 0.28.

Some additional information about the frequency response of a broadband amplifier can be obtained using a pulse generator. Remember that a pulse consists of a fundamental frequency plus a great number of even and odd harmonic components with specific phase relationships with each other, as well as with the fundamental frequency. If that phase relationship is not maintained, the waveshape of the pulse deteriorates. If an essentially stable pulse waveform is passed through an amplifier, the amplifier's output can be examined for any aberrations in that waveform. The presence of those aberrations indicates that the phase response of the amplifer is not uniform—i.e., that there are peaks and/or valleys in the amplifier's frequency-response curve. That would be caused by either leading or lagging reactive elements in the circuit. At that point, further analysis with a sweep generator or a low-distortion audio oscillscope is needed.

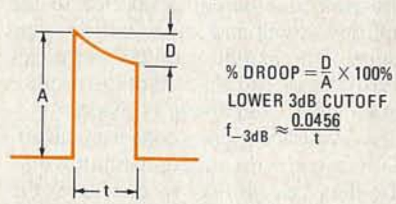


FIG. 11—PULSE DROOP is useful in finding the lower 3-dB point of an amplifier.

As noted earlier, rise-time measurements let you determine approximately the upper frequency-response limits of a broadband amplifier. A few precautions must be taken when making such rise-time measurements. One thing that must be considered is the effect of the test setup. Each part of that setup plays a role in determining the rise time of the output that is displayed; in other words, the rise time of the pulse is changed slightly as it passes through the various parts of the test setup. The displayed rise time, therefore, is actually a function of the rise times through each part of that setup and can be found from:

$$T_R = 1.1 \sqrt{T_G^2 + T_A^2 + T_P^2 + T_O^2}$$

where T_R is the display rise time, T_G is the rise time of the pulse generator, T_A is the rise time of the amplifier under test, T_P is the rise time of the probe, and T_O is the rise time of the oscilloscope.

Because of its exceedingly fast rise time, a pulse generator is extremely convenient for measuring propagation delay and phase delay. Both analog and digital circuits introduce some fixed time delay to signals that pass through them. For example, if a J-K flip-flop is clocked, it will take several nanoseconds for the results of that clocking to appear at the output of the flip-flop. That delay in response is called the propagation delay of the flip-flop.

Analog amplifiers also suffer from propagation delay. The easiest way to measure that delay is to use a dual-trace oscilloscope and a pulse generator. The pulse-generator output is applied to the amplifier's input and to one oscilloscope channel. The amplifier output is the applied to the second channel of the oscilloscope, and a comparison is made.

If a dual-trace oscilloscope is not available, you can use a pulse generator with a pulse-delay capability. In that case, the input to the amplifier is connected to the delayed generator output. The amplifier output and the non-delayed pulse-generator output are both applied to the oscilloscope. The pulse-delay control of the generator is then adjusted until a single pulse is obtained. The amount of delay neccessary to display the single pulse is equal to the propagation delay of the amplifier.

In order to successfully combine the amplifier output with the pulse-generator output, some series-limiting resistance must be used. Great care must be taken to insure that the added circuitry does not contribute additional phase shift. Figure 12 shows an example of such a situation.

Pulse generators are also useful in evaluating the high-frequency charateristics of diodes and transistors. The diodes used in either radio-frequency or digital applications are required to recover very rapidly from switches between reverse- and forward-bias.

When a diode is forward-biased, the area at the junction is filled with majority carriers. ("Majority carrier" is a term used in semiconductor electronics to describe the predominant type of carrier in a semiconductor material. In n-type material, the predominant carrier is the electron; in p-type material it is the absence of an electron, which is called a *hole*.) When the diode is reverse-biased, the junction has few majority carriers. Obviously, the change in the number of majority carriers at the junction can not occur instantaneously.

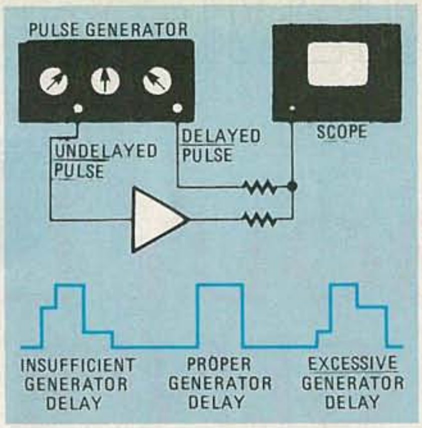


FIG. 12—A PULSE GENERATOR is used here to measure the propagation delay through an amplifier.

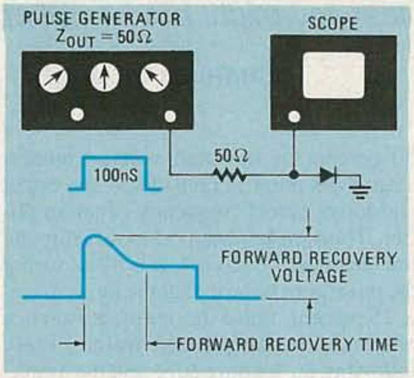


FIG. 13—MEASURING THE FORWARD recovery voltage and forward recovery time of a switching diode. The pulse generator should be set for a 100-nanosecond pulse width with a less than 1 percent duty cycle. The output voltage of the generator should be set to produce a specified steady-state current in the diode.

Let's first look at what happens when a diode is suddenly switched from reverse- to forward-bias. When that happens, the majority carriers move to the area around the junction. But, until that area is filled with those majority carriers, the voltage across the diode is considerably greater than its normal forward-biased voltage. That voltage *transient* is of concern if the diode is to be used in switching applications. Figure 13 shows a test setup that can be used to measure that *transient*, as well as the waveform that would be displayed on the scope. The size and duration of the transient can be found by inspecting the waveform as shown.

The forward-recovery specifications of a diode are normally given for some steady forward-current value, once the transient conditions have subsided. It is that forward current, combined with a 50-ohm resistor, that determines the pulse generator's output voltage; pulse duration should be 100 nanoseconds. A generator having a 10- to 20-nanosecond rise time is suitable for that test, and no offset voltage is required.

Now, let's consider what happens when a diode is suddenly reverse-biased. When that happens, a large reverse current flows until there are few majority carriers left around the junction. How long that current flows is important if a diode is to be used in a switching application. Figure 14 shows the test setup used to measure that, as well as the waveform that is likely to be seen on the scope.

The requirements placed on the pulse generator and the oscilloscope used to measure reverse-recovery time are somewhat greater than those for forward-recovery time. Reverse-recovery time in diodes is on the order of a few nanoseconds, and the rise time of the pulse generator must be considerably less. In many cases, the rise time of both the pulse generator and the scope must be less than 1 nanosecond. However, generators with more moderate specifications can be used to test slower diodes.

Figure 15 shows the test setup used to measure the turn-on and turn-off times of a switching transistor, as well as the typical waveforms that would be displayed on the scope. That test is one of the most important ones done when you are analyzing the operation of a switching transistor.

As with a diode, transistor specifications are given at some specified base- and collector-current levels. The bias and B+ voltages supplied to the circuit establish proper transistor operation and should be selected so that those currents are at the proper level. Note that turn-on time is determined by noting the point where the generator's output rises to 10 percent of its final value and the point where the transistor's output drops to 90 percent of its initial value. Conversely, turn-off time is measured between the points where the generator's output drops 10 percent from its maximum level, and the transistor's output rises to 90 percent of its initial value. Once again, for transistors with reasonable switching speeds, the pulse generator and the oscilloscope must have relatively good rise-time specifications. However, pulse generators with more moderate capabilities can be used to perform those tests on some slower transistors. Other transistor measurements that can be made include storage time, stage rise time, and voltage breakdowns.

Using a pulse generator when testing transistors and diodes has several advantages. Two of the most obvious are that they can be used to supply a bias offset voltage, (eliminating additional power supplies) and that their sharp rise times eliminate the need to measure the rise time of the generator itself. In addition, pulse generators can be operated at extremely low duty cycles. For instance, in the diode and transistor tests we just discussed, duty cycles of one percent or less are called for. Such low duty cycles let you perform tests that could not be safely done under steady-state conditions. Such steady-state testing would overheat many of the devices, possibly destroying them, or at least changing their electronic characteristics. Even though peak power developed in a circuit when using a pulse generator may far exceed the maximum permissible continuous power, with that device's low duty-cycle the average power is well within its ratings.

Sources of error

A pulse generator is probably one of the easiest instruments to use improperly. The vast number of settings and modes make it easy to set up improperly. Therefore, using a pulse generator without an oscilloscope is not advisable. With a scope, you can easily spot setup errors and correct them.

The most frequent errors in using a pulse generator are human errors. For example, a common mistake is exceeding the allowable duty cycle. As noted earlier, a 70 percent duty cycle is common for most pulse generators. The most usual mistake here, however, does not involve exceeding the duty cycle by a small amount (such as 75 percent as opposed to 70 percent, for example), but by exceeding it by orders of magnitude. That happens when, for instance, a pulse-repetition rate of 1 kHz has been established, but a pulse width of 10 milliseconds is chosen instead of 10 microseconds. In that situation, the duty cycle has been exceeded by a factor of 10.

On pulse generators with a pulse-delay feature, a similar error occurs. In that case, the delay time exceeds the time established by the pulse-repetition rate. A pulse generator set for a repetition rate of 1 pulse-per-millisecond might have the delay generator set at 10 milliseconds. Due to the nature of the monostable multivibrator used to generate the delay time, the first pulse is chosen to generate the 10-millisecond delay interval, and the following nine pulses are ignored. The result is one pulse-per-10 milliseconds, even though the pulse-repetition rate has been set for 1 pulse-per-millisecond.

Variable rise- and fall-times, although a useful feature, can also give rise to errors. For instance, assume a pulse width of 20 nanoseconds is desired. If, however, the rise- and fall-times are set at 15 nanoseconds, the time required to reach the maximum output and drop back to zero would be a total of 30 nanoseconds, 10 nanoseconds greater than the pulse width. Thus, the pulse does not have enough time to reach the proper levels, making any measures of amplitude incorrect.

As noted previously, improper transmission lines or terminations can seriously degrade pulse characteristics. Care must be taken to prevent pulses that are distorted beyond recognition.

In similar fashion, certain situations require the pulse to be split between two different transmission lines and later recombined by some form of circuity. If narrow pulses at a high rate, and relatively long cables are used, great care must to taken to insure that both pulses arrive at the proper termination simultaneously. If that is not done, pulse-stretching may occur.

In many cases, both the amplitude and the offset controls of the pulse generator have extremely coarse calibration; that can cause misadjustment. Errors can easily occur when setting the generator's output amplitude. A 50 percent setting, for instance, does not mean 50 percent of the rated amplitude. The output specification of the generator indicates a maximum output, but that output is usually given in terms of "not less than." In many cases, the actual output can exceed that rated output by as much as 20 to 25 percent. As a result, the most accurate way to set the output amplitude is to monitor the generator's output on a scope. Another possible error in setting the output amplitude can be introduced by using an output attenuator. Those errors are caused by using the wrong level of attenuation and are quite large—at least one order of magnitude.

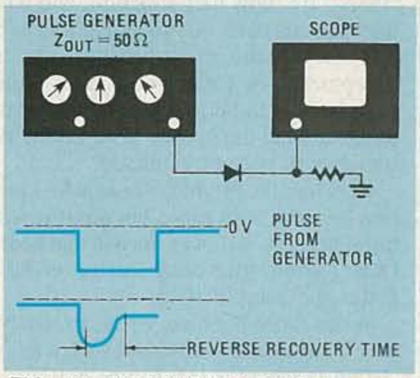


FIG. 14—MEASURING DIODE reverse-recovery time. A 100-nanosecond pulse-width with a duty cycle of less than 1 percent should be used. The generator rise time should be less than the expected reverse-recovery time. The positive pulse offset is set to generate the specified forward current. A 60-ohm resistor converts the output current to voltage for display on the oscilloscope.

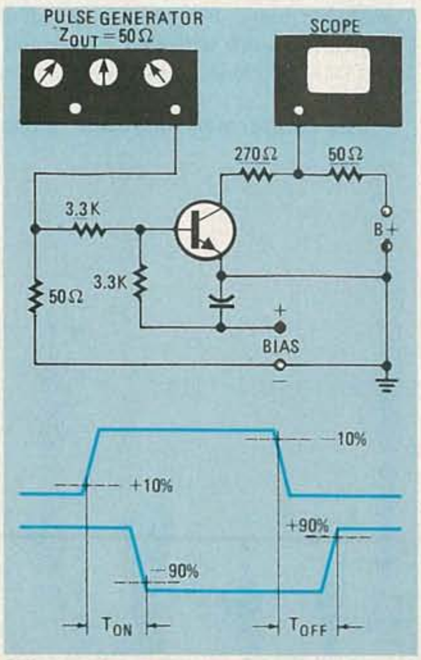


FIG. 15—MEASURING THE SWITCHING time of a transistor. The pulse generator is set for a 100-nanosecond pulse-width with a duty cycle of less than one percent.

Generator-induced errors

A pulse generator is usually not calibrated very precisely. However, if you are fully aware of all its specifications and what they mean, you will have little or no problem in getting maximum use from the instrument. However, failure to recognize some of these specifications can result in generator-induced measurement errors. Jitter can occur in the repetition rate, the amount of pulse delay, and the pulse width. The amount of jitter must be taken into consideration when a rather stable pulse-width, delay, or repetition-rate is required.

When using a pulse generator, especially over extended periods of time, it is necessary to reset the operating parameters, many of which can vary over time, or with changes in temperature and other factors. Certain pulse-generator characteristics are affected by changes in the load (for example, the baseline offset, which is often simply a current generator operating into a known load).

Frequently, certain pulse-generator controls interact somewhat. For example, any changes in the rise time and fall time of the output pulse can cause changes in the pulse width and amplitude.

When you use the dual-pulse or twin-pulse mode, make sure that the delay time is long enough to permit the first pulse to return to zero before the second pulse is generated. It is possible to set two pulses with such a short delay time between them that they never return to the baseline.

Finally, it is important to remember that the best way to get the most out of a pulse generator is to use it with a good oscilloscope. **R-E**

"I'd like to turn it off, father, but he's telling me to stay tuned, and he's *bigger than you!"*

HOBBY CORNER

Learning about microprocessors

EARL "DOC" SAVAGE K4SDS, HOBBY EDITOR

WHAT DO YOU KNOW ABOUT MICROprocessors? If nothing else, I hope you know at least that a microprocessor is the "heart" or "brains" of a microcomputer. Actually, maybe "brains" is the wrong word to use, because a microcomputer is just as dumb as an electric motor, in spite of appearances to the contrary—but that's another story.

You should certainly be aware that a microprocessor is not a microcomputer, and vice versa. You will find that, through carelessness or ignorance, those terms are used interchangeably on occasion. Do not be confused. A microprocessor is one small integrated circuit. A microcomputer is made up of a group of IC's that includes a microprocessor as the "controller of operations." The microprocessor, then, can be thought of as the foreman of a crew that, together constitutes a microcomputer. (We will ignore for now the so-called "single-chip computer.")

Why should you be concerned about microprocessors since you have no interest in microcomputers? There are two good reasons. The first is that more and more, microcomputers are effecting every aspect of our lives; whether you like it or not, in all likelihood, you will, eventually have to learn at least a little about them.

The second reason is perhaps more important. In the past, microprocessors were found only in computers. Today, you can find them in microwave ovens, television and radio receivers, cars, games, and other devices. Before long, you will find them in everything except the simplest devices.

If you don't learn what microprocessors are, how they function, and what they can and can't do, you are going to be left out of the most interesting developments in electronics. You won't even be able to fix many of the electrical things around the house. Your hobby activities will become outdated.

Consider the plight of those who know how to work with tubes but are lost with transistors. (I, too, was once in that boat.) Others know trnasistors but never have gotten the hang of IC's.

When those hobbists write, invariably they want to know how and where to get started in catching up. I hope you won't let progress pass *you* by too. Microprocessors are here and they are already becoming common in many applications.

Make no mistake—in spite of anything you may have heard ot the contrary, a microprocessor is not just another "run-of-the-mill" IC. They are complex little devils that can be made to do some remarkable things. Yet, they are not all that difficult to work with and understand if you tackle them in an organized, logcial manner.

One of the most thorough in-depth treatments of microprocessors that I have found is published by the McGraw-Hill Book Company, Gregg Division, (1221 Avenue of the Americas, New York, NY 10020). *Introduction To Microprocessors,* by Charles M. Gilmore, is a textbook that can be used in a classroom or for independent study. The treatment of the material is quite thorough and, in one way at least, unique.

That text is not about the Z80, 6809, 8085, 1802, or any of the other available microprocessors. It is, in fact, about an imaginary microprocessor. Because of that, you learn about microprocessors in general and not just a specific one. It is a relatively easy matter to apply what you've learned to any microprocessor you work with later. Do not misunderstand—this book is not simply an introduction to microprocessors; the author gets right down to the nitty-gritty of the subject.

Don't get caught having to play catch-up later—do yourself a favor and find out about microprocessors now.

Flashing-light "doorbell"

Tom Haase of Oklahoma City sent the schematic shown in Fig. 1. That is his simple answer to a request we ran asking for a way to let deaf persons know the doorbell is ringing.

As indicated, the reed switch is placed very close to the coil in the doorbell or buzzer. The magnetic field of the coil causes the switch to close, activating the 555 one-shot. That, in turn, starts the 3909 LED flasher, which pulses the relay and flashes the light.

Tom has installed three of those devices for friends who are deaf. Tom also suggests that a strobe light could be used by omitting the 3909 flasher.

Thanks, Tom, for a neat solution to a serious problem.

A shocking project

I got a nice letter from a fellow in Australia the other day. He asked for some help on a project. At least that was his intention, but he was really asking me to help get him in trouble.

My Australian friend wanted to hot-wire his car with a "shocker" to keep vandals away from it. Well, it is possible to shock a person without killing him but who is to say who might touch the car?

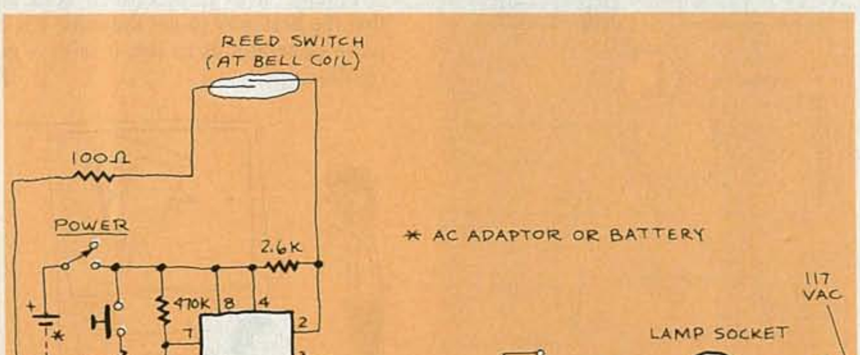


FIG. 1

Someone with a weak heart could brush by it accidently and suffer a fatal shock.

The letter reminded me of a guy who wired his garbage cans to raw AC "to keep the dogs out of them." That nut could have electrocuted someone.

Be smart. Don't let your knowledge of electronics overcome good sense. I don't know about the laws in Australia, but I suspect that there, as well as here, a guy could get himself in serious trouble by pulling a stunt like that.

Something for nothing

Seldom, if ever, does one get something for nothing. There is another scam going around that I'd like to warn you about; you should be on guard if it comes your way.

