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Radio-Electronics®

THE MAGAZINE FOR NEW IDEAS IN ELECT

New From Heath
TWO COMPUTER SYSTEMS
For The Hobbyist

TV MODULATOR
Feeds Video Signals
To Your TV's
Antenna Terminals

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Build 10-Function Unit
Includes Timer And Alarm
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How To Turn 8mm Silent
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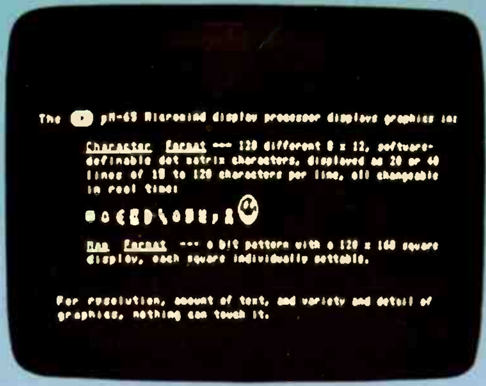
R-E Lab Tests Optonica ST-3535 Tuner & Hitachi SR-903 Receiver ★



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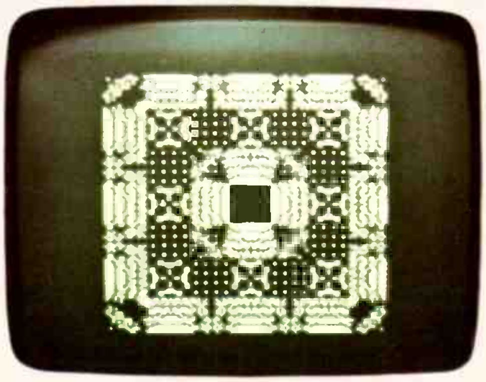

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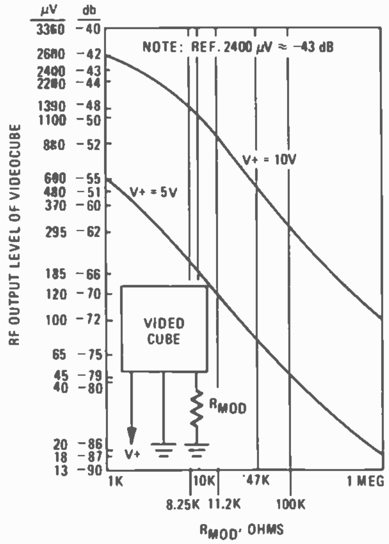
Electronics publishers since 1908 AUGUST 1977 Vol. 48 No. 8

ON THE COVER

Two major new computer systems are now available to the hobbyist. Teamed with a video terminal and a tape reader/punch/duplicator we photographed them for this month's cover. For full details see the complete story starting on page 43.



VIDEOCUBE INTERFACES video to RF antenna inputs of TV set. One resistor sets RF output level.

. . . **turn to page 33**

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looking ahead

Home computers: The video game will evolve into the home computer earlier than expected—later this year and early next. The home computer currently is a specialized and sophisticated hobbyist product, but video game manufacturers hope to convert every television set into an electronic brain, and prices initially can be expected to be as low as $200 or $300.

Most of the new home computers presumably will begin life as programmable games, but be expandable to computer operation, presumably as special programs are added. Bally, the pinball machine manufacturer, expects to introduce a programmable game later this year at under $300, with cartridges $20 each, including computer capability. Said a Bally spokesman: The game is expandable to do "anything IBM computers did a few years ago." Arnold Greenberg, president of toy manufacturer Coleco, calls home computers "one of the imminent next generations" and says his company is "deep into that project."

APF Electronics plans to introduce a $200 computer this year "priced to attract both the consumer and the small businessman." Magnavox plans a game-computer combination at less than $200 that can "do home math problems, take care of tax forms, solve financial problems." Magnavox says it's already listed 1,800 potential home computer applications.

PCM recording: Pulse code modulation (PCM) tape recording has audio professionals excited. One of the first such recorders shown in the U.S. was the subject of a paper at the recent Audio Engineering Society convention in Los Angeles by Mitsubishi. The recorder lays down nine parallel tracks on ¼-inch tape running at 15 ips and records 60 minutes on a 10-inch reel. Here are the specs: Tape-speed variation, none. Crosstalk, wow-and-flutter, none. Harmonic distortion, 0.01%. Frequency response, DC to 20,000 Hz, ±0.5 dB. Price of the Mitsubishi unit is $3,600.

If that's a little steep, just wait a while. Sony will soon demonstrate a new black box that converts its Betamax videocassette recorder into a super-hi-fi PCM audio recorder. Specs and price still unknown, but it's scheduled to be unveiled for the Japanese market next fall—so an American version can't be too far off.