You know, of course, about the illegal chain letters that promise riches. It seems that someone has come up with a new version.

One of our readers from Welland, Ontario, Canada sent me a "membership form" from a "Book Club." Most of the chain letters that I've seen ask for money, but this one asks for books and magazines instead. Interestingly, almost half of the names/addresses on the list are from Central America (the rest are from the U.S.). The reader thinks that they got his name and address from a letter published in a magazine. **R-E**

COMMUNICATIONS CORNER

Touch-Tone devices and FM adjustments

HERB FRIEDMAN, COMMUNICATIONS EDITOR

AS MORE AND MORE COMMUNICATIONS systems requiring *Touch-Tone* signals for access and operation made their appearance, I found that the *Touch-Tone* pad I had purchased several years ago had become a constant companion.

The pad was purchased from a **Radio-Electronics** advertiser and was either standard Bell System "surplus," or salvage from a *Touch-Tone* phone. I installed it in a matching plastic case, for which I paid a couple of dollars (it's now selling for $10-$15), added a battery for power and a set of output-signal clip leads, and I carried it in my attache case or the glove compartment of my car.

If I needed to access my 2-meter repeater's autopatch I plugged the pad into a small jack I had installed on my 2-meter mobile rig. (That was before I got Heathkit's combination mobile mike and *Touch-Tone* pad.) To enter information into my computer from a remote point I clipped the leads from the pad across the phone line if I couldn't locate a *Touch-Tone* phone during my travels.

Like just about all other Bell System equipment, the gadget has never failed. The only problem is that its frequencies are determined by pot coils (inductors) that are huge by contemporary standards. Until recently I was always lugging around some sort of case just to carry the pad.

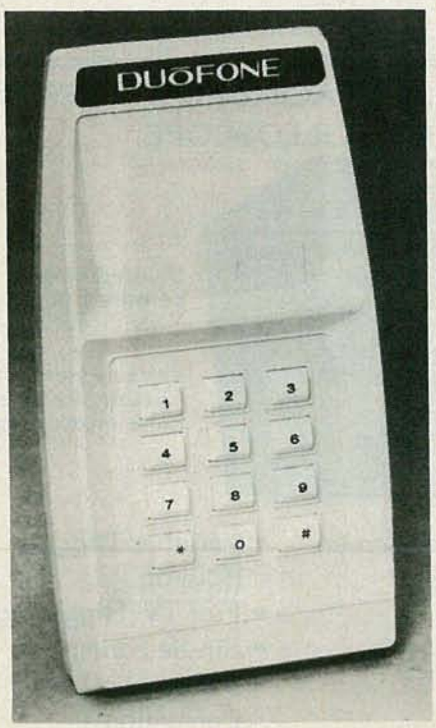


FIG. 1

Though the earliest users of portable *Touch-Tone* pads were radio amateurs and other hobbyists, with the tremendous expansion in communications circuits and computers requiring *Touch-Tone* signals for control or data, there has been created a need for a truly portable *Touch-Tone* generator that can be easily coupled to a standard telephone. One of the earliest—and still popular—devices was the *Soft Touch*. That was a gizmo the user substituted for the telephone transmitter (mouthpiece) by unscrewing the handset's transmitter and temporarily replacing it with the device, which consists of a small microphone surrounded by 12 *Touch-Tone* "buttons." Unfortunately, if the phone's assembler gave the mouthpiece an extra twist when assembling it, nothing short of a special strap wrench would be able to get it loose.

A much easier way to handle "portable" signaling with *Touch-Tones* is Radio-Shack's *Mini Tonedialer*, which is certain to be the first of many similar gadgets.

The device, shown in Fig. 1, is a battery-powered, shirtpocket-sized device with the standard *Touch-Tone* keypad arrangement on one side and a small speaker on the other. To transmit *Touch-Tones,* you simply place the side with the speaker against a telephone's transmitter (or a microphone), and press the key corresponding to the desired number (0-9) or symbol (* or #). The speaker reproduces the corresponding tones for as long as the key is depressed.

Unlike my old authentic telephone pad that had to be carried around in a briefcase or in a small camera bag, Radio Shack's unit actually fits in a shirt pocket because it measures only 2.4 × 4.4 × 0.7 inches. (You can even button the pocket of a Western-style shirt with it inside.) Its overall weight, including batteries, is about 1.5 ounces—less than that of some pocket pens.

What makes all that possible, of course, is the integrated circuit. The entire dialer consists of a single IC that generates the tones; a miniature crystal for the time-base reference; a transistor "output" stage that drives a 1.6-inch speaker; three resistors, and a capacitor. Except for the speaker, everything—including the batteries—is installed on a printed-circuit board whose foils also serve as the switch contacts. The low parts-count is the reason the whole thing costs only about $35.

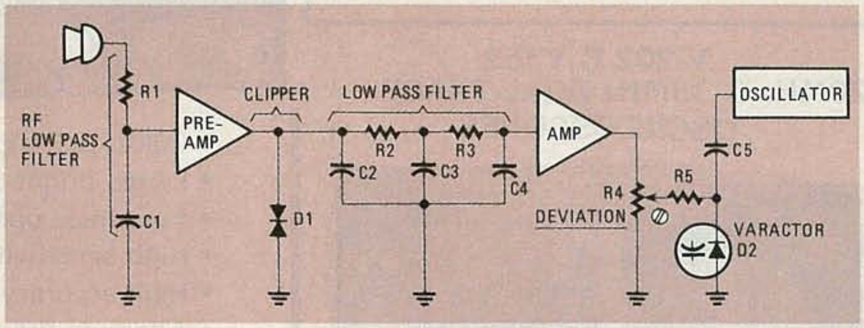


FIG. 2

Setting FM levels

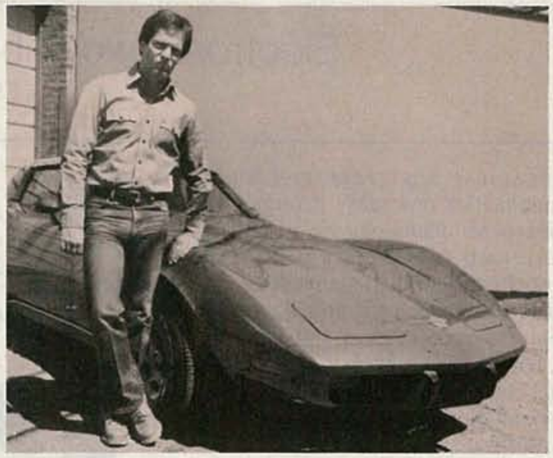
Lately, it seems that there's a lot of commercial VHF and UHF FM gear floating around the surplus dealers and flea markets. The stuff is obviously good because I've worked on many that were converted to the amateur frequencies. Often, though, I've found that the hobbyists get lost in the modulator.

Actually, frequency-modulation systems are rather simple: A typical block diagram is shown in Fig. 2. The output from the microphone is usually fed to the preamplifier through an R-C network (R1/C1) that serves as a low-pass filter to keep RF that might be picked up by the microphone cable out of the preamplifier. To equalize the loud and soft voice levels, the preamp's output is clipped by diode(s) D1. The clipper simply sets a ceiling on

continued on page 110

"Mobile antenna mounting and cable routing on today's cars are a nightmare"

"We just can't find a high performance antenna that doesn't need a ground plane"



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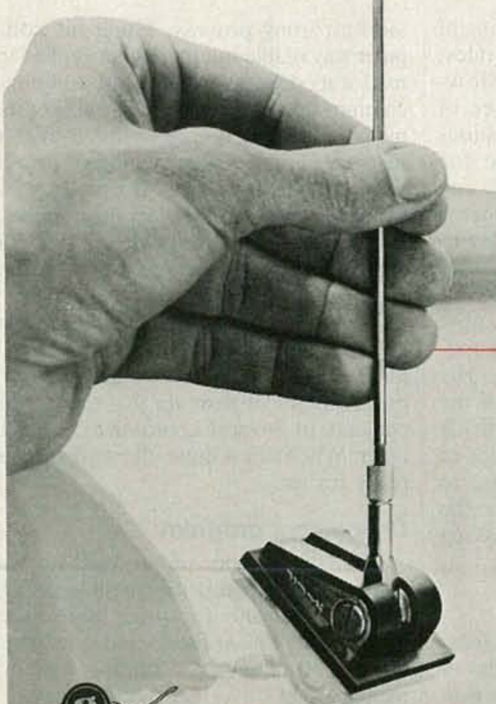

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CIRCLE 20 ON FREE INFORMATION CARD

COMPUTER CORNER

Electronic worksheets for your computer

LES SPINDLE*

THE BUSINESS SOFTWARE FIELD IS A dynamic market nowadays. Competition and improved technology are combining to make each new product just a little more sophisticated than the one that preceded it. Computer programs now serve not only as proofreaders and grammarians, but also as program writers, teachers of languages and operating systems, and sophisticated accountants. But no single software development has had the impact of VisiCorp's (formerly Personal Software) 1980 introduction of *VisiCalc*.

Dozens of current software releases are fashioned after the simple, but revolutionary, concept that *VisiCalc* pioneered—the micro as an electronic worksheet for financial planning.

The "Visiclones" (as they are sometimes referred to) enable the user to format a "worksheet" of figures on the screen, then modify those figures in any number of different ways and see the results of the modifications.

Mathematical relationships between any of the rows and/or columns can be defined. Suppose, for instance, that you want the bottom row to be the sum of all the rows above it. That can be accomplished with one simple command. Other mathematical calculations—log and trig functions, percentages, etc.—can easily be accomplished in the same manner.

If one item on the worksheet is changed, every other item whose value depends on that item is automatically changed at the same time. It is possible to add new rows and columns or to change the order of existing ones. Meanwhile, the items whose values depend on the new setups are also automatically changed.

The program is an ideal tool for projecting budgets, planning expenditures, and charting various business strategies. Printouts of the various combinations can be made, for a step-by-step presentation of the pros and cons of each strategy. Presenting the various phases of an operation to a board of directors' meeting, for instance, can be both efficient and impressive. But even more important than that is the time saved by the user as he works out his options in the planning process.

For example, suppose a retail sales manager wants to make an intelligent guess as to sales trends over a yearly period. He devices a format consisting of several variables, such as interest rates, his best-selling products, his slow-moving merchandise, the number of salesmen in the field, and the previous year's sales. To further enhance the credibility of the outcome, he takes into account the fact that in his line, winter is the heaviest selling season. With his format completed, he enters all the necessary data, then begins to examine the results.

His analysis will take much less time than if he had sat down with adding machine, scratchpad, and a big eraser. His report will project sales for each of the next 18 months. After consulting with his associates, he will likely have dozens of data changes to enter when he returns to re-work the projections. But, once the initial program has been set up, making those changes is simple.

FIG. 1

How they're used

How does a user format the worksheet to fit his particular application? Most of the programs are well-documented with simple commands and self-prompting menus that lead him step-by-step through the formatting process. Using his computer's available internal memory, he formats a model consisting of the rows and columns that he will need. The size of the model is restricted only by the available memory. Filing and retrieving of data is done using disks, so that is usually not a factor in the size of the worksheet model.

Once the model is visible on the CRT screen, the user can decide how to define each row and column on the "blank" worksheet. Each coordinate location is assigned either an alphanumeric comment, a label (such as a row description), or a constant or formula that relates the contents of several coordinates to each other. When that is done, the worksheet is ready for use.

Choosing a program

With the number of products on the market, it is sometimes difficult to decide on the best one for your particular application. You are restricted somewhat by your computer's operating system, memory capacity, and microprocessor. Some versions are configured for a particular computer and its specific operat-

*Managing Editor, *Interface Age* magazine

ing system, such as *TRSDOS* for the *TRS-80* or *CDOS* for Cromemco. A number of new products, though, are *CP/M*-based, and can be used on any computer that can run the *CP/M* disk-operating system. In most cases, however, you should be able to find several options for your setup.

Once you've found the products, you can examine the specific features offered by each program to determine which is best suited for your applications. Following are some of the features to keep in mind as you make your choice. Keep a checklist handy as you shop.

First, determine the size of the matrix. Find out how many rows and columns are possible and analyze your needs to see whether their capacity is sufficient for your applications. Be aware that it is seldom possible to use all the rows and columns at the same time since both are affected by the total memory-capacity of the computer.

Investigate the arithmetic precision of the program. There are limitations on the number of digits that certain programs can accommodate, and they may affect you if your calculations involve very large or very small numbers.

See whether the program allows for a "comment column." That is a position, of varying length, that allows you to write some description of the row beside it. The feature can be useful for complex transactions that require more description.

Does the program include graphics capabilities? Bar charts and the like are sometimes desirable, especially for meetings and formal presentations.

Is split-screen capability available? Some of the more advanced programs allow it, and it can be a tremendous asset in comparing the results of related plans.

Can the program interface with other programs? If data from word-processing, general ledger, payroll, or other programs at work in your system can be used directly by your worksheet, or vice-versa, the door is opened for a wealth of time-saving features. Suppose you are producing a written sales-report and would like to integrate a worksheet as part of the presentation. Without word-processor-interfacing capabilities, you would have to re-enter the entire sheet in order to integrate it into the report.

For clarity of reading, the ability to line up figures in a row correctly is crucial. For instance, if the decimal points in the numbers 596.83 and 9344.7 were not aligned vertically, it would be hard to distinguish which were the fractional elements simply by glancing at the column.

Does the program allow for partial printouts? Can you print one row or column, or a section of a report without taking the time to run the entire program?

Is it possible to jump to one point in the model instantaneously from another? If you are in column C, row 7, can you

continued on page 108

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CIRCLE 18 ON FREE INFORMATION CARD

STATE OF SOLID STATE

DC voltage-controlled switches

ROBERT F. SCOTT, SEMICONDUCTOR EDITOR

THIS MONTH WE'LL TAKE A LOOK AT A DC-controlled switch that can replace the usual rotary or pushbutton used to connect various signal sources to the input of an audio amplifier. In this case, the selector switch feeds the input to the graphic equalizer circuit that we discussed in the June 1982 issue.

National Semiconductor has just announced the LM1037 and LM1038 DC Controlled Audio Switches. Both are designed to allow any one of four stereo-input sources to be connected to the stereo-output lines. Channels are selected by applying a DC voltage level to the channel-select control pins. Features of the LM1037/38 switches are:

- Wide supply-voltage range (5 to 30 volts)
- Click-free operation
- Low distortion, 0.04% typical
- High signal-to-noise ratio
- High audio-input impedance
- Low audio-output impedance
- Wide control-voltage range (2 to 50 volts)
- High input-impedance on select pin

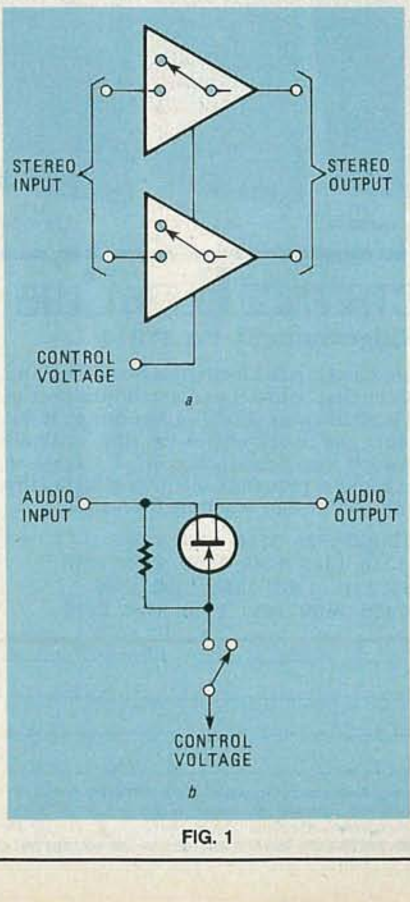

FIG. 1

TABLE 1

Parameter	Min	Typ	Max	Units	Conditions
Supply voltage	5	12	30	volts	
Supply current (LM1037)		7		mA	V_{supply} = 12
Supply current (LM1037)		10		mA	V_{supply} = 30
Supply current (LM1038)		14		mA	V_{supply} = 12
Supply current (LM1038)		20		mA	V_{supply} = 30
Voltage gain	−0.2	0		dB	
Signal handling			3.2	$volts_{rms}$	V_{supply} = 12
Distortion (THD)		0.04	0.1	percent	$1V_{rms}$ input @ 1 kHz
S/N Ratio (CCIR)		−100		dB	$1V_{rms}$ input @ 1 kHz
Crosstalk between stereo channels	−80	−100		dB	$1V_{rms}$ @ 1 kHz
Crosstalk between connected and unconnected channels	−80	−100		dB	$1V_{rms}$ @ 1 kHz
Relative output in muted state	−80	−90		dB	$1V_{rms}$ @ 1 kHz

The LM1037 has four control or channel-select pins; one for each stereo-input source. If no channel is selected, the outputs are muted and clamped to the DC output level.

The LM1038 is designed so that channels can be selected by BCD input pulses. Two input pins feed clock-enabled latches so that the BCD pulses can be strobed from a bus. Or, the clock-input pin can be permanently enabled and the channels selected by DC voltage levels. A separate pin allows the output to be muted, via either a pulse or a DC level.

To date, only preliminary specifications (Table 1) on the LM1037/38 have been released, so we don't have complete details on the structure of the semiconductor device used as the switch elements; but I'll bet that the switch is some form of FET. In similar analog switches from other manufacturers, JFET's, MOSFET's and CMOS (N-channel and P-channel FET's in parallel) have been used as gates or switches. Figure 1-a is a functional diagram of a stereo-audio switch. When the control voltage is applied, the switches close so that the input signals pass through to the output terminals. Figure 1-b is the circuit of a basic analog switch using a JFET as the switch element.

Figure 2 is the functional block diagram of the LM1037. The channel-selection details are outlined in Table 2 (See page 86).

Emitter and detector product guide

The *Infrared/Photodetector Product Guide* lists a line of GaAs IR emitting diodes and photodiodes, phototransistors, and photovoltaic cells. The IR emitters develop a wavelength of either 820 or 950 nM (nanometers) depending on the device. Detectors can be selected with maximum sensitivity specified at wavelengths ranging from 555 to 950 nM. The guide includes dimensioned outline drawings.—**Litronix,** 19000 Homestead Road, Cupertino, CA 59014.

Unique monolithic active filter

National Semiconductor's MF10 is the first monolithic active filter that does not

TABLE 2

Inputs switched to output pins

Input channel		1A	2A	1B	2B	1C	2C	1D	2D	
Pin no.		2	4	6	8	11	13	17	15	12
DC control	1	VL	VL	VL	VL	VH	VH	VL	VL	VL
conditions	3	VL	VL	VL	VL	VL	VL	VH	VH	VL
(pins)	16	VH	VH	VL	VL	VL	VL	VL	VL	VL
	18	VL	VL	VH	VH	VL	VL	VL	VL	VL
Output pin		10	9	10	9	10	9	10	9	9 & 10 (MUTE)
Output channel		1	2	1	2	1	2	1	2	

Low switching-level: VL < 0.8 volts
High switching-level: VH > 2.0 volts

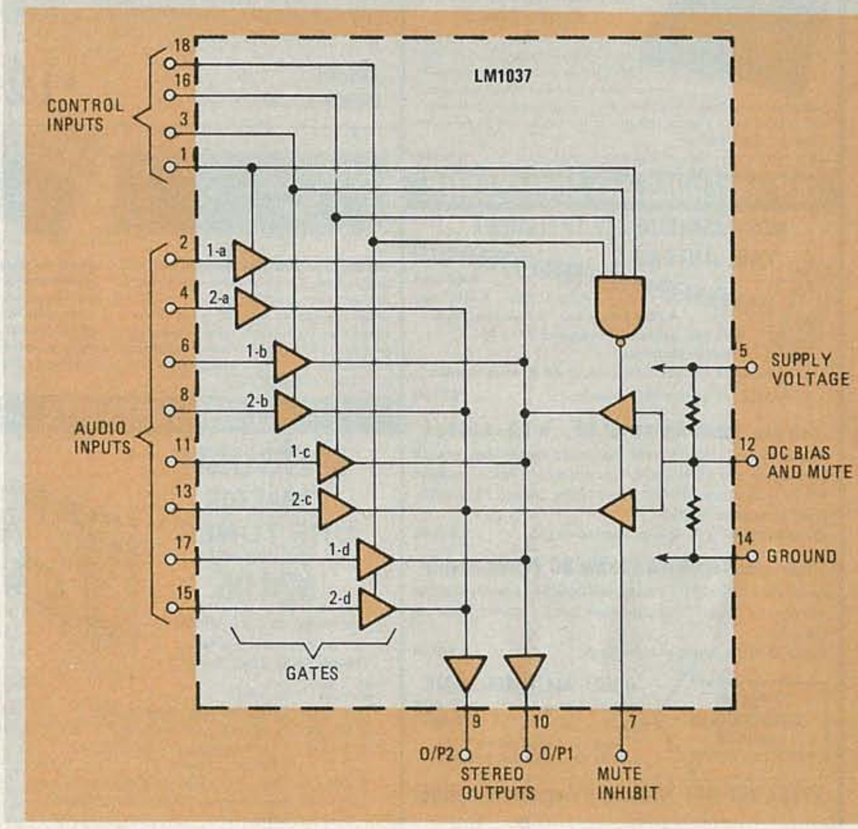

FIG. 2

require external capacitors to operate, and is capable of performing a variety of functions. It is ideal for signal processing, telecommunications, modems, instrumentation, and audio equipment. The center frequencies of all previously available active filters are adjusted with external resistors and/or capacitors. The MF10 filter is unique in that the center frequencies of its various second-order functions are directly proportional to an external clock frequency and fixed at an accuracy of 0.6%, or directly proportional to both the clock frequency and external resistor ratios. Gain and selectivity (Q) are adjusted using external resistors.

The clock and three or four resistors are the only external components necessary to operate the MF10 so the device is less sensitive to external component variations. Frequency stability is directly dependent on the quality of the clock. A single clock can be used to drive an almost infinite number of MF10 filters.

Unlike other available monolithic filters which have been designed for a specific function, the general-purpose MF10 can perform a wide variety of functions including allpass, highpass, bandpass, and notch. Up to fourth-order functions, and any configurations such as Butterworth, Bessel, Cauer, and Chebyshev

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CIRCLE 2 ON FREE INFORMATION CARD

STATE OF SOLID STATE

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can be had by cascading the two second-order building blocks. The center frequency can be as high as 20 kHz with a Q of 500. Typically, the lowpass and bandpass outputs can sink 0.75 mA and source 3 mA while the notch, allpass, and highpass outputs sink 1.5 mA and source 3 mA. The devices come in 20-pin DIP packages and cost $3.50 in lots of 100.—**National Semiconductor,** 2900 Semiconductor Drive, Santa Clara, CA 95051.

Optocouplers feature back-to-back LED's

Motorola has introduced two new dual-LED Optocouplers designed specifically for AC input applications. The devices—the HIAA1 and HIAA2—consist of two gallium-arsenide (GaAs) infrared-emitting diodes connected in inverse parallel, and optically coupled to a single silicon phototransistor (detector) in the standard 6-pin DIP package.

The Optocouplers can be used to detect the presence, absence, or interruption of AC power and trigger a desired action. A major application is the detection of a ring signal on telephone lines while providing isolation from the ring lines. The HIAA1 and HIAA2 are directly interchangeable with GE devices bearing the same type numbers, while providing for up to 7500 volts. The HIAA1 has a current transfer ratio of 20% and costs $1.98 in lots of 1 to 99. The HIAA2 has a 10% current transfer ratio and costs $1.70 in lots of 1 to 99.—**Motorola Semiconductor Products,** P.O. Box 20912, Phoenix, AZ 85036.

Tunable low-pass sampled-data filters

The MC145414 dual-tunable low-pass filter from the Motorola MOS Integrated Circuits Group is the latest addition to the growing family of CMOS switched-capacitor filters.

The MC145414 has a typical power dissipation of 30 mW when active and 1 mW in the power-down condition. Operating voltage can be obtained either from a single or split power-supply with a voltage range of 10 to 16 volts. It can interface to either TTL or CMOS devices. The device is useful in LPC (*L*inear *P*redictive *C*oding) or CVSD (*C*ontinuously *V*ariable *S*lope *D*etection) speech applications, modems, or other applications where a precision low-pass filter is needed. Specifications include a dynamic range better than 80 dB, passband ripple less than 0.3 dB, and idle noise typically 100 dBrnC0 (Decible RMS noise C-message weighted referenced to zero). The device is offered in a 16-pin DIP plastic or ceramic package and is available for $4.50 each in lots of 1000.—**Motorola Inc.,** 3501 Ed Bleustein Blvd., Austin, TX 78721. R-E

STEREO IMAGE EXPANDER

continued from page 65

stereo effect comes primarily from the studio's mixer-board. You can "A/B" the effect with the ON/OFF switch.

The majority of studio recordings are made from a mix of simultaneous "dry" sources and create an artificial image based on intensity differences between channels rather than on time and phase information. Even so, most of them will open up and sound more spacious—the speakers will become "transparent." Some recordings will do fascinating—and frequently spectacular—things when turned loose by the expander. Try any of Pink Floyd's or Tomita's releases to really put the expander through its paces.

Background reading

The first mention of loudspeaker crosscoupling and its effects appeared in a paper given by B.B. Bauer to the AES in 1961. A detailed exploration of the problem, a solution and test results appear in an article entitled:

"Head related two channel stereophony with loudspeaker reproduction" by P. Damaske, pp. 1109 to 1115 of the *Journal of the Acoustic Society of America,* Vol. 50, No. 4, Part 2, 1972

R-E

SERVICE CLINIC

Color-burst reference oscillators

JACK DARR, SERVICE EDITOR

A TV SET'S COLOR-REFERENCE-oscillator signal, with a frequency of 3.58 MHz (actually 3.579545 MHz), is a very important one. If it isn't present—with a few exceptions that will be noted soon—no color will be seen. Figure 1 shows how the video signal, with and without the reference signal, would appear on a scope. The frequency of the signal must be precise; if the oscillator shifts in frequency by as little as ¼-Hz, you will see a very obvious tint change. That means that the AFC must be very tight.

FIG. 1

Two basic types of circuit are found in older sets, and are still in use in current ones. The older circuit is a crystal-controlled oscillator; the crystal determines the frequency, and an amplifier stage does the rest. The circuit can be made to free-wheel by killing the color sync. Its tuning can be set very near the precise point needed and when the sync is restored, it locks in and stays. Precise control is obtained by comparing the output of the oscillator with the color-burst signal, which is transmitted along with the rest of the TV signal. Many circuits of that type use an AFC circuit almost identical to those used in horizontal-oscillator stages.

The second type of circuit also uses a crystal, but not as the frequency-determining element in an oscillator circuit. In fact, there is no true oscillator. The color-burst signal is fed to a preamplifier stage, and then through the crystal, which is actually used as a very-narrow-band filter. The signal from the crystal "filter" is fed to a very-high-gain amplifier stage (often mislabelled a "3.58-MHz oscillator"). It isn't an oscillator; what it does is amplify the burst signal, which makes it "ring" longer. In fact, there is still signal present when the next color-burst signal comes along, so it's clipped and becomes a standard RF-signal, which is fed to the demodulators. The frequency of those circuits isn't controlled. There's no need to, because we're using the color-burst frequency itself as the oscillator signal.

The crystals used in the two circuits are not identical. They oscillate at the same frequency, of course; but apparently they're different cuts (one for use as an oscillator; the other for use as a filter) and neither one will work satisfactorily in the other circuit. (I determined that from experience—and a whole afternoon of work!)

The symptoms of oscillator failure are obvious. The black-and-white picture will be good, but there will be no color at all. If you run into that situation, the first and best test is to scope the output of the 3.58-MHz circuit, looking for an RF signal of the correct amplitude. Incidentally, you don't really need a wideband scope for that test. If there's a signal present you may see it as a blur, but the *amplitude* of the signal is the important thing; if the level is too low, the demodulators will not work properly.

The first step is to check the active device (tube or transistor) by substitution. If that doesn't bring things back to normal, check all the DC voltages around the stage to make sure that they're normal. As a last resort, try a new crystal, making sure you use the right type! If the crystal fails to work in the "oscillator" circuit, there'll be no feedback. In the filter circuit, you'll see RF on the input side of the crystal but nothing on the output side. In filter circuits, make sure that the color-burst signal is present, too.

In some sets, (mainly the "oscillator" type) sometimes you can see an odd symptom. (I got a letter only this week that complained, "...I've lost the red. The screen is a bluish green but there's no color where it ought to be.") A color-bar signal shows no colors in the bars, but the white spaces between them will be a definite bluish-green. That indicates that the oscillator is dead, but somehow there is enough of the color-burst signal getting through to the demodulators to make the screen glow bluish-green, which is the result of the phase of that signal.

The problem isn't confined to older sets. In one solid-state set, a middle-aged Philco, the 3.58-MHz oscillator is a small IC op-amp. The original part has a history of failure at odd intervals. The best cure I've found is replacement with a different brand of IC—practically every one of the replacement-transistor/IC makers has a substitute for it.

Loss of the oscillator signal kills the color. If, on the other hand, you lose the color sync, you get fairly bright color showing on the screen, but as "rainbows"—narrow bands of red, green, and blue, slanted exactly like the bars you see when the horizontal oscillator's out of sync. The picture itself, though, will be steady. Start by checking for the color-burst signal; a dead burst-amplifier can be one cause of the problem. For a definite check, run a complete setup procedure on the oscillator. If the oscillator will make colors in the bars at the right places, but they float, the problem is narrowed down to the sync. In a few cases, the crystal can cause that. It'll be *almost* on frequency, but "right on the edge", and the sync won't lock.

Another problem, found mainly in older sets, is good horizontal lock, but very poor color sync. Before running the setup on the oscillator, check the position of the horizontal-hold control. If the color suddenly locks in when you move it toward the center of its range, you've solved the problem.

The reason why the color sync is lost is that if the horizontal oscillator is almost to the fallout point, there will be a small phase-shift in the gating pulse. That's the pulse that "gates out" the color-burst signal from the rest. If the pulse is off frequency, it gets there a little too late or too early and you lose the color-burst signal, and thus the color sync. Always check the horizontal-hold control setting first; it may save you a lot of trouble! **R-E**

SERVICE QUESTIONS

SHORTED CRT

There's a arcing in the neck of the picture tube in this RCA CTC-58. My tube checker shows a heater-to-cathode short in the green gun (I have an isolation transformer for that kind of test). With the tube socket off, I can read 25 kV on the focus

pin of the tube. Please help!—D.W., Taos, NM

There's a good chance that the CRT is bad. At times you'll find "particle shorts" between grids G3 and G4; G3 is the focus grid and G4 is connected directly to the high-voltage supply. You might try disconnecting the tube socket and HV lead, and discharging a medium-size capacitor (around 20–30 μF) across the focus pin and ultor button (charge the capacitor from the B+ supply). If there is a particle short there, that may blow it out. While the spacing between those two electrodes is very small, there shouldn't be any leakage at all there. Also check the focus circuit to see if any of its components have been damaged.

RESISTOR BURNOUT

In this Zenith 19HC50, resistor R221 (1½-ohms, ½-watt) in the base return of the horizontal-output transistor, keeps burning up. I replace it, and it's out again in three or four weeks. Last time I used two 3-ohm, ½-watt resistors in parallel to increase the current-handling capacity, but they burned up too. That resistor's very hard to get at; I'd sure like a permanent fix!—D.M., Chicago, IL

I know what you mean; it's always the hard-to-reach parts that have to be replaced. Now—what makes a resistor burn up? Excess current! In your case, it can't be too much DC or the set wouldn't work at all. The only thing left is pulse-current, and there is a sizable pulse—about 15-volts peak-to-peak—across that resistor.

There's also a 50-μF electrolytic capacitor across the resistor to bypass that pulse to ground. If it's open, the pulse could generate enough current to overload the resistor. Replace the 50-μF capacitor, and stay with 1-watt resistors to be safe.

POOR FOCUS

The focus is poor on this Zenith 19EC45. I replaced the tripler and the HV is now OK, but the focus voltage is only 500 volts. When I disconnect the lead to the picture tube the voltage rises to 4.6 kV, but when I connect it again, the voltage drops back down. Could the focus electrode in the CRT be shorted?—A.G., Binghampton, NY

It's possible, but not likely. More probably, there's leakage across the arc-gap in the CRT socket. Take it apart and check for carbon paths, etc.

(Feedback: Bingo! A.G. says, "I took the socket apart and found a burnt path from the focus pin to the CRT ground lead, which apparently was shorting the focus voltage to ground. Thanks.")

ASSORTED HINTS

Problem: Poor vertical size (two or three inches short of filling the screen) in a Toshiba TAC-9330 (Sams 1500-3).

Solution: Check the two-ohm resistor from ground to IC302 (vertical osc/amp/output)—the one I had read about five ohms. That isn't the only possible cause of the problem, but it's easy to overlook unless you're using a digital meter.

Problem: Intermittent but repeated failure of power-supply diodes in a Philco E-21.

Solution: Try replacing the tripler. I did that and the set's worked well ever since. It must be that the *tripler* was intermittent.

Now for a request. I need a power transformer for a Lectrotech V-7 vectorscope. I wrote to the company, but got no reply; maybe you can help.

Thanks to A.Y. of Lexington, NC for the hints. To answer your request, call (800) 851-3584 and a nice fellow by the name of John Evans at Thordarson will try to help you out. I'm almost sure they have something that will do the job, since they have quite a few scope power-transformers in their catalog.

HORIZONTAL HOLD PROBLEM

I've got a Magnavox T936 with very poor horizontal hold. I'm not having any luck with it, and could sure use some advice.—C.D., Hightstown, NJ

Take out the AFC diode unit and check it for balance. Also, check all the resistors and capacitors around the AFC circuit. To make sure that the problem is in the AFC, ground the grid of the AFC tube and see if you can get a floating picture with one straight side. If you can, the oscillator is OK and the cause is due to the AFC section.

(Feedback: "I tried the test and it worked—the AFC diode-unit wasn't balanced. I also checked the resistors and found that a 68K unit that was supposed to drop the voltage to +33-volts was open, even though it looked perfect. A new resistor and new diode unit fixed everything.")

OPEN CAPACITOR BURNS RESISTOR

I noticed a question here recently about an RCA CTC-31 that was burning up R163. You said it was the plate load for the horizontal oscillator, but I think it's an isolation resistor. It burns up because filter capacitor C118B is open. Therefore the AC from the oscillator must go to ground through C119A, so it also goes through R163 and burns it up.

I've run into the problem in a number of 1967/1968 RCA chassis.

Thanks to B.W., of Loew's TV in Central City, NE for that information.

SPECIAL RESISTOR

This Portland RP-209HN had no sound or video, and only a faint raster. Those sets are made in Korea by the Taihan Corp., and there is no Sam's Photofact for them as yet. However, I was able to get a service manual from the U.S. office of the manufacturer; that address is Taihan (America) Corp., 8960 Lurline Ave., Chatsworth, CA 91311. Once that problem was solved, however, I ran into a new one. Turns out that the cause of the problem was R905, one of the critical "safety" parts. That being the case, I decided to order one from the company. That was until I found out that it could take up to six months to get one. Instead I used a 62-ohm Sylvania Flameproof resistor and it seems to work perfectly. By the way, there is a mistake on the parts list concerning that resistor—they list it as R05 instead of R905.—*M.B. Danish, Aberdeen Proving Ground, MD*

VERTICAL PROBLEM

I had no vertical sweep on this RCA CTC-71. Tried changing C120, a 470-μF capacitor. The raster came back and I thought that all was well. Not long after, however, the set came back with the same problem. I've been told that this capacitor has a high failure rate, but I'd like your opinion—R.C., Philadelphia, PA

Considering that two of those failed in a short period of time, I'd try using a replacement with a higher working voltage. Many times if a part fails repeatedly it's due to the original rating being a bit too low.

(Feedback: That was it—used a higher working voltage as you recommended and it appears to have solved the problem for good. Thanks!)

FINDING INTERMITTENTS

I've recently come across a new method for finding intermittents. I've used it with good success and I'd like to share it with you. I use an electric engraving-pencil—the type used for engraving names on personal belongings—as a "vibration tool." Just put a six-inch piece of rubber or plastic tubing on the end of it, set the pencil for its lowest speed, and hold it against the piece of equipment you are working on. That will dig out intermittent solder joints, etc. quite quickly. In case you are worried that this method could damage your gear, NASA uses a "shaker table" to test out its equipment and this tool is not nearly as rough.—*R.E. Grist, Bayside, CA*

WEAK VERTICAL SYNC

I can stop the vertical roll on this RCA CTC-66 using the vertical-hold control, but the slightest disturbance causes the picture to begin rolling again—any ideas?—S.C., Mentone, CA

The symptoms you're describing indicate that the problem is weak vertical sync. Check the sync separator and all the DC voltages, etc. Sometimes that is caused also by leaky shunt capacitors in the vertical integrators.

(Feedback: The sync separator, Q503, showed leakage. Replaced it with an RCA SK-3024 everything's fine.) R-E

NEW PRODUCTS

For more details use free information card inside back cover.

CURVE TRACER, the *model 501A*, is designed to work in association with an oscilloscope to display characteristic curves for a wide variety of discrete semiconductor devices. It displays the unique characteristic curves for each type of semiconductor device. By examining those curves, the user can determine all significant operating characteristics of the device under test.

Test parameters measured include gain (beta), cutoff current, leakage current, output admittance, and breakdown voltage. The instrument can be used to evaluate bipolar and FET transistors, diodes, SCR's, diacs, triacs, and other devices.

The *model 501A* is priced at $300.00.—**B&K PRECISION,** Dynascan Corporation, 6460 West Cortland Avenue, Chicago, IL 60635.

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CIRCLE 152 ON FREE INFORMATION CARD

SCANNER CONVERTER, the *Scanverter CVR-1*, allows complete coverage of the 225-400 MHz military/federal-government aircraft band when used with a standard aircraft-band scanner. Listeners can hear NASA space-shuttle radio links to Earth, military air-tactical war games, Coast Guard search and rescue missions, FLEETSATCOM military satellites, Federal government agencies' in-flight communications, and more.