Direct-dial CB: Texas Instruments' debut in CB manufacture consists of two super-deluxe units—one mobile, one base station—with a unique direct-dial, or selective calling, feature. Either of the new transceivers can activate any other individual TI unit when the operator punches in a pre-determined five-digit number on the pushbutton keyboard, placing or receiving calls on any of the 40 CB channels or 80 SSB channels. Any five-digit number may be chosen as a calling number, and there are 8,000,000-to-1 odds against any two users selecting the same code in a given area. The radios can also be programmed to call the five most often-used numbers by pushing a single button. The transceivers employ two micro-processors. Prices of the units are over $300.

New picture tubes: RCA, Sylvania and Zenith are offering television set manufacturers new picture tubes which makes possible the use of the self-converging slot-mask in-line-gun principle in the 25-inch size without a reduction in resolution. All three tubes have 100-degree deflection, thereby shortening front-to-back depth. The gun is a tri-potential type, the third voltage adding sharpness and resulting in an electron-beam spot size smaller than that of a conventional gun in a regular slot-mask tube. If these large tubes achieve set manufacturer acceptance, the slot-mask will have captured the TV industry across the board in all sizes, resulting in easier-to-manufacture sets which require fewer critical adjustments.

New color TV's: Electronic varactor tuning, automatic color circuits and energy-saving chassis are the key features of the new 1978 color sets. In most cases, this year's changes aren't dramatic, but represent a continuation of trends that started in some models introduced earlier. Here's a rundown on some of the recently introduced lines:

Zenith—*Color Sentry* automatic color adjustment system is now available in every screen size from 13 to 25 inches, in 49 of its 55 models. Likewise, you can find electronic tuning in all screen sizes, and 22 models have wireless remote control. No major innovations—but rather a spread of high-end features throughout the line.

RCA—The power-saving "Xtended Life" chassis, first introduced in 19-inch models (**Radio-Electronics,** June 1977), has now been adapted to all 25-inch sets, resulting in 25% energy savings in the 27.5-kV *XL-100* sets and 30% in the 29.5-kV *ColorTrak* sets. Varactor tuning is in all 25-inch *ColorTrak* models; only three 25-inch sets lack the *ColorTrak* automatic color feature.

Sony—Resting on its laurels this year, with addition of only two really new models—a 7.7-inch battery portable color set and a 21-inch remote-controlled varactor-tuned model. Sony's big change came last year with the brighter *Trinitron Plus* tube and the addition of electronic tuning to remote models.

Panasonic—Became the second manufacturer (after GE) to introduce a set which automatically adjusts to the broadcaster's vertical interval reference (VIR) signal to set color and tint. The VIR feature is in one 19-inch model. Panasonic also added *Color Pilot,* its own automatic color circuit. Its 25-inch sets (made by Panasonic of Canada) use the new Sylvania 100-degree tri-potential slot-mask tube.

Sylvania—All the results weren't in at press time, but one feature is a new pushbutton-keyboard tuner that permits digital random-access tuning of any TV channel, accompanied by another series of programmable pushbuttons which can be set for the viewer's favorite channels for instant recall to bring in the channel at a single push of the button.

Hitachi—Probably America's most elaborate remote control is on one 19-inch set, with 23 pushbuttons

continued on page 79

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Fiber-optic phone link now installed in England

Europe's first high-capacity telephone link using laser beams over optical fibers was demonstrated in Harlow, England, by four European companies of ITT. The light-carrying fibers run nearly 6 miles through normal underground cable ducts between telephone exchanges in Hitchin and Stevenage, two towns about 26 miles north of London. The fibers are contained in a cable 7 millimeters (approximately 1/4 inch) in diameter, and can carry nearly 2,000 simultaneous conversations.

The 7-mm diameter optical cable runs through normal telephone cable ducting between the two towns where post-office exchange buildings house the multiplexing and optical terminal equipment. Two repeaters are spaced at 3-km intervals in standard repeater cases in manholes along the route. Each repeater point is equipped with two regenerators, one for each direction of transmission. A total of six gallium aluminum arsenide lasers is used in the system.

The optical cable comprises two working fibers, a spare fiber, four metal conductors (two of which carry the power to the repeaters and two of which are "order wires" used by technicians) and a filler fiber that rounds out the cable. These eight cores are grouped round a central steel strength member and completely sheathed in polyethylene. In spite of its novel method of transmission, the new system works with standard multichannel digital multiplex equipment.

The new optical telephone link will undergo several months of testing with speech and test signals, to demonstrate the system's ability to handle live telephone calls, and the suitability for use in public telephone networks.

EIA writes to the President; wants action on TV imports

The Electronic Industries Association, in a letter signed by president V. J. Adduci, has asked President Carter to give "serious and appropriate consideration" to US International Trade Commission findings that television receiver imports are causing injury to the domestic television receiver manufacturing industry. Appended was a resolution by the EIA Board of Governors stating in part:

"The Board of Governors of the EIA supports the findings of import injury to the U.S. television receiver manufacturing industry announced by the ITC March 8, 1977; and further:

"The Board specifically urges the President of the United States to give immediate, serious and appropriate consideration to these specific findings of import injury; and further

"The Board of Governors directs the President of the Association to pursue this matter with the White House in order to determine how most effectively to communicate the impact of these findings and so advise the industry."