An exclusive development called "bandstacking" allows the entire 175 MHz-wide UHF aircraft band to be compressed into the 118-136 MHz range tunable on any scanner capable of standard aircraft recep-

continued on page 100

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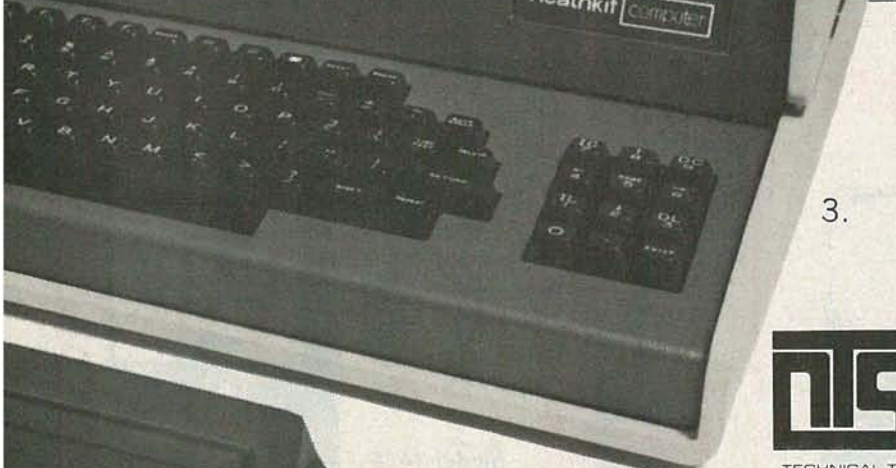

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NEW PRODUCTS

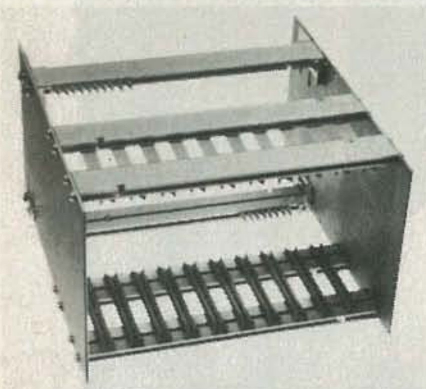
continued from page 95

tion. No tuning or adjustments are necessary with the fully automatic converter. Reception for hundreds of miles is possible with the use of an outside antenna.

A handy list of active nationwide UHF aircraft channels is included, and the unit comes complete with power cord, interconnect cable, and full instructions.

The *Scanverter CVR-1* is priced at $99.95, plus $2.00 shipping.—**Grove Enterprises, Inc.,** Brasstown, NC 28902.

MINI CARD CAGE, *model CCK19S,* is a miniature card rack for STD bus microcomputer systems. It occupies only .21 cubic feet,



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yet holds up to 10 STD bus cards; it can easily be installed in desk-top consoles, video terminals, printers, controllers, or other equipment with limited space.

The rack accepts either mother boards from Vector and other manufacturers, or card edge connectors with 28/56 .125-inch spaced contacts. It is form-compatible with all 4.48-inch wide by 6.5-inch long STD microcomputer cards. It is shipped disassembled with all hardware and can be assembled quickly. The captive screws in the cage T-struts permit easy locating of the mother board or discrete connectors. The *model CCK19S* is priced at $39.50.—**Vector Electronic Co., Inc.,** 12460 Gladstone Ave., Sylmar, CA 91342.

DMM, *model 6502,* features six versatile computing functions not available on similarly priced competitive instruments. A total of 14 pushbuttons, combined with a self-prompting display, provides flexibility in the manipulating and recording of data. Two storage registers allow a display to be scaled by any slope and offset. A single NULL key stores a display as a "zero" value and automatically subtracts that value from all subsequent measurements. Two keys store any entered value as a reference, and display future measurements as a percent deviation from that value. High and low limits can also be stored, and a LIMIT key then allows the display of values within those limits, or HI and LO annunciators if the measured value is outside of the limits. A START key initiates the continuous storage of maximum and minimum values. A MIN key similarly displays the minimum value. A RESET key allows the instrument to return temporar-

CIRCLE 154 ON FREE INFORMATION CARD

ily to the DMM mode without losing any programmed computation.

A FILTER mode activates a binary weighted average of the last four measurement conversions, assuring more accurate and stable readings in the presence of noise. To assure a rapid response to step changes, the filter function is automatically inhibited when successive conversions differ by more than 2% of full scale. All computing functions may be operated singly or chained, if desired, to perform more multiple operations.

The *model 6502* is priced at $758.00.—**Weston Instruments,** 614 Frelinghuysen Avenue, Newark, NJ 07114.

CIRCLE 00 ON FREE INFORMATION CARD

ANTENNA TUNER, *model PT-407,* is a general-purpose tuner for 1.8-30 MHz to match antennas fed with coaxial or open-wire lines, single wire, or mobile antennas. The 300-watt power rating makes it suitable for most amateur-radio setups.

The *model PT-407* has a large airwound coil, a large balun for open-wire feed, and has ceramic insulation throughout. It is housed in an 8 × 4 × 7-inch aluminum cabinet with brushed-aluminum control panel and black-vinyl cover. All controls are on the front panel; coaxial connectors are SO-230, and porcelain feedthrough insulators are used for balanced line and single-wire inputs.

CIRCLE 155 ON FREE INFORMATION CARD

The *model PT-407* is priced at $149.95.—**Palomar Engineers,** PO Box 455, 1924-F W. Mission Road, Escondido, CA 92025.

MULTITESTER, *model M110,* has 21 ranges, designed for servicing electronic equipment, gas appliances, heating, air-conditioning, and refrigeration equipment. The ranges are specifically chosen to place most measurements near mid-scale. For example: mid-scale on the low-ohm range, 5 ohms, facilitates testing motor windings, relay, and contactor coils.

CIRCLE 156 ON FREE INFORMATION CARD

The *model M110* features a fuse-protected OHM circuit, mirrored scale-diode-protected movements, and easy-to-read three-color-coded scale plate and front panel. Accuracy specifications for the *model M110* are: DC, ±3% full-scale; resistance, ±3% of scale length; AC, ±4% full-scale. Input impedance is 30,000 ohms-per-volt DC; 15,000 ohms-per-volt AC.

The *model M110* is supplied with carrying case, test leads, batteries, and instructions, and is covered by a one-year warranty; the suggested retail price is $44.95.—**Universal Enterprises,** 14270 N.W. Science Park Drive, Suite 101, Portland, Oregon 97229.

DIGITAL THERMOMETER, *model 871,* is an improved second-generation instrument that offers the versatility and performance of laboratory-bench thermometers. It is designed for situations in which temperature is a critical concern, particularly in electronics design and manufacturing. The *model 871's* dual-channel capacity is practical and convenient, allowing the user to monitor inlet/outlet temperatures, do wet-bulb/dry-bulb measurements, and check other situations where temperature differential is important.

The *model 871* is supplied with a three-foot, beaded-junction sensor, so that the user may begin taking measurements at once; it is the only thermometer sold with a sensor. A broad selection of optional probes is available, and includes immersion, penetration, surface, air/gas, and hypodermic types to handle any application; custom and special-purpose probes may also be obtained.

CIRCLE 157 ON FREE INFORMATION CARD

The *model 871* is priced at $225.00.—**Keithley Instruments, Inc.,** 28775 Aurora Road, Cleveland, OH 44139. **R-E**

ANALOG DESIGN

continued from page 62

veloped across R_G from that developed across R_S. If it is desirable to make R_S very large, all you need do to compensate for the voltage, V_{RS}, that is developed across it, is to either increase R_G or reduce R_X. The larger voltage now developed across R_G, subtracted from the increased voltage developed across R_S due to its increased value, establishes a reasonable negative bias voltage.

Before calculating the values of R_X and R_G, we should know what values of I_D and R_S are desireable. That can readily be done by averaging values that are found on the JFET's specification sheet.

First determine the average pinch-off voltage, $\overline{V_P}$. It is midway between the maximum and minimum pinch-off voltages specified for the device.

In a similar fashion, calculate the average I_{DSS}, $\overline{I_{DSS}}$, the drain current when $V_{GS} = 0$.

Finally, choose a reasonable value for an average gate-to-source bias voltage, $\overline{V_{GS}}$. It frequently is equal to about $0.4 \times \overline{V_P}$.

All those factors are then substituted into the following equation to determine the average quiescent drain current, $\overline{I_D}$:

$$\overline{I_D} = \overline{I_{DSS}}\left(1 - \frac{|\overline{V_{GS}}|}{|\overline{V_P}|}\right) \qquad (17)$$

Absolute values of $\overline{V_{GS}}$ and $\overline{V_P}$ are used so that polarities can be ignored.

Now that we have determined $\overline{I_D}$, we can turn our attention to establishing a relationship between R_S and V_G, the voltage between the gate and ground. It is:

$$V_G = \overline{I_D}R_S - \overline{V_{GS}} \qquad (18)$$

We obviously want to make R_S as large as possible to improve stability, but there are some limitations. Voltages are developed across R_S and R_D due to the presence of I_D. When I_D is at its maximum, the sum of the voltages across R_S and R_D should be several volts less than V_{DD} if the transistor is to operate in the pinch-off region. Hence $(R_S + R_D)I_D$ must be less than V_{DD}. The value of R_D is usually determined by other circuit requirements, so that limits the value of R_S. Once the maximum value for R_S has been determined, the value of V_G is found from:

$$V_G = \left(\frac{R_G}{R_G + R_X}\right)V_{DD} \qquad (19)$$

But the values for R_G and R_X cannot be selected at random because of the presence of the leakage current, I_{GSS}. If ΔV_{GS} is the allowable bias voltage variation in the design, ΔI_D is the allowable drain

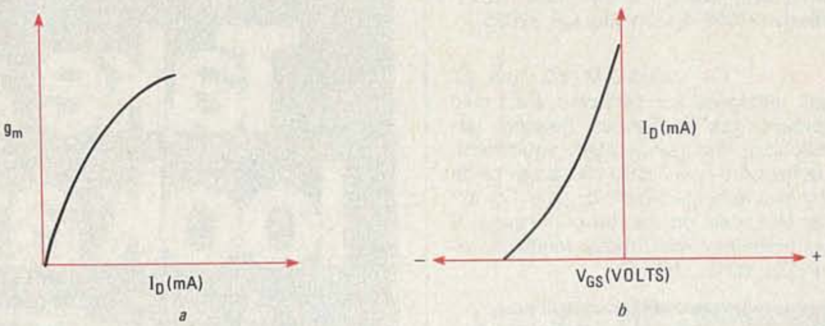

FIG. 9—THESE CURVES are extremely useful when designing MOSFET bias circuits. The curves for the device you are designing for can be found on that device's specification sheet.

current variation, ΔI_{GSS} is the amount the leakage gate current changes over the operating temperature range, and R_S is the value of the source resistor, the parallel equivalent resistance, R_P, of R_G and R_X can be no larger than:

$$R_P = \frac{R_G R_X}{R_G + R_X} < \frac{\Delta I_D R_S - \Delta V_{GS}}{\Delta I_{GSS}} \quad (20)$$

Once you've calculated R_P, you can find R_G and R_X from:

$$R_X = \frac{R_P V_{DD}}{V_{GS}} \quad (21)$$

$$R_G = \frac{R_P V_{DD}}{V_{DD} - V_{GS}} \quad (22)$$

Substituting that information into equation 19, we can determine V_G.

Biasing MOSFET's

MOSFET gates are insulated from their substrates and channels. Because of that, the leakage current is much lower than the I_{GSS} of a JFET. Furthermore, this leakage current remains constant regardless of the MOSFET's temperature.

Leakage current was a very important factor in bipolar device designs because it affected the output current. Collector current increased rapidly with leakage current and temperature causing the temperature and current to keep rising until the transistor, in many instances, destroyed itself. As for the MOSFET, that is not a problem because the output current here actually drops as the temperature of the transistor rises.

As for bias voltage, no gate current other than leakage current flows regardless of the gate's polarity with respect to the source. Despite that, n-channel enhancement\depletion-type MOSFET's are usually biased so that the gate is negative with respect to the source. But they could, if desired, be biased so that the gate is positive with respect to the source. Enhancement-type devices, however, MUST be biased so that the gate is positive with respect to the source.

The circuits we used to bias the JFET, shown in Fig. 8, can also be used for biasing MOSFET's. There is one additional consideration, however. Some MOSFET's have a lead from the substrate. If that should be the case connect that lead to the source of the transistor.

Two curves, a plot of g_m vs. I_D and a plot of I_D vs. V_{GS}, are useful when designing MOSFET bias circuits; a typical example of each of those is shown in Fig. 9-a and FIg. 9-b, respectively. Be aware that those curves will, of course, vary greatly among different types of MOSFET's; the curves for the specific device you are working with will be found on the device's specification sheet.

For a specific V_{DS}, calculating the values for the circuit shown in Fig. 8-a is relatively easy if you follow these steps.

1. Determine the g_m required for the circuit being designed.

2. Extend a line from that point on the vertical (g_m) axis of the plot of g_m vs. I_D found in the device's specification sheet to the curve itself. Drop a vertical line from the intersection point to the I_D axis. Where that line crosses the I_D axis is the desired value of I_D.

3. Following a procedure similar to the one in the last step, use the value of I_D to find the desired value of V_{GS} from the plot of I_D vs. V_{GS} found in the device's specification sheet. Once that is done, the values of I_D, V_{GS}, and V_{DS} are known.

4. Calculate R_S. For the circuit shown in Fig. 8-a, it is equal to V_{GS}/I_D.

5. As the voltage across R_D must be equal to $I_D R_D$, V_{DD} must be equal to $I_D R_D + V_{DS}$.

The design procedure is somewhat more complex when working on the bias network for the circuit shown in Fig. 8-b. Here, the bias voltage is the sum of the voltage across R_S, as just determined, and the voltage across R_G. If the voltage across R_G is to be positive with respect to ground, the voltage across the resistor can

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EQUIPMENT REPORTS

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The *DR44-6* has a suggested retail price of $2125.00.

DP4044 preselector

Enclosed in a matching 19-inch rack-panel metal enclosure, the *DP4044* Preselector features two-stage tuning accomplished by a concentric-control variable capacitor (dual section, 365-pF-per-section).

All RF coils are fully shielded. A 4-gang rotary switch selects the reactive components for each band within the 0- to 30-MHz range of the unit.

Both the input and output impedances of the *DP4044* are 50 ohms. The *DP4044* is not designed to match other impedances and may display insertion loss if the line impedance deviates from the nominal value.

We measured the insertion loss of the unit and it followed closely the specified table provided by the manufacturer, averaging 3 to 6 dB throughout the short-wave range. The loss becomes progressively greater at lower frequencies.

The RF selectivity is very sharp, requiring slight peaking every time the receiver is tuned more than a few percent past the peak position. The tuning range is continuous from 150 kHz through 30 MHz; the 0-150 kHz position is an untuned low-pass filter.

We found the *DP4044* to be quite effective in isolating discrete frequencies throughout its tuning range, although attention must be given to proper impedance-matching to avoid insertion losses. Users must remember that this is a preselector and *not* an impedance-matching antenna tuner.

As with all other passive preselectors, the user must not expect an increase in signal strength—only isolation of the frequency of interest. For that application, the *DP4044* works well. The *DP4044* has a suggested retail price of $235.00.

The *DS111* speaker

A companion matching speaker is also available; it includes several switch-selectable filtering combinations.

It is housed in a 10½-inch wide × 5-inch high × 6 ½-inch deep black and aluminum cabinet containing a 3 inch × 5 inch oval speaker. The *DS111* audio-processing speaker accessory features two front-panel controls: and on/off switch (switched off, the unit is simply disconnected; no external speaker jack is provided) and a rotary control with positions labeled LOUDNESS/FLAT/SSB/CW/HI PASS/LO PASS.

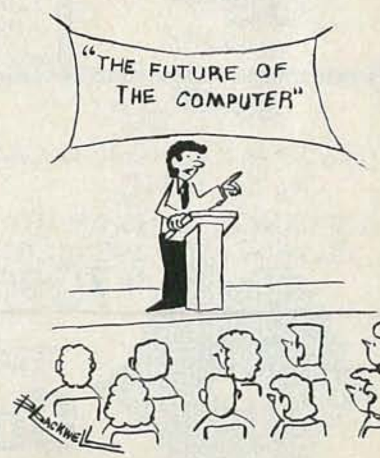
The speaker system is passive, designed around a tapped toroidal inductor that is used in combination with a series of four electrolytic capacitors. Because of the size of the windings on the toroid, very little insertion loss was noted.

In the LOUDNESS position, the bass and treble frequencies are passed, while mid-range frequencies are attenuated. In the FLAT position, the internal speaker is connected directly to the audio-input terminals (a pair of spring-loaded push terminals on the rear apron).

The SSB position attenuates both bass and treble frequencies while passing the midrange frequencies. In the CW position, a narrow midrange (800 Hz) is passed, while bass and treble are rolled off more steeply than the SSB position.

The HI PASS and LO PASS positions provide bass and treble roll-off respectively.

The *DS111* is certainly useful, especially when used with a receiver's selectivity controls, but that is no substitute for good IF selectivity in a receiver. The *DS111* has a suggested retail price of $85.00 **R-E**



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CASSETTE RECORDERS

continued from page 70

Normal tape movement, no audio

A Sanyo *M1000* cassette recorder ran nicely, but had no audio output. Rotating the volume control back and forth did not generate any sound from the speaker. A 1-kHz signal was injected at the volume control, but there was still no sound. Even when the signal was injected at pin 9 of the audio-amplifier IC nothing happened. An electrolytic coupling-capacitor was soldered to pin 13 of the IC and connected to an external speaker, but there was *still* no output.

Although the voltages at the IC were near normal, the IC was determined to be defective. Another LA4100 power-IC was installed and that solved the no-sound problem.

In summary, troubleshooting portable cassette-recorder/players is no different from working on other cassette players. You may find the components a little more compact and closer together but—then again—you may find fewer components to worry about. In fact, working with portable units can prove to be a pleasant diversion. **R-E**

COMPUTER CORNER

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suddenly switch to column A, row 3 if you need to access that information?

Can data be stored separately from the model? For instance, do you have to access the model itself in order to check the contents of row 5 (say that's for August), or can you access a separate file that will indicate the August sales?

Is there backup capability during the model-construction process? If a power failure or operator error occurs, will the entire model be lost, or is it backed up as it is created, so that only a small part of the work will have to be repeated?

Several computational features can make significant differences in the flexibility of your system. Are boolean-algebra functions (AND, OR, NOR, etc.) available for problems involving logic? Does the program allow for net-present-value computations that are often necessary in financial projections? For engineering and statistical projects, are roots and exponential functions available? Can the program compute percentages of increase; for instance, can it be determined that column A (sales for summer months), was 45% down from column B (October-December sales)?

All those features—and more—can be found among the various packages. You should investigate all the features offered by a package before committing yourself to it.

Where do you begin your search? The tried-and-true *VisiCalc* (VisiCorp, 2895 Zander Rd., San Jose, CA 95134) is a good place to start. Originally available just for the *Apple II,* the program is now available for the *Atari 800,* the IBM *Personal Computer,* the *TRS-80,* and Hewlett-Packard and Commodore systems.

If you are using *CP/M,* your choices include *T/MarkerII* (Lifeboat Associates, 1651 Third Ave., New York, NY 10028) (see Fig. 1), *Microplan* (Chang Labs, 10228 N. Stelling Rd., Cupertino, CA 95014), *MagiCalc* (Peachtree Software, 3 Corporate Square, #700, Atlanta, GA 30329), *SuperCalc* (Sorcim, 405 Aldo Ave., Santa Clara, CA 95050), *Multiplan* (Microsoft, 10700 Northrup Way, Bellevue, WA 98004), and *CalcStar* (MicroPro, 1299 4th St., San Rafael, CA 94901).

Phase One Systems (7700 Edgewater Dr., Oakland, CA 94621) produces *Masterplan,* a spreadsheet program to run under the *OASIS* operating system.

The business-software market has its share of programs for general ledger, accounts payable/receivable, and payroll. But financial-planning programs are in a class by themselves, providing a practical, time-saving service for the business environment. **R-E**

HEART RATE MONITOR

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you cannot divide by zero. When the Heart-a-Matic is first turned on, there is no guarantee as to what data will be present on the data bus. The 4508 that controls the bus at power-up will come up with data that seems to vary with the particular IC used. In a nutshell, there is no guarantee that there won't be all zeros on the data bus when the power is first supplied. The problem is resolved by IC22-e. It is configured as a half-monostable that outputs a pulse about one and a quarter seconds long. The IC is connected, via diode D2, to the most-significant-bit on the data bus.

When power is first turned on, the output pulse insures that there is some number greater than zero on the bus. Without that half-monostable and the "Mickey Mouse Logic" (M^2L) using D2, all zeros might appear and the Heart-a-Matic would try to divide by zero. If that happened, the batteries would give out before the answer showed up in the display.

The 12-volt power supply is made up of eight "AA" cells connected in series. Its output is fed to a standard 7805 regulator used in a slightly non-standard way. Be-

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COMMUNICATIONS CORNER

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the volume level: The loud sounds are clipped, while the soft sounds are allowed to pass through unprocessed.

Clipping the audio waveform causes distortion, and results in the generation of odd-order harmonics. For example, if the modulating signal is 1.5 kHz, clipping will produce substantial output at the third harmonic of 4.5 kHz and the fifth harmonic of 7.5 kHz, which are outside the upper narrow-band FM limit of 3 kHz. A low-pass filter consisting of R2/R3 and C2/C3/C4 strips out everything above 3 kHz before the signal gets to the next modulation amplifier.

The output from the amplifier is fed to a potentiometer, R4, which serves as a "deviation" (modulation level) adjustment, and then on to a varactor diode that's connected to the master oscillator. In that type of circuit it's necessary only to adjust the deviation control until the test equipment indicates the desired deviation.

Confusion sometimes sets in if a separate clipping adjustment is provided. Note that in the circuit shown, the clipping level in relation to the microphone signal is fixed; it's established by the preamplifier's gain and by diode D1. You will often find that there's a gain control for the preamp, or a level adjustment between the preamp's output and the clipper; either way, you can set the degree of clipping for a specific level into the microphone, or tailor the clipping level to the voice level of a specific user. Just remember that the transmitter's deviation—the modulation of the RF signal—is set with a single control. **R-E**

ANALOG DESIGN

continued from page 103

be found using equation 19. Complications arise if that voltage must be negative with respect to ground. Now the upper terminal of R_X should no longer be connected to $+V_{DD}$, but is instead connected to a negative supply. That supply is called $-V_{GG}$. Equation 19 still applies, except that $-V_{GG}$ is substituted for V_{DD}. The values of R_X, R_G, and R_S are still found as outlined above for the JFET.

Transistor applications

From here on, we will concentrate on designing practical circuits that use bipolar and FET transistors. We will start with small signal audio applications and continue our discussion detailing high frequency circuits, feedback, and so on. Regardless of what type of circuit you are designing, you will need to apply the material we've detailed over the past two months if you are to be successful. **R-E**

NEW BOOKS

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FREQUENCY SYNTHESIZERS THEORY AND DESIGN (Second Edition) by Vadim Manassewitsch. John Wiley & Sons, Inc., One Wiley Drive, Somerset, NJ 08873. 582 pp including appendices and index; 6¼ × 9¼ inches; hardcover; $36.00.

The original edition of *Frequency Synthesizers* was the first book to provide designers and users with a comprehensive treatment of the basic principles of synthesizer design, and an understanding of the problems often associated with it. This second edition is a significant expansion and updating of that volume. As with the first edition, this book recommends design procedures, provides useful design tools, and demonstrates the implementation of theory and circuit design with numerous practical examples.

Definitions and comprehensive descriptions of important concepts, such as phase noise and spurious outputs, and techniques for their analysis and measurement, are also provided. Detailed descriptions of some synthesizers are given to show the practical use of the design techniques that are presented in the text.

New to this second edition are two approaches—coherent direct digital synthesis and fractional-N phase-locked loop—in the chapter on frequency synthesis; updated test-equipment information; two new state-of-the-art synthesizers illustrating the application of design principles, and an entirely new chapter of troubleshooting techniques.

CIRCLE 111 ON FREE INFORMATION CARD

AMATEUR RADIO THEORY AND PRACTICE, by Robert L. Shrader W6BNB. Gregg Division, McGraw-Hill Book Company, 1221 Avenue of the Americas, New York, NY 10020. 340 pp including appendices and index; 7¼ × 9¼ inches; softcover; $14.95.

For those who want to get an amateur-radio license, here is a complete beginner's text that requires of the reader no previous background in radio or electronics. It explains in simple terms all of the basic theory that is needed to pass any and all of the amateur-radio license examinations given by the Federal Communications Commission (FCC). This volume is also valuable for the licensed amateur as it contains much information that the amateur needs to know in order to operate a radio station and its equipment properly.

The first chapter discusses the scope of the Amateur Radio Service, the five grades of amateur licenses available, and some of the interesting phases of amateur radio that a license will allow one to enjoy. Chapters 2 through 20 present the basic electrical, electronics, and radio theory that should prepare the reader to pass any of the written license tests. Chapter 21 is a "how to" that outlines how the reader can learn to send and receive Morse code at the speed required for any of the amateur licenses. Chapter 22 contains a nontechnical condensation of many of the important amateur-radio rules and regulations that were not included in the earlier chapters.

Each chapter contains its main body of information plus a very helpful checkup quiz, every few pages—answers to be found on the following page. And at the end of chapters, you will find representative questions listed under the five amateur-license grades.

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PET BASIC: TRAINING YOUR PET COMPUTER, by Ramon Zamora, Robert Albrecht, and William Scarvie. Reston Publishing Company, Inc., Reston, VA 22090. 310 pp including appendices and index; 5⅞ × 8⅞ inches; softcover; $12.95.

If you are a newcomer to the *PET*, you'll find that each chapter in this book has been written for those learning to use the *PET*. There are many examples, do-it-yourself exercises, and fun-filled explorations. The text will encourage the user to experiment and try out the numerous features and capabilities of the *PET*; it even shows how to create *graphical* images on the *PET* screen without difficulty.

For those who have been *PET* owners for some time, this book will prove to be a handy reference source, and a means of discovering new things that the *PET* can do. Each chapter includes a set of exercises for review that will help the owner to learn more, and develop greater skill in using that dynamic machine.

CIRCLE 113 ON FREE INFORMATION CARD

INTRODUCTION TO RADIO FREQUENCY DESIGN, by W.H. Hayward. Prentice-Hall, Inc., Englewood Cliffs, NJ 07632. 383 pp including index; 7 × 9½ inches; $27.95.

This book is designed for three specific reader groups: the working engineer, scientist, technician, or manager; the student of engineering or computer science, and the electronics hobbyist, including the radio amateur.

A central theme emphasized throughout the book is simplicity. More formal treatments of individual subjects are found in the references listed at the end of the individual chapters. Mathematics is used in the text as required to convey information to the reader.

The individual chapters cover: low-frequency transistor models, filter basics, coupled resonator filters, transmission lines, two-port networks, practical amplifiers and mixers, oscillators and frequency synthesizers, and the receiver: an RF system. **R-E**

CIRCLE 114 ON FREE INFORMATION CARD

HEART RATE MONITOR

continued from page 109

cause R27 is placed on the ground leg of the regulator, we are able to trick the device into putting out six volts instead of the standard five. That operating voltage was chosen for the Heart-a-Matic to provide a compromise between battery life and reliable operation. The monitor draws an average of 60 milliamps during operation allowing long battery life.

A low-battery warning is provided by R47, Q3, and SCR1. The voltage at the base of Q3 determines the voltage drop across R46. When it reaches a particular level, enough current will flow through the resistor to provide sufficient current to trigger SCR1. When the rectifier fires, the signal is routed to the decimal points of the display with the help of another bit of M^2L logic, causing them to remain lit constantly. Diode D1 allows the beep generator to continue operating, and resistor R7 was chosen to make the decimal points light up much more brightly than they do during the heartbeat—so there will be no mistaking that the batteries are getting low and should be replaced.

The trip point of SCR1 is set with R47, a 500 kilohm multi-turn potentiometer. Once the decimal points light, the SCR's latching action will keep them lit. Note that if the Heart-A-Matic is rapidly turned on, off, and back on again, the low-battery warning will appear. That's because C25 has not had time to discharge completely and the remaining charge fools the low-battery circuit into thinking that the batteries—not the capacitor—are not putting out enough voltage. A wait of about ten seconds is sufficient to prevent that from happening.

Now that we know how the Heart-a-Matic works, the next step is to build one. We will show you just how that is done in the next part of this article. **R-E**

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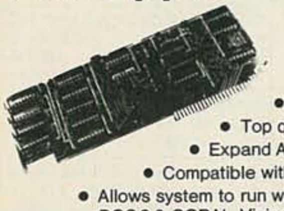

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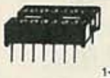

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LM702H	1.99	RC4151N	3.70
LM709N/H	.29	RC4194TK	4.95
LM710N/H	.75	RC4195TK	5.40
LM711N/H	.39	ULN2001	1.25
LM715N	1.95	ULN2003	1.50
LM723N/H	.65	SN75450N	.59
LM733N/H	.98	SN75451N	.35
LM739N	1.15	SN75452N	.49
LM741CN/H	.33	SN75453N	.49
LM741CN-14	.19	SN75454N	.49
LM747N/H	.75	SN75491N	.89
LM748N/H	.39	SN75492N	.89
LM760CN	2.95	SN75493N	.89
LM1310N	1.90	SN75494N	.89
MC1330	1.95	TL494CN	4.20
MC1350	1.95	TL496CP	1.65
MC1358	1.75		

74S00

74S00	$ .39	74S124	3.69	74S244	$2.99
74S02	.43	74S133	.54	74S251	1.35
74S03	.45	74S134	.66	74S253	1.35
74S04	.52	74S135	1.15	74S257	1.29
74S05	.52	74S136	1.60	74S258	1.29
74S08	.49	74S138	1.29	74S260	.75
74S09	.49	74S139	1.29	74S280	2.79
74S10	.42	74S140	.73	74S287	2.99
74S11	.42	74S151	1.29	74S288	2.55
74S15	.42	74S153	1.29	74S373	3.10
74S20	.42	74S157	1.29	74S374	3.10
74S22	.42	74S158	1.29	74S387	2.75
74S30	.42	74S160	2.79	74S471	7.95
74S32	.49	74S174	1.49	74S472	7.95
74S38	1.19	74S175	1.49	74S473	7.95
74S40	.49	74S188	2.69	74S474	9.95
74S51	.42	74S194	1.89	74S475	9.95
74S64	.46	74S195	1.89	74S570	5.75
74S65	.46	74S196	1.89	74S571	5.75
74S74	.69	74S240	2.75	74S572	8.95
74S86	.72	74S241	2.75	74S573	8.95
74S112	.72	74S242	2.99	74S940	2.90
74S113	.72	74S243	2.99	74S941	2.90
74S114	.72				

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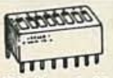

2 Position	$ .99	7 Position	$1.39
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7403	.22	7480	.49	74164	.87
7404	.22	7482	.95	74165	.87
7405	.23	7483	.55	74166	1.20
7406	.35	7485	.65	74167	1.95
7407	.35	7486	.35	74170	1.69
7408	.26	7489	1.75	74172	4.75
7409	.23	7490	.39	74173	.79
7410	.22	7491	.57	74174	.89
7411	.29	7492	.45	74175	.85
7412	.29	7493	.45	74176	.75
7413	.39	7494	.69	74177	.75
7414	.59	7495	.65	74179	1.34
7416	.29	7496	.69	74180	.75
7417	.29	7497	2.90	74181	1.75
7420	.22	74100	2.90	74182	.75
7421	.35	74107	.32	74184	2.25
7422	.29	74109	.37	74185	2.25
7423	.29	74116	1.95	74186	9.95
7425	.29	74121	.29	74188	3.90
7426	.29	74122	.39	74190	1.15
7427	.25	74123	.59	74191	1.15
7429	.45	74125	.39	74192	.85
7430	.23	74126	.44	74193	.85
7432	.29	74128	.59	74194	.85
7437	.25	74132	.69	74195	.68
7438	.29	74136	.75	74196	.85
7439	.29	74139	.95	74197	.85
7440	.19	74141	.79	74198	1.39
7441	.79	74142	2.95	74199	1.39
7442	.57	74143	2.95	74221	1.19
7443	.95	74144	2.95	74251	.95
7444	.95	74145	.62	74273	1.05
7445	.79	74147	1.95	74276	1.89
7446	.79	74148	1.20	74279	.75
7447	.65	74150	1.09	74283	1.40
7448	.79	74151	.67	74284	3.90
7450	.19	74152	.67	74285	3.90
7451	.19	74153	.67	74290	1.25
7453	.19	74154	1.19	74298	.95
7454	.19	74155	.78	74365	.68
7459	.25	74156	.78	74366	.68
7460	.23	74157	.69	74367	.68
7470	.29	74158	1.65	74368	.68
7472	.29	74159	2.49	74390	1.45
7473	.34	74160	.88	74393	1.90
7474	.34			74490	1.90

74LS00

74LS00	$ .26	74LS113	$ .43	74LS245	$2.20
74LS01	.28	74LS114	.43	74LS247	1.10
74LS02	.28	74LS122	.55	74LS248	1.10
74LS03	.28	74LS123	1.19	74LS249	1.19
74LS04	.35	74LS124	1.35	74LS251	1.40
74LS05	.28	74LS125	.89	74LS253	1.40
74LS08	.28	74LS126	.52	74LS257	.85
74LS09	.35	74LS132	.79	74LS258	.98
74LS10	.28	74LS136	.49	74LS259	2.95
74LS11	.39	74LS138	.85	74LS260	.65
74LS12	.33	74LS139	.85	74LS261	2.49
74LS13	.47	74LS145	1.25	74LS266	.59
74LS14	.95	74LS148	1.49	74LS273	1.75
74LS15	.33	74LS151	.79	74LS275	4.40
74LS20	.26	74LS153	.79	74LS279	.59
74LS21	.33	74LS154	1.70	74LS283	.99
74LS22	.33	74LS155	1.19	74LS290	.99
74LS26	.33	74LS156	.99	74LS293	.99
74LS27	.33	74LS157	.85	74LS295	1.10
74LS28	.33	74LS158	.75	74LS298	1.19
74LS30	.26	74LS160	1.05	74LS324	1.75
74LS32	.33	74LS161	1.15	74LS347	1.95
74LS33	.55	74LS162	1.05	74LS348	1.95
74LS37	.45	74LS163	1.05	74LS352	1.19
74LS38	.39	74LS164	1.19	74LS353	1.19
74LS40	.26	74LS165	.89	74LS363	1.49
74LS42	.79	74LS166	2.48	74LS365	.69
74LS47	.79	74LS168	1.15	74LS366	.69
74LS48	.95	74LS169	1.15	74LS367	.69
74LS51	.26	74LS170	1.99	74LS368	.69
74LS54	.29	74LS173	.89	74LS373	1.89
74LS55	.29	74LS174	.89	74LS374	1.89
74LS73	.45	74LS175	.89	74LS375	.69
74LS74	.42	74LS181	2.20	74LS377	1.95
74LS75	.59	74LS190	1.15	74LS385	1.95
74LS76	.45	74LS191	1.15	74LS386	.65
74LS78	.45	74LS192	.98	74LS390	1.95
74LS83A	.79	74LS193	.98	74LS393	1.95
74LS85	1.19	74LS194	1.15	74LS395	1.70
74LS86	.45	74LS195	.95	74LS399	2.35
74LS90	.57	74LS196	.89	74LS424	2.95
74LS92	.75	74LS197	.89	74LS668	1.75
74LS93	.75	74LS221	1.15	74LS670	2.29
74LS95	.88	74LS240	1.69	81LS95	1.69
74LS96	.98	74LS242	1.69	81LS96	1.69
74LS107	.45	74LS243	1.69	81LS97	1.69
74LS109	.45	74LS244	1.49	81LS98	1.69
74LS112	.43				

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4013	.45	4050	.69	14419	4.95
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4015	1.15	4052	1.10	4502	1.65
4016	.59	4053	1.10	4503	.69
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4023	.29	4070	.49	4512	1.39
4024	.75	4071	.35	4515	2.75
4025	.25	4072	.35	4516	1.45
4027	.65	4073	.35	4518	1.39
4028	.85	4075	.35	4520	1.25
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01N	.22	74LS47N	.72	74LS139N	.55	74LS192N	.74	74LS298N	.99
02N	.24	74LS73N	.35	74LS148N	1.39	74LS193N	.74	74LS348N	1.65
03N	.24	74LS74N	.32	74LS151N	.43	74LS194N	.74	74LS362N	9.95
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05N	.25	74LS76N	.44	74LS155N	.87	74LS240N	1.19	74LS366N	.59
08N	.25	74LS85N	.89	74LS157N	.48	74LS241N	1.19	74LS367N	.59
09N	.25	74LS86N	.35	74LS158N	.48	74LS242N	1.19	74LS368N	.59
10N	.24	74LS90N	.42	74LS160N	.79	74LS243N	1.19	74LS373N	1.96
11N	.28	74LS92N	.54	74LS161N	.75	74LS244N	1.25	74LS374N	1.96
12N	.25	74LS93N	.54	74LS163N	.69	74LS245N	1.95	74LS375N	.64
13N	.36	74LS96N	.72	74LS164N	.58	74LS251N	.69	74LS377N	1.25
14N	.48	74LS107N	.42	74LS165N	.89	74LS253N	.69	74LS378N	.99
20N	.29	74LS112N	.36	74LS166N	1.64	74LS257N	.69	74LS390N	1.44
21N	.27	74LS122N	.45	74LS170N	1.59	74LS259N	1.49	74LS393N	1.44
26N	.25	74LS123N	.69	74LS173N	.72	74LS266N	.42	74LS447N	.89
30N	.34	74LS125N	.49	74LS174N	.44	74LS273N	1.19	74LS624N	1.68
32N	.27	74LS132N	.58	74LS175N	.45	74LS279N	.44	74LS670N	1.36
38N	.28	74LS133N	.49	74LS189N	4.45	74LS280N	1.96		

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TC	.49	555TC	.27	1489APC	.64	SN76477N	2.75
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N4728A — IN4752A (1 WATT)	.17	IN4149	.035	IN4003	.07
N4753A — IN4764A (1 WATT)	.32	IN4150	.035	IN4004	.08
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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
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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

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Range:	20 Hz to 525 MHz
Sensitivity:	Less than 50 MV to 150 MHz Less than 150 MV to 500 MHz
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Time base:	1.0 ppm TCXO 20-40°C
Power:	12 VAC @ 250 ma

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PRICES:

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SPECIFICATIONS:

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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

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Time base:	2.0 ppm 20-40°C
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PRICES:

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BP-3, Nicad pack +AC adapter/charger	19.95
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LM7806 +6 reg	10/$5
LM7808 +8V reg	10/$5
LM7815 +15V reg	10/$5
LM7818 +18V reg	10/$5
LM7824 +24V reg	10/$5
LM7906 -6V reg	10/$5
LM7908 -8V reg	10/$5
LM7915 -15V reg	10/$5
LM7918 -18V reg	10/$5
LM7924 -24V reg	10/$5

CMOS

4010	40/$4
4015	40/$5
4016	50/$5
4019	40/$5
4022	40/$5
4023	60/$6
4025	50/$5
4028	60/$5
4030	50/$5
4040	20/$5
4069	50/$5
4071	50/$5
4073	50/$5
4075	50/$5
4093	50/$5
4116	50/$5
4507	50/$5
4512	50/$5

ODDS AND ENDS

Misc. pots - some funny shafts, some duals, some singles, no time to select	35/$5
250 Ohm trimpots	50/$5
500 Ohm	50/$5
25A/50V diode bridges	5/$5
Dynamic mic originally designed for Cartrivision with extension cable (miniplug male and female); stereo pair	$5
Extension cable as above	5/$5
Stereo amps with LM380s and pots. May even work!	2/$5
15 MHz crystal oscillator in small can	2/$5
Colorburst crystal 3.58 MHz	
1 MHz HC-6 crystal	5/$5

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OAKLAND AIRPORT, CA 94614-0355

Send the coupon below to **Bill Godbout Electronics,** RE Parts Sale, PO Box 2355 Oakland Airport, CA 94614-0355.

Please send the parts circled above to (PLEASE PRINT OR TYPE):

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Street Address (necessary for UPS delivery) ______________________

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Town __________ State __________ ZIP __________

Subtotal for parts:	
Californians add tax	$
Handling (strike out for orders over $25)	$ 2.00
Postage (allow 5%, excess refunded)	$
TOTAL	$

CIRCLE 82 ON FREE INFORMATION CARD

CIRCLE 69 ON FREE INFORMATION CARD

JE600 Hexadecimal Encoder Kit

FULL 8-BIT LATCHED OUTPUT 19-KEY KEYBOARD

The JE600 Encoder Keyboard Kit provides two separate hexadecimal digits produced from sequential key entries to allow direct programming for 8-bit microprocessor or 8-bit memory circuits. Three additional keys are provided for user operations with one having a bistable output available. The outputs are latched and monitored with 9 LED readouts. Also included is a key entry strobe. Features: Full 8-bit latched output for microprocessor use. Three user-define keys with one being bistable operation. Debounce circuit provided for all 19 keys. 9 LED readouts to verify entries. Easy interfacing with standard 16-pin IC connector. Only +5VDC required for operation. Size: 3½"H x 8¼"W x 8¾"D

JE600/DTE-HK (After assembled as pictured above) **$99.95**

JE600 Kit 19-Key Hexadec. Keyboard, PC Board & Cmpnts. (no case) .. **$59.95**
K19 19-Key Keyboard (Keyboard only) **$14.95**
DTE-HK (case only — 3½"Hx8¼"Wx8¾"D) **$44.95**

JE610 ASCII Encoded Keyboard Kit

The JE610 ASCII Keyboard Kit can be interfaced into most any computer system. The kit comes complete with an industrial grade keyboard switch assembly (62-keys), IC's, sockets, connector, electronic components and a double-sided printed wiring board. The keyboard assembly requires +5V @ 150mA and −12V @ 10 mA for operation. Features: 60 keys generate the 126 characters, upper and lower case ASCII set. Fully buffered. Two user-define keys provided for custom applications. Caps lock for upper-case-only alpha characters. Utilizes a 2376 (40-pin) encoder read-only memory chip. Outputs directly compatible with TTL/DTL or MOS logic arrays. Easy interfacing with a 16-pin dip or 18-pin edge connector. Size: 3½"H x 14½"W x 8¾"D

JE610/DTE-AK (After assembled as pictured above) ...**$124.95**

JE610 Kit 62-Key Keyboard, PC Board, & Components (no case).....**$ 79.95**
K62 62-Key Keyboard (Keyboard only) ...**$ 34.95**
DTE-AK (case only — 3¾"Hx11"Wx8¾"D)**$ 49.95**

NEW! JE212 — Negative 12VDC Adapter Board Kit for JE610 ASCII KEYBOARD KIT Kit/ Provides -12VDC from incoming 5VDC . $9.95

JE215 Adjustable Dual Power Supply

General Description: The JE215 is a Dual Power Supply with independent adjustable positive and negative output voltages. A separate adjustment for each of the supplies provides the user unlimited applications for IC current voltage requirements. The supply can also be used as a general all-purpose variable power supply.

FEATURES:
- Adjustable regulated power supplies, pos. and neg. 1.2VDC to 15VDC.
- Power Output (each supply): 5VDC @ 500mA, 10VDC @ 750mA, 12VDC @ 500mA, and 15VDC @ 175mA.
- Two, 3-terminal adj. IC regulators with thermal overload protection.
- Heat sink regulator cooling
- LED "on" indicator
- Printed Board Construction
- 120VAC input
- Size: 3-1/2"w x 5-1/16"L x 2"H

JE215 Adj. Dual Power Supply Kit (as shown) . . $24.95

(Picture not shown but similar in construction to above)
JE200 Reg. Power Supply Kit (5VDC, 1 amp) . . $14.95
JE205 Adapter Brd. (to JE200) ±5,±9 & ±12V . . $12.95
JE210 Var. Pwr. Sply. Kit, 5-15VDC, to 1.5amp. . $19.95

HP-Display Sale-National

5082 Series — 0.43 Inch — 7-Segment

Part Number	Color	Description	1-3 Price	SALE PRICE
5082-7650	Hi Eff Red	CA - LHD	.99	4/$2.49
5082-7651	Hi Eff Red	CA - RHD	.99	4/$2.49
5082-7653	Hi Eff Red	CC - RHD	.99	4/$2.49
5082-7656	Hi Eff Red	Overflow ± 1RHD	.99	4/$2.49
5082-7660	Yellow	CA - LHD	.99	4/$2.49
5082-7661	Yellow	CA - RHD	.99	4/$2.49
5082-7663	Yellow	CC - RHD	.99	4/$2.49
5082-7670	Green	CA - LHD	.99	4/$2.49
5082-7671	Green	CA - RHD	.99	4/$2.49
5082-7673	Green	CC - RHD	.99	4/$2.49
5082-7676	Green	Overflow ± 1RHD	.99	4/$2.49
5082-7750	Red	CA - LHD	.99	4/$2.49
5082-7751	Red	CA - RHD	.99	4/$2.49
5082-7756	Red	Overflow ± 1RHD	.99	4/$2.49
5082-7760	Red	CC - RHD	.99	4/$2.49

CA-Comm. Anode CC-Comm. Cathode LHD/RHD-Left/right hand dec.

UTIC
Mini Stereo AM/FM Receiver

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WITH HEADPHONES
For Joggers, Cyclists, Skaters & Sports Events

FEATURES: Lightweight headphones. Left/right balance control. Full fidelity stereo sound. Additional black soft carrying case & shoulder strap. Belt clip (hands free). Operates on 3 AA cell batteries (not incl.). Compact size: 3⅛" x 4⅞" x 1". Wt. 6 oz.

Model 2830 . . . . $29.95

KEYBOARDS — POWER SUPPLIES

9½"Lx4¼"Wx1"H

ALPS 26-KEY CALCULATOR KEYBOARD
Features: 7 Position, 3 Position and 2 Position Switches (ON/OFF). These are from Olivetti's Top of the Line. Mechanical SPST Switching: 22-pin Edge Card Connection.
Part No. KB26 . . . .$1.95 each or 2/$3.49

16⅝"L x 5¼"W x 1⅝"H

MICRO SWITCH 69-KEY KEYBOARD
Data Entry Keyboard, Encoded Output: 8-bit Parallel EBC DIC. Switching: Hall Effect, 24-pin Edge Card Connection. Complete with Pin Connection.
Part No. KB69SD12-2 . . . .$19.95 each

16¾"L x 5½"W x 1⅝"H

DATANETICS 74-KEY KEYBOARD
ASCII Encoded Keyboard, Output: Even Parity ASCII, Supply voltage +5, -12 volt. Switching: Mechanical SPST — 50-pin Connection. Complete with Pin Connection.
Part No. KB354 . . . .$29.95 each

23"Lx5¾"Wx1-3/8"H

MICRO SWITCH 85-KEY KEYBOARD
Word Processing Keyboard, 26 Pin Edge Card Connection. Supply Voltage +5VDC. Main Keyboard is QWERTY. Additional Key Pads for Cursor and word processing functions.
Part No. 85SD18-1 . . . .$29.95 each

18¼"L x 5¾"W x 1⁵⁄₁₆"H

MICRO SWITCH 88-KEY KEYBOARD (PARALLEL ASCII)
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.
Part No. 88SD22 . . . .$69.95 each

POWER SUPPLY — 5VDC @ 1 AMP REGULATED Transaction Tech
Output +5VDC @ 1 amp (also +30VDC) reg. Input 115VAC 60Hz. Two-tone (black/beige) self-enclosed case. 6 ft., 3 cond. black power cord. Size: 6½"W x 7"D x 2¾"H. Wt. 3 lbs.
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. 6¾"W x 7¾"D x 3-7/8"H - wt. 7 lbs.
Part No. PS407D . . . .$24.95 each

POWER SUPPLY — 5VDC @ 7.5 AMP, 12VDC @ 1.5 AMP SWITCHING
Input: 115VAC, 50-60Hz @ 3 amp/230VAC, 50Hz @ 1.6 amp. Fan volt./power supply select switches (115/230VAC). Output: 5VDC @ 7.6 amp, 12VDC @ 1.6 amp. 8 ft. blk. pow. cord. 11½"W x 13¼"D x 3¾"H. Wt. 6 lbs.
Part No. PS94VO . . . .$49.95 each

POWER PAC — Heavy Duty Multi-Voltage Power Supply — 5VDC, 12VDC, 24VDC
Output: +5VDC @ 30A, +12VDC @ 2A, -12VDC @ 4A & +24VDC @ 3A. Input: 115VAC, 7A, 220VAC, 3.5A. Reg.: ± .15% line & load comb. Ripple: 10MV peak to peak (3MV RMS). Overvolt. protect.: 5V, +12V, -12V. Overcur. protect. incl. 15½"L x 6"H x 11-7/8"D. Wt. 40 lbs.
Part No. 285-016 . . . .$89.95 each

SOC 2-6 (Pictured)

SORENSEN Regulated Power Supplies

Sorensen's open construction (SOC) power supplies are series-regulated solid-state systems, designed to provide reg. DC voltages at 6 levels (2-28 v/range). These units are open-framed on sturdy black anodized aluminum for excellent mounting.

FEATURES: 115/208/230VAC Input @ 50-63Hz. Low Ripple: 1.5mVrms, 5mV P-P maximum. Adjustable current limit. Voltage adjustment control. All schematics and specifications supplied with unit. Series A,B,C,E have three mounting surfaces (Series F, bottom mounting only).

Part No.	Series	Output Voltage Adjustment Range min.	max.	Output Current amps (Adc) @40°C	@50°C	@60°C	Size (Inches)	Weight	Price
SOC 2-6	B	1.9	2.1	6.0	4.9	3.8	5.63 x 4.88 x 2.50	4.3 lbs.	$19.95
SOC 2-25	F	1.9	2.1	25.0	21.5	17.5	16.00 x 4.88 x 4.88	16 lbs.	39.95
SOC 5-3	A	4.75	5.25	3.0	2.4	1.8	4.00 x 4.88 x 1.62	2 lbs.	24.95
SOC 5-18	E	4.25	5.25	18.0	15.0	12.0	14.00 x 4.88 x 2.76	12 lbs.	39.95
SOC 5-25	F	4.75	5.25	25.0	21.5	17.5	16.00 x 4.88 x 4.88	16 lbs.	44.95
SOC 12-11	E	11.4	12.6	11.0	9.2	6.6	14.00 x 4.88 x 1.62	12 lbs.	44.90
SOC 12-15	F	11.4	12.6	15.0	12.75	9.5	16.00 x 4.88 x 4.88	16 lbs.	49.95
SOC 15-5	C	14.25	15.75	5.0	4.2	3.5	7.00 x 4.88 x 3.37	6.6 lbs.	39.95
SOC 15-9.5	E	14.25	15.75	9.5	7.6	5.6	14.00 x 4.88 x 1.62	12 lbs.	44.95
SOC 15-13	F	14.25	15.75	13.0	10.5	8.0	16.00 x 4.88 x 4.88	16 lbs.	49.95
SOC 28-0.8	A	26.6	29.4	0.8	.64	.45	4.00 x 4.88 x 1.62	2 lbs.	24.95

22D300 (Pictured)

Powertec Sub-Modular DC Power Supplies

SM Series power supplies include rectifying, filtering, regulating, overload and overvoltage protection functions. You need only connect the sub-module to the appropriate secondary transformer tap and bolt the unit to a heatsink.

REGULATION: LINE; .10% for a change from -10% to +10% input voltage. LOAD; .15% for a 0-100% load change (units below 5V output maintain 5V regulation). OUTPUT RIPPLE: 1mV RMS, 3mV P-P typical. 5mV P-P maximum. INPUT CHARACTERISTICS: Requires low-level AC input. Derate output current 15% for operations at 50Hz.

Part Number	-100 *4.75V to 7.0V	-200 *7.0V to 10.5V	-300 *10.5V to 15.75V	-500 *22.0V to 30.0V	Power Transformer Requirements (Transformers Not Included) Primary	Secondary	Size (Inches)	Wt.	Price
22AA-300			0.23A		115–120VAC	17VAC .5A no CT	2.50 x 3.00 x .98	2 oz.	$14.95
22B-200		2.2A			115–120VAC	22VAC .3A w/CT	3.00 x 5.75 x 1.18	8 oz.	14.95
22B-300			1.7A		115–120VAC	28VAC 2.5A w/CT	2.75 x 5.75 x 1.18	8 oz.	19.95
22C-100	6.0A				115–120VAC	16VAC 8A w/CT	2.80 x 7.50 x 1.18	8 oz.	24.95
22C-500				2.5A	115–120VAC	48VAC 3A w/CT	2.80 x 7.50 x 1.18	8 oz.	24.95
22D-300			6.8A		115–120VAC	28VAC 10A w/CT	3.00 x 7.00 x 3.30	2 lbs.	24.95
22E-100	18.00A				115–120VAC	16VAC 24A w/CT	2.90 x 7.00 x 3.30	2 lbs.	29.95

*Voltage Adjustment Range — Current ratings apply over entire voltage range.

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JUMPER AND CABLE ASSEMBLIES

Custom Cables!

STANDARD DIP JUMPERS

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"	3.20
DJ14-2-14	924106-24	14	double end	24"	3.49
DJ14-3-14	924106-36	14	double end	36"	3.79
DJ16-1	924112-12	16	single end	12"	1.85
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"	3.35
DJ16-2-16	924116-24	16	double end	24"	3.69
DJ16-3-16	924116-36	16	double end	36"	4.05
DJ24-1	924122-12	24	single end	12"	2.69
DJ24-2	924122-24	24	single end	24"	3.39
DJ24-3	924122-36	24	single end	36"	3.95
DJ24-1-24	924126-12	24	double end	12"	4.79
DJ24-2-24	924126-24	24	double end	24"	5.29
DJ24-3-24	924126-36	24	double end	36"	5.89

JAMECO Part No.	AP Cross Reference	No. Pins	Description	Wire Length	Price
DJ40-1	924132-12	40	single end	12"	5.89
DJ40-2	924132-24	40	single end	24"	6.79
DJ40-3	924132-36	40	single end	36"	7.59
DJ40-1-40	924136-12	40	double end	12"	10.95
DJ40-2-40	924136-24	40	double end	24"	11.89
DJ40-3-40	924136-36	40	double end	36"	12.79

STANDARD DB25 SERIES CABLES

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

Part No.	Cable Length	Connectors	Price
DB25P-4	4 feet	1-DB25P	$ 9.95 ea.
DB25S-4	4 feet	1-DB25S	10.95 ea.
DB25P-4-P	4 feet	2-DB25P	16.95 ea.
DB25P-4-S	4 feet	1-DB25P/1-DB25S	17.95 ea.
DB25S-4-S	4 feet	2-DB25S	18.95 ea.

$10.00 Minimum Order — U.S. Funds Only
California Residents Add 6½% Sales Tax
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Spec Sheets — 25¢ each
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5¼" Mini-Floppy Disc Drive

FOR TRS-80 MODEL I, III (Industry Standard)

Pertec Computer Corp.

Features single or double density. Recording mode: FM single, MFM double density. Power: +12VDC (±0.6V) 1.6 amps max., +5VDC (±0.25V) 0.8 amps max. Unit as pictured at left (does not incl. case, power supply or cables). 30-page data book included. Weighs 3½ pounds. Size: 5¾"W x 8"D x 3¼"H

Limited Quantity!

Part No. Price
FD200 . . . . **$179.95**
Single-sided, 40 tracks, 250K bytes capacity
FD250 . . . . **$199.95**
Double-sided, 35 tracks, 438K bytes capacity

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

**Model 1 = From 4K to 16K Requires (1) One Kit
Model 3 = From 4K to 48K Requires (3) Three Kits
Color = From 4K to 16K Requires (1) One Kit
**Model 1 equipped w/Expansion Board up to 48K (2) Two Kits Req'd.
— One Kit Required for each 16K of Expansion —

TRS-80 16K Conversion Kit — Kit comes complete with 8 each MM5290 (UPD416/4116) 16K Dynamic RAM (*ns) & documentation for conversion.
TRS-16K2 *150ns $16.95
TRS-16K3 *200ns $14.95
TRS-16K4 *250ns $10.95

Pee Wee Boxer Fan

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

PWS2107U Cleaned & tested (used) . . . $ 7.95 ea.
PWS2107F New . . . . $12.95 ea.

Muffin® Fan

- 105cfm free air delivery
- 4.68" sq. x 1.50" depth.
- 10 yrs. cont. duty at 20°C
- Impedance protected, ambients to 70°C
- 115V 50/60Hz 14W Wt. 17 oz.

MU2A1-U Cleaned & tested (used) . . . . $ 7.95 ea.
MU2A1-N New . . . . $12.95 ea.

½ Price Sale! — **COMPUTER GRADE CAPACITORS** — ½ Price Sale!

mfd	wvdc	price	mfd	wvdc	price	mfd	wvdc	price	mfd	wvdc	price
250	150	1.95	4,500	50	3.95	20,000	20	2.95	43,000	10	5.95
500	200	2.49	5,500	25	4.49	21,000	15	3.95	45,000	5	5.95
1,250	3	.99	6,100	40	2.49	22,000	15	4.95	52,000	20	5.95
1,500	25	1.95	7,000	60	4.95	23,000	7	1.95	55,000	15	5.95
1,500	50	2.95	10,000	15	2.95	23,000	18	2.95	58,000	20	5.95
2,000	10	2.95	10,000	16	3.95	23,000	20	3.95	65,000	10	7.95
2,100	200	2.95	11,000	19	4.95	24,000	20	2.95	73,800	5	7.95
2,250	100	3.95	13,000	16	2.95	27,000	10	2.95	80,000	15	9.95
2,300	33	2.95	14,000	13	2.95	32,500	25	4.95	90,000	10	8.95
2,500	15	2.95	15,500	10	4.95	40,000	25	5.95	120,000	15	10.95
3,000	25	1.95	18,000	10	3.95	42,000	10	4.95	160,000	10	8.95
3,600	40	3.95									

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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

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

Mostek DC/DC Converter

1⅛"L x 7/8"H x 1/4"D

+5 VOLTS TO -9 VOLTS

Input: +5V. Output:-9V (regulated) @ 30mA. Printed circuit mounting.
DC10 . . . . **$2.95 ea. or 2/$4.95**

AC250 (Pictured)

Wall Transformers AC and DC Types

Part No.	Input	Output	Price
AC 250 (above)	117V/60Hz	12VAC 250mA	$3.95
AC 500	117V/60Hz	12VAC 500mA	$4.95
AC1000	117V/60Hz	12VAC 1 amp	$5.95
AC1700	117V/60Hz	9VAC 1.7 amp	$3.95
AC9004	117V/60Hz	9.2VAC 2.5 amp	$2.95 or 2/$4.95
DC 800	120V/60Hz	8VDC 400mA	$1.95 or 2/$2.95
DC6912	120V/60Hz	6,9,12VDC 300mA	$9.95
DV5490	117V/60Hz	9.5VDC 275mA	$2.49 or 2/$3.95
DC900	120V/60Hz	9VDC 500mA	$3.95
DC1200	120V/60Hz	12VDC 300mA	$2.95 or 2/$4.95

MOTOROLA AM/FM Stereo Push Button Car Radio

FOR VOLKSWAGEN SCIROCCO, RABBIT, AUDI 5000 AND FOX
(with minor adjustments, can be used in any automobile)

Includes bezel trim & everything pictured. Two ea. 4x6 speakers & grille (1½" deep). All cables & leads for hook-up. Incl. all instruction Manuals for easy installation. Cut-out dim.: 7"W x 1¾"H x 6½"L.

Model 5VW3901 . . . . $49.95

C/MOS

4001	.25	4028	.65	4081	.20	74C04	.50
4002	.25	4029	.75	4082	.20	74C32	.45
4006	.85	4030	.35	4093	.60	74C42	1.00
4007	.27	4034	1.75	4099	1.75	74C73	.75
4008	.70	4035	.75	4501	.95	74C74	.50
4009	.45	4040	.65	4506	.70	74C76	.70
4010	.45	4042	.55	4510	.65	74C83	1.30
4011	.22	4043	.65	4511	.65	74C85	1.30
4012	.22	4044	.55	4514	1.40	74C86	.50
4013	.35	4046	.90	4515	1.50	74C90	.30
4014	.70	4049	.30	4516	.75	74C93	.95
4015	.70	4050	.30	4518	1.25	74C154	2.50
4016	.30	4051	.80	4520	.70	74C157	1.75
4017	.60	4052	.75	4528	1.25	74C160	1.20
4018	.50	4053	.75	4553	2.75	74C161	1.15
4019	.45	4066	.50	4583	.70	74C163	1.15
4020	.70	4069	.20	4585	.86	74C165	1.25
4021	.85	4068	.20	74C00	.27	74C173	1.30
4022	.80	4070	.35	74C02	.27	74C174	1.30
4023	.25	4071	.25	74C04	.27	74C175	1.20
4024	.45	4072	.25	74C08	.30	74C192	1.30
4025	.25	4076	.35	74C10	.27	74C901	.50
4027	.40	4077	.35	74C20	.27	74C914	1.75
						74C921	3.95

CPU'S & SUPPORT CHIPS

8080A	3.75	8251	5.75
8085A	7.50	8255	6.95
AMD 2901	8.95	8258	6.95
8202	25.00	8257 (AM9517)	7.95
8212	2.25	8X300	25.00
8214	3.60	6802	6.00
8216	2.50	Z80A CPU	6.00
8224	3.25	Z80A S10	12.95
MM5307	9.95	Z80A P10	6.00
8226	2.75	Z80 CTC A	7.50
8228	4.50	TMS 9927 NL	9.95
8155	9.00	8275	16.95
		6845	16.95
		6810	2.50

RAM's

8264 (4164-2)	11.95
2114L-3	1.85
4116-3	1.75
4116-2	1.95
21L02-3	.90
TMS 3409	1.75
MK4027-3	3.50
MK4096-11	2.95
6116-3	8.95
TMS 4060NL	3.95
MM5280	1.75
2101-1	2.45
Z6104-4	2.50
MK4006P	1.95
IM7001	4.95
5101E	2.95
2111AL	2.45
MK4802-J3	10.95
93L422	5.95

ROM's

2708	2.95
2716 + 5V	5.75
2732	9.95
1702A	4.95
2532	9.95
2764-25	18.95
82S23	1.95
82S112	4.00
82S115	4.00
82S123	1.95
82S129	1.95
82S130	1.95
3628A-3	3.00
AM9214C	2.95
8255-5 (74188A)	1.25

INTERFACE & DRIVERS

1488	.90
1489	1.10
8130	2.50
8830	2.50
8833	2.50
8834	2.00
8837	2.00
MM5321	9.50
MM5369	2.50

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MM1403	1.75
MM1404	1.75
MM5013	2.50
MM5055	2.50
MM5056	2.50
MM5057	2.50
MM5058	2.50
MM5061	2.50

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TR1602B	3.95	COM2017	3.75
PT1482B	3.25	AY3-8700	2.25

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2N2646 UJT .... $ .45
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2.2UF 20V	5/$1.00	33UF 20V	$ .60
3.3UF 20V	4/$1.00	47UF 20V	$ .85
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TMS 8275 ...... 16.95

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4116-2 .... 1.85
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93L422 BIPOLAR . 5.95
4164-2-64K 11.95
2147 J3-4KX1 STATIC 6.95

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2716 .... 5.75

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200	.70	.80	1.90	9.00
400	1.20	1.40	2.60	12.00
600		1.80	3.60	15.00

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PRV	1A	10A	25A
100	.45	.80	1.55
200	.84	1.30	2.10
400	1.30	1.90	3.10
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7403	.17	7475	.40	74166	.70
7404	.24	7476	.40	74167	1.25
7405	.24	7480	.45	74170	1.60
7406	.33	7483	.50	74173	.75
7407	.35	7485	.65	74174	.65
7408	.27	7486	.42	74175	.60
7409	.24	7490	.45	74176	.75
7410	.17	7491	.45	74177	.75
7411	.22	7492	.45	74180	.75
7412	.30	7493	.45	74181	1.90
7413	.42	7494	.60	74182	.45
7414	.50	7495	.60	74190	.70
7416	.33	7496	.60	74191	.75
7417	.37	74107	.35	74192	.70
7420	.17	74116	1.50	74193	.79
7425	.30	74121	.35	74194	.85
7426	.33	74122	.39	74195	.45
7427	.30	74123	.42	74196	.75
7430	.17	74125	.45	74197	.75
7432	.27	74126	.45	74221	.85
7437	.27	74145	.75	74279	.60
7438	.27	74148	1.25	74365	.65
7440	.17	74150	1.10	74367	.65
7441	.75	74151	.50	74368	.65
7442	.45	74153	.40	74390	.90
7445	.70	75154	1.10	75324	1.75
7446	.75	74155	.50	75325	1.50
7447	.85	74157	.50	75492	1.05
7448	.65	74160	.85	8T31	2.00
7450	.17	74161	.65	8T32	2.75
		74162	.60	9601	.75
				9602	.75
				DS0056H	1.50

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74LS01	.20	74LS109	.38	74LS221	.80
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74LS03	.24	74LS113	.45	74LS241	.95
74LS04	.25	74LS114	.55	74LS242	1.20
74LS05	.25	74LS123	.65	74LS243	1.20
74LS08	.25	74LS124	1.25	74LS244	1.10
74LS09	.25	74LS125	.45	74LS245	1.50
74LS10	.24	74LS126	.45	74LS247	.75
74LS11	.25	74LS132	.55	74LS248	1.10
74LS12	.25	74LS136	.45	74LS251	.68
74LS13	.45	74LS137	.95	74LS253	.68
74LS14	.45	74LS138	.52	74LS257	.68
74LS15	.35	74LS139	.52	74LS258	.68
74LS20	.25	74LS151	.40	74LS259	1.40
74LS21	.25	74LS153	.40	74LS266	.60
74LS22	.25	74LS155	.60	74LS273	1.15
74LS26	.35	74LS156	.80	74LS279	.48
74LS27	.28	74LS157	.48	74LS280	1.80
74LS28	.45	74LS158	.48	74LS283	.85
74LS30	.22	74LS160	.75	74LS290	.75
74LS32	.30	74LS161	.70	74LS293	.95
74LS37	.30	74LS162	.80	74LS298	1.00
74LS38	.30	74LS163	.65	74LS320	2.00
74LS40	.40	74LS164	.85	74LS365	.80
74LS42	.44	74LS165	.85	74LS366	.80
74LS47	.65	74LS166	1.10	74LS367	.58
74LS51	.22	74LS168	1.75	74LS368	.58
74LS54	.25	74LS170	1.50	75LS373	1.25
74LS73	.35	74LS173	.70	74LS374	1.25
74LS74	.35	74LS174	.45	74LS377	1.25
74LS75	.35	74LS175	.40	74LS386	.65
74LS76	.45	74LS181	1.95	74LS390	1.30
74LS83	.68	74LS190	.80	74LS393	1.30
74LS85	.85	74LS191	.80	74LS398	2.50
74LS86	.40	74LS192	.72	74LS670	1.60
74LS90	.39	74LS193	.72	74LS682	3.00
74LS92	.50	74LS194	.75	81LS97	1.10
74LS93	.50	74LS195	.90	81LS98	1.10
74LS96	.70	74LS196	.85	8T26	1.25
				8T97	.95

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LM301/748	.30	LM358	.50	710	.45
741CV	.25	LM361	1.75	349	.95
741C	.35	LM377	1.60	711CH	.40
747	.50	LM380	.95	LM1808	1.75
1456	.80	LM382	.80	CA758	1.75
1458	.50	LM383	2.50	CA3018	1.95
4136	.85	LM386	1.40	CA3078	1.50
3900	.45	LM387	1.25	CA3080	.95
LM307	.30	LM393	1.00	CA3086	.95
LM308	.75	LM553	2.25	CA3140	1.20
LM324	.65	LM555	.45	LM2901	.95
LM339	.65	LM556	.85	8038CC	3.90
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LF353	1.25	565	1.40	TL062 CP	.95
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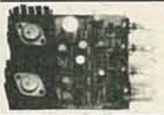

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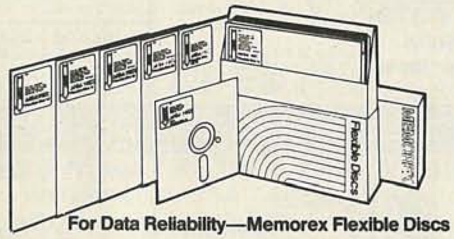

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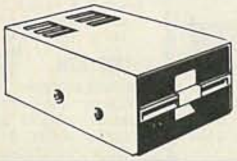

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SANYO MONITORS

MODEL NO.	DESCRIPTION	LIST	SALE
VM 4509	9" B&W, 10 MHz	$190.00	$169.00
DM 5109	9" Green, 10 MHz	$200.00	$180.00
DM 8012	12" B&W, 18MHz	$250.00	$225.00
DM 8112	12" Green, 18MHz	$260.00	$235.00
DMC 6013	13" Color	$470.00	$425.00
DMC 6113	13" RGB Color	$995.00	$895.00

IC SOCKETS

	LP	WW		LP	WW
8-pin	**5/ .75**	**5/1.91**	22-pin	**5/1.62**	**5/4.66**
14-pin	**5/1.00**	**5/2.40**	24-pin	**5/1.80**	**5/4.77**
16-pin	**5/1.20**	**5/2.65**	28-pin	**5/2.10**	**5/5.87**
18-pin	**5/1.35**	**5/2.98**	40-pin	**5/3.02**	**5/6.89**
20-pin	**5/1.52**	**5/4.55**			

SPECIAL OF THE MONTH

2532 EPROM	4116 (200nS)	2732 EPROM
$9.95 ea.	8/$13.50 32/$43.20	$8.95 ea.

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Brand New Micro Computer Power Supply

- Switching regulation
- Multiple DC outputs:
  +5V 4A −12V 1A
  +12V 1A −2.2 to 15V 0.5A
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- Over-voltage protection with IC monitor
- 110/220 V input
- Factory assembled
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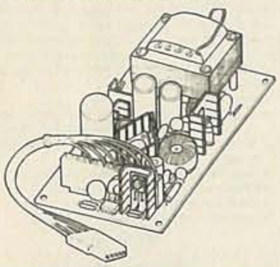
- $49.00 each, freight prepaid (Calif residents pls add $3 sales tax)



Model A501 Power Amp

- Pure Class A 25W + 25W
- Switchable to Class AB 100W + 100W
- Switchable to Bridge Class A 100W mono
- Switchable to Bridge Class AB 300W mono
- Frequency Response 5-200KHz (-1dB)
- Signal-to-Noise Ratio 120dB
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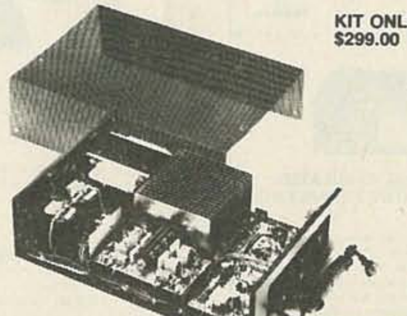
KIT ONLY $299.00



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6514 J-5 1KX4-CMOS Super Low Power 350 n.s. Similar to 2114 Same Pin Out	2.95
8108-5 IKX8 NMOS 5V 500 NS 22 Pin	2.50

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LS14	.89	LS157	.79	LS290	.99
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LS109	.39	LS241	.99	LS393	1.19
LS123	.99	LS242	1.49	LS399	.99

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	DM8131 6 Bit Unified Bus Comparator	2.99
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CRT CONT	68B45 - Motorola (HD46505SP) CRT Controller	17.59
PROMS	82S123-32X8 Tri State Bi polar PROM	1.99
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EPROM

1702A 256X8 1 us	2.50
2708 1KX8 450 n.s.	2.95
27A08 1KX8 350 n.s.	3.95
2716 2KX8+5v 450 n.s. (Buy 2 Get 1 FREE.)	5.95
2716-1 2KX8+5v 350 n.s.	7.95
2732 4KX8 450 n.s. Intel Pin Out	9.95
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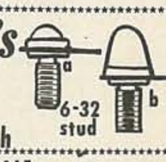

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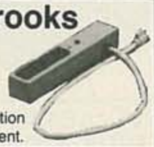

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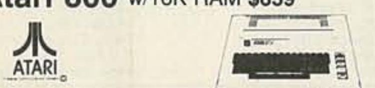

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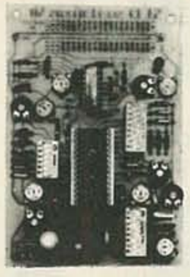

The SE-01 is a complete kit that contains all the parts to build a programmable sound effects generator. Designed around the new **Texas Instruments SN76477 Sound Chip**, the board provides banks of MINI DIP switches and pots to program the various combinations of the SLF Oscillator, VCO, Noise, One Shot, and Envelope Controls. A Quad Op Amp IC is used to implement an Adjustable Pulse Generator, Level Comparator and Multiplex Oscillator for even more versatility. The 3¼" x 5" PC Board features a prototype area to allow for user added circuitry. Easily programmed to duplicate **Explosions, Phasor Guns, Steam Trains,** or almost an infinite number of **other sounds**. The unit has a multiple of applications. The low price includes all parts, assembly manual, programming charts, and detailed 76477 chip specifications. It runs on a 9V battery (not included). On board 100MW amp will drive a small speaker directly, or the unit can be connected to your stereo with incredible results! (Speaker not included). **76477 is included.** Available separately for **$3.15 each**.

The Super Music Maker

REVISION 2
$24.95
(Basic Kit)
SEE SPECIAL OFFER BELOW

- Comes with 25 pre-programmed tunes.
- On board 7 watt amplifier drives 8 ohm speaker directly.
- Works on 12VAC or 12 VDC.
- Uses either 2708 or 2716 EPROM for expanded tune playing capability. Listing available pre-programmed ROM's.

A true electronic music maker based on a microprocessor chip. The Super Music Maker is the only kit that allows easy addition of pre-programmed tunes by plugging in one memory chip (ROM). Over 20 different ROM's with over 500 tunes are available. Use the kit for a **Car Horn, Doorbell, Door Announcer,** etc. If you have an EPROM programmer our manual tells you how to program your own tunes. Kit includes quality plated and drilled PC Board and all components.

OPTIONAL ACCESSORIES

DIP SWITCHES One 8 pos., one 5 pos., for tune address	**2.00/set**
WALLPLUG TRANSFORMER For operation on 117VAC house current	**3.00**
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HORN SPEAKER 8 watt, 8 Ohm with mounting bracket	**6.25**

SPECIAL OFFER
Buy a Super Music Maker kit for $24.95 and get **FREE,** a 2708 ROM pre-programmed with 35 popular tunes. This offer gives you over 60 songs to choose from!

7 Watt Audio Amp Kit $6.95

SMALL, SINGLE HYBRID IC AND COMPONENTS FIT ON A 2" x 3" PC BOARD (INCLUDED). RUNS ON 12VDC. GREAT FOR ANY PROJECT THAT NEEDS AN INEXPENSIVE AMP. LESS THAN 3% THD @ 5 WATTS. COMPATIBLE WITH SE-01 SOUND KIT.

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If you have trouble sleeping and you would like the rest of the neighborhood to share your misery then this little kit will be for you! There is no way to accurately describe the unearthly howls, screams and tones that come out of this kit. Four separate tone oscillators are mixed, cancelled and stepped at a varying rate. 10 Watts of crazy sounds. A great fun kit or a practical burglar alarm. Complete with PC board and all necessary components less speaker. For 6-12 VDC. ORDER DA-02.

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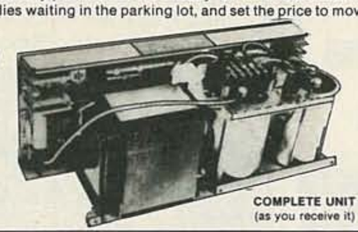

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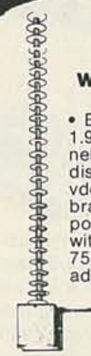
Amateur 32-Element Yagi Antenna

• Not a kit, so it's easier to sell • 1.9-2.5 Ghz • 38½" long • Die-cast waterproof aluminum housing • Withstands temps −40° to +140°F. • 50-ohm type "N" connector • Mounting hardware included.

Only $19.95

2 Ghz MICROWAVE ANTENNA



with 52 dB Overall Gain

• Built-in down converters • Tune 1.9-2.5 Ghz • Operates on channels 2-6 • 22 dB gain resonant disc antenna • Standard 12-16 vdc power supply • Mounting brack for horizontal or vertical polarity • **Comes with:** 60' coax with connectors, 3' jumper cable, 75-300 ohm and 300-75 ohm adapters, complete instruction.

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with Separate Down Converters
FULL-YEAR WARRANTIES!

58 dB Gain Just $144.95 — 62 dB Gain Only $169.95

• Tuneable temp-compensated L.O. • Power supply with built-in A-B switch • High gain, low noise figures • Convenient mounting tabs • Weather-resistant housings • For distant or low signal areas • Two microwave pre-amp stages • 2.1-2.3 Ghz • 20 Mhz input band-width • Noise figure: 5 dB • TV channels 2-6 • 75-ohm type "F" output • 50-ohm type "N" input impedance • Aluminum housing • Withstands temps from −40° to +140°F.

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			Each	100 pcs
2101	256 x 4	(450ns)	1.95	1.85
5101	256 x 4	(cmos) (450ns)	4.95	3.95
2102-1	1024 x 1	(450ns)	.89	.85
2102L-2	1024 x 1	(LP) (250ns)	1.69	1.55
2102L-4	1024 x 1	(LP) (450ns)	1.29	1.15
2111	256 x 4	(450ns)	2.99	2.49
2112	256 x 4	(450ns)	2.99	2.79
2114	1024 x 4	(450ns)	8/16.95	1.95
2114L-2	1024 x 4	(LP) (200ns)	8/15.95	1.90
2114L-3	1024 x 4	(LP) (300ns)	8/18.95	2.25
2114L-4	1024 x 4	(LP) (450ns)	8/17.95	2.10
2147	4096 x 1	(55ns)	9.95	call
TMS4044-4	4096 x 1	(450ns)	3.49	3.25
TMS4044-3	4096 x 1	(300ns)	3.99	3.75
TMS4044-2	4096 x 1	(200ns)	4.49	4.25
MK4118	1024 x 8	(250ns)	9.95	call
TMM2016	2048 x 8	(150ns)	call	call
HM6116-4	2048 x 8	(cmos) (200ns)	call	call
HM6116-3	2048 x 8	(cmos) (150ns)	call	call
HM6116-2	2048 x 8	(cmos) (120ns)	call	call
HM6116LP-4	2048 x 8	(LP) (cmos) (200ns)	call	call
HM6116LP-3	2048 x 8	(LP) (cmos) (150ns)	call	call
HM6116LP-2	2048 x 8	(LP) (cmos) (120ns)	call	call
Z-6132	4096 x 8	(Qstat) (300ns)	34.95	call

LP = Low Power   Qstat = Quasi-Static

DYNAMIC RAMS

			Each	100 pcs
TMS4027	4096 x 1	(250ns)	2.50	2.00
MK4108	8192 x 1	(200ns)	1.95	call
MM5298	8192 x 1	(250ns)	1.85	call
4116-120	16384 x 1	(120ns)	8/29.95	call
4116-150	16384 x 1	(150ns)	8/18.95	1.95
4116-200	16384 x 1	(200ns)	8/13.95	call
4116-250	16384 x 1	(250ns)	8/11.95	call
4116-300	16384 x 1	(300ns)	8/13.80	call
2118	16384 x 1	(5v) (150ns)	4.95	call
MK4816	2048 x 8	(5v) (300ns)	24.95	call
4164-200	65536 x 1	(5v) (200ns)	call	call
4164-150	65536 x 1	(5v) (150ns)	call	call

EPROMS

			Each	8 pcs
1702	256 x 8	(1us)	4.95	4.50
2708	1024 x 8	(450ns)	3.75	3.50
2758	1024 x 8	(5v) (450ns)	9.95	8.95
TMS2516	2048 x 8	(5v) (450ns)	6.95	5.95
2716	2048 x 8	(5v) (450ns)	4.95	3.95
2716-1	2048 x 8	(5v) (350ns)	9.00	8.50
TMS2716	2048 x 8	(450ns)	9.95	8.95
TMS2532	4096 x 8	(5v) (450ns)	9.95	7.95
2732	4096 x 8	(5v) (450ns)	9.95	7.95
2732A-2	4096 x 8	(5v) (200ns)	call	call
2764	8192 x 8	(5v) (450ns)	call	call
TMS2564	8192 x 8	(5v) (450ns)	call	call

5v = Single 5 Volt Supply

EPROM ERASERS

	Timer	Capacity Chip	Intensity (uW/V,²)	
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-320T	X	32	15,000	595.00

Z-80

2.5 Mhz

Z80-CPU	6.00
Z80-CTC	5.95
Z80-DART	15.25
Z80-DMA	17.50
Z80-PIO	6.00
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

8200

8202	34.95
8205	3.50
8212	1.85
8214	3.85
8216	1.80
8224	2.50
8226	1.80
8228	4.90
8237	19.95
8238	4.95
8243	4.45
8250	14.95
8251	4.75
8253	9.25
8253-5	9.85
8255	4.75
8255-5	5.25
8257	8.50
8257-5	8.95
8259	6.90
8259-5	7.50
8272	39.95
8275	29.95
8279	9.50
8279-5	10.00
8282	6.65
8283	6.65
8284	5.70
8286	6.65
8287	6.50
8288	25.00
8289	49.95

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8035	7.25
8039	7.95
INS-8060	17.95
INS-8073	29.95
8080	3.95
8085	7.95
8085A-2	11.95
8086	59.95
8088	39.95
8089	89.95
8155	7.95
8156	8.95
8185	29.95
8185-2	39.95
8741	39.95
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1791	29.95
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1797	54.95
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8272	39.95
UPD765	39.95
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2143	18.95

INTERFACE

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8T28	2.49
8T95	.99
8T96	.99
8T97	.99
8T98	.99
DM8131	2.95
DP8304	2.29

MISC

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76477	3.95
AY3-8910	12.95
MC3340	1.49
95H90	7.99
11C90	13.95
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3242	7.95
MC3480	9.00
MC4024	3.95
MC4044	4.50
3205	3.50

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BR1941	11.95
4702	12.95
COM5016	16.95
MM5307	10.95

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AY5-1013	3.95
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IM6402	7.95
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AY5-3600	11.95
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74C923	5.50

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MM5369	3.95
MM5375	4.95
MM58167	8.95
MM58174	11.95
MSM5832	6.95

6800

68000	call
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6802	10.95
6808	13.90
6809E	19.95
6809	19.95
6810	2.95
6820	4.95
6821	4.95
6828	14.95
6840	12.95
6843	34.95
6844	25.95
6845	16.95
6847	12.25
6850	3.45
6852	5.75
6860	10.95
6862	11.95
6875	6.95
6880	2.95
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	6.95
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

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1.0 mhz	4.95
1.8432	4.95
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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
10.0	3.95
14.31818	3.95
15.0	3.95
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18.432	3.95
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74LS01	.25	74LS86	.40	74LS169	1.75	74LS298	1.20
74LS02	.25	74LS90	.65	74LS170	1.75	74LS324	1.75
74LS03	.25	74LS91	.89	74LS173	.80	74LS352	1.55
74LS04	.25	74LS92	.70	74LS174	.95	74LS353	1.55
74LS05	.25	74LS93	.65	74LS175	.95	74LS363	1.35
74LS08	.35	74LS95	.85	74LS181	2.15	74LS364	1.95
74LS09	.35	74LS96	.95	74LS189	9.95	74LS365	.95
74LS10	.25	74LS107	.40	74LS190	1.00	74LS366	.95
74LS11	.35	74LS109	.40	74LS191	1.00	74LS367	.70
74LS12	.35	74LS112	.45	74LS192	.85	74LS368	.70
74LS13	.45	74LS113	.45	74LS193	.95	74LS373	1.75
74LS14	1.00	74LS114	.50	74LS194	1.00	74LS374	1.75
74LS15	.35	74LS122	.45	74LS195	.95	74LS377	1.45
74LS20	.25	74LS123	.95	74LS196	.85	74LS378	1.18
74LS21	.35	74LS124	2.99	74LS197	.85	74LS379	1.35
74LS22	.25	74LS125	.95	74LS221	1.20	74LS385	1.90
74LS26	.35	74LS126	.85	74LS240	1.29	74LS386	.65
74LS27	.35	74LS132	.75	74LS241	1.29	74LS390	1.90
74LS28	.35	74LS136	.55	74LS242	1.85	74LS393	1.90
74LS30	.25	74LS137	.99	74LS243	1.85	74LS395	1.65
74LS32	.35	74LS138	.75	74LS244	1.29	74LS399	1.70
74LS33	.55	74LS139	.75	74LS245	1.90	74LS424	2.95
74LS37	.55	74LS145	1.20	74LS247	.75	74LS447	.37
74LS38	.35	74LS147	2.49	74LS248	1.25	74LS490	1.95
74LS40	.35	74LS148	1.35	74LS249	.99	74LS624	3.99
74LS42	.55	74LS151	.75	74LS251	1.30	74LS668	1.69
74LS47	.75	74LS153	.75	74LS253	.85	74LS669	1.89
74LS48	.75	74LS154	2.35	74LS257	.85	74LS670	2.20
74LS49	.75	74LS155	1.15	74LS258	.85	74LS674	9.65
74LS51	.25	74LS156	.95	74LS259	2.85	74LS682	3.20
74LS54	.35	74LS157	.75	74LS260	.65	74LS683	2.30
74LS55	.35	74LS158	.75	74LS266	.55	74LS684	2.40
74LS63	1.25	74LS160	.90	74LS273	1.65	74LS685	2.40
74LS73	.40	74LS161	.95	74LS275	3.35	74LS688	2.40
74LS74	.45	74LS162	.95	74LS279	.55	74LS689	2.40
74LS75	.50	74LS163	.95	74LS280	1.98	74LS783	24.95
74LS76	.40	74LS164	.95	74LS283	1.00	81LS95	1.69
74LS78	.50	74LS165	.95	74LS290	1.25	81LS96	1.69
74LS83	.75	74LS166	2.40	74LS293	1.85	81LS97	1.69
						81LS98	1.69

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LM301V	.34	LM1800	2.99
LM308V	.98	LM1889	2.49
LM309K	1.49	LM3900	.59
LM311	.64	LM3909V	.98
LM317T	1.95	LM3914	3.95
LM317K	3.95	LM3915	3.95
LM318	1.49	LM3916	3.95
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LM324	.59	75452V	.39
LM337K	3.95	75453V	.39
LM339	.99		
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LM380	1.29	TL071	.79
LM386V	1.50	TL072	1.19
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LM1458V	.69	XR 2208	3.90
LM1488	.99	XR 2211	5.25
LM1489	.99	XR 2240	3.25

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

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

CMOS

4000	.35	4071	.30
4001	.35	4072	.30
4002	.25	4073	.30
4006	.95	4075	.30
4007	.29	4076	.95
4008	.95	4078	.30
4009	.45	4081	.30
4010	.45	4082	.30
4011	.35	4085	.95
4012	.25	4086	.95
4013	.45	4093	.95
4014	.95	4098	2.49
4015	.95	4099	1.95
4016	.45	14409	12.95
4017	1.15	14410	12.95
4018	.95	14411	11.95
4019	.45	14412	12.95
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4026	1.65	4512	.95
4027	.65	4514	1.25
4028	.80	4515	2.25
4029	.95	4516	1.55
4030	.45	4518	1.25
4034	2.95	4519	1.25
4035	.85	4520	1.25
4040	.95	4522	1.25
4041	1.25	4526	1.25
4042	.75	4527	1.95
4043	.85	4528	1.25
4044	.85	4531	.95
4046	.95	4532	1.95
4047	.95	4538	1.95
4049	.55	4539	1.95
4050	.55	4543	2.70
4051	.95	4555	.95
4053	.95	4556	.95
4060	1.45	4581	1.95
4066	.75	4582	1.95
4068	.40	4584	.95
4069	.35	4584	.95
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7815T	.89	7915T	.99
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7805K	1.39	7905K	1.49
7812K	1.39	7912K	1.49
7815K	1.39	7915K	1.49
7824K	1.39	7924K	1.49
78L05	.69	79L05	.79
78L12	.69	79L12	.79
78L15	.69	79L15	.79

T = TO-220 K = TO-3
L = TO-92

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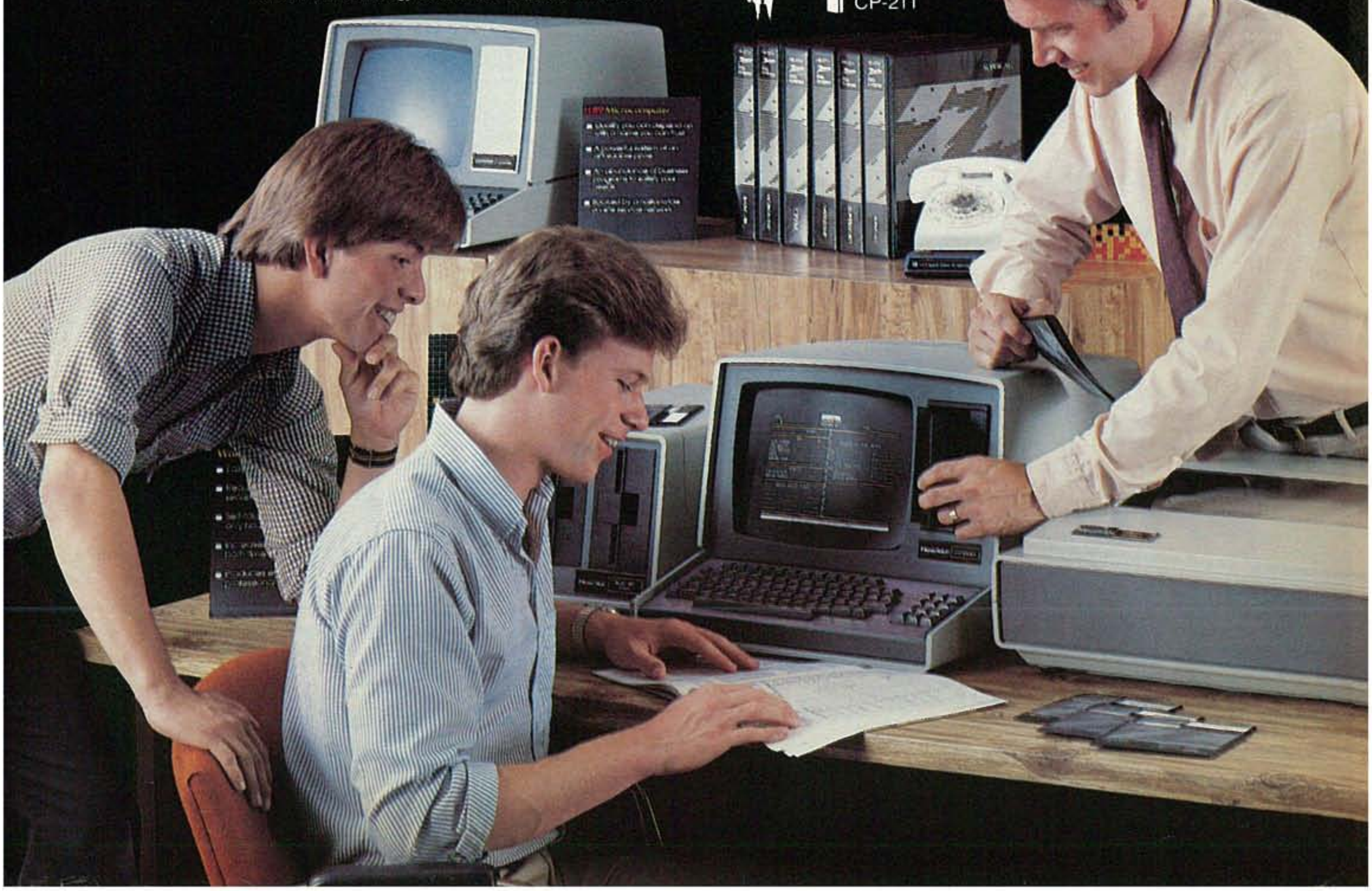

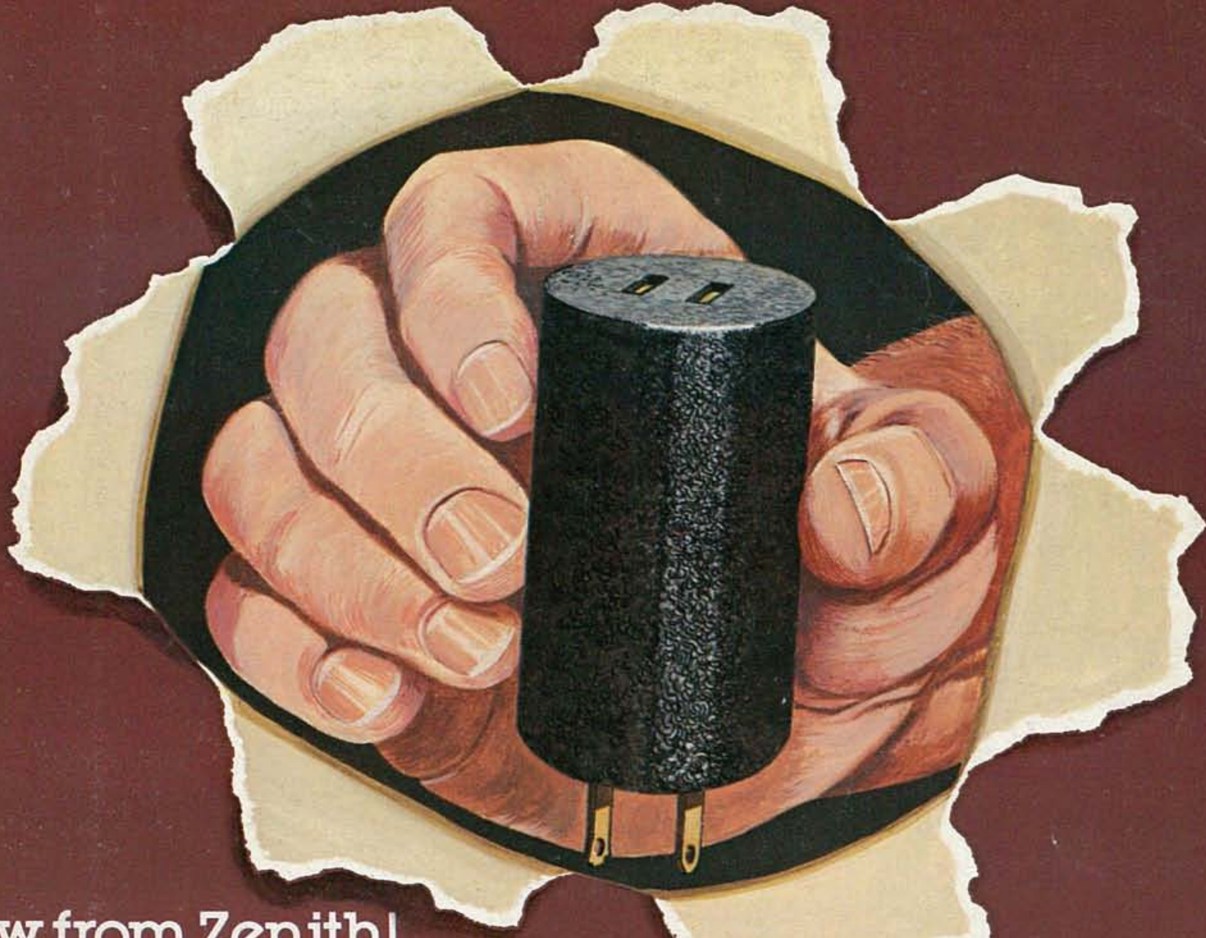

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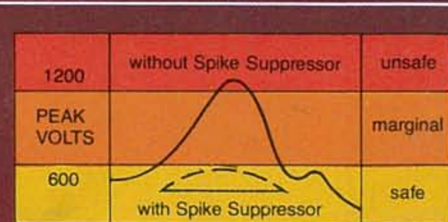

In this graph, the solid curve represents the excess voltage or "spike" imposed on an electric system and, represented by the dotted line, the protection provided household appliances as the Zenith Spike Suppressor absorbs the excess voltage and prevents it from surging thru the system.

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