Mobile telephone control head is microprocessor controlled

The new deluxe Motorola *Pulsar II* mobile telephone head features a number of significant technological advances over conventional units. It offers pushbutton dialing, abbreviated dialing, on-hook dialing and call processing, recall of last number dialed, channel review and select, channel number display, and illuminated dial pad and graphics. The pushbutton pad is located on the back of the handset, allowing the subscriber to dial a number in safety and with one hand.

Abbreviated dialing for up to ten numbers is available. The numbers are programmed by the subscriber from the dial pad and can be changed readily. A reference directory on the underside of the handset identifies the stored numbers and their memory locations. On-hook dialing allows a number to be entered from the dial pad with the handset in the cradle and holds the number in the microprocessor. Dialing is initiated when desired, by pressing the SND button.

There are three modes of operation: Home, Roam and Manual. In the Home mode, the receiver scans and selects only the channels available in the home city. The radio is prevented from locking in on a foreign channel. In the Roam mode, the subscriber selects the channels for the city in which he is operating at the time. The Manual mode is used in systems where there is no automation.

New pulse generating method produces narrower pulses

A new approach to pulse generation that requires only a permanent magnet, a short length of specially treated magnetic wire, and a pickup coil, produces narrow pulses of 1 volt or more, independent of the rate of change of the magnetic field. Superficially resembling other types of generators that depend on a magnetic core with a coil around it, plus an increasing or decreasing magnetic field, its action is quite different. Instead of a steady rise in voltage in the coil as the magnetic field increases, there is little or no change up to a certain threshold level. Then the core (Wiegand wire) goes to full magnetic saturation, producing a sharply defined pulse of fixed width.

The effect is based on the discovery by John Wiegand that by a combination of torsional strain and stretching in the manufacturing process, a magnetic wire of a homogeneous alloy may be made to have a hard "shell" that requires a much higher magnetic field to change its direction of magnetization than does the soft inner core. The practical effect is that an increasing magnetic field gives rise—once a threshold field strength is reached—to a sudden large change of flux, which induces a voltage pulse in a pickup coil wound around or close to the Wiegand wire.

A typical Wiegand wire could be about an inch long and 10 mils (.01) inch in diameter. A pickup coil of about 1,000 turns of No. 38 wire (more or less, depending on the application) would produce the voltage. Such a wire would produce a 1.5-volt pulse with a width at half amplitude of about 20 μsec. For most applications a magnetic field of as little as 100 to 150 oersteds is ample, permitting the use of a very small magnet.

A wide range of applications is possible—a large number of devices using pulses can be improved by the constant-voltage, non-rate-dependent characteristics of the Wiegand wire. In a rotating system—for example—such as a tachometer or electronic ignition equipment, the voltages produced by an ordinary magnetic pickup varies with speed—with the Wiegand wire it is constant at all speeds.

New York Consumer Hi-Fi Show to go into new quarters

The 1977 Consumer Hi-Fi Show, September 16, 17 and 18, will be held at the Sheraton Inn, 42nd Street and Twelfth Avenue, New York, NY. The new location, states show president Charles Ray, offers many conveniences, including inside hotel

continued on page 12

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New NRI Memory Expansion Kit

The Model 832 NRI Digital Computer now comes with a new Memory Expansion Kit. Installed and checked out in 45 minutes, it doubles the size of the computer's memory, significantly increasing the scope and depth of your knowledge of digital computers and programming. With the large-scale IC's you get the only home training in machine language programming . . . experience essential to trouble-shooting digital computers.

electronics at home.

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All courses are available with low down payment and convenient monthly payments. All courses provide professional tools and "Power-On" equipment along with NRI kits engineered for training. With the Master Course, for instance, you build your own 5" wide-band triggered sweep solid state oscilloscope, digital color TV pattern generator, CMOS digital frequency counter, and NRI electronics Discovery Lab.

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NRI's Complete Communications Course includes your own 400-channel VHF transceiver

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continued from page 6

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The area is at the hub of the new federally sponsored Westway and within blocks of present access to upper Manhattan and other New York City boroughs, to Hudson River tunnels and New Jersey bridges, and to westward and northbound roads into Westchester County and Connecticut. Also, the Circle Line boat pier on the Hudson River, is diagonally across from the Sheraton.

National Service Convention in Florida, August 16–21

The National Electronic Service Convention, sponsored by the National Electronic Service Dealers Association and the NESDA Florida Chapter/Orange County, opens Tuesday, August 16, and runs through Sunday, August 21, at the Sheraton Towers Hotel, Orlando, FL. Besides the regular annual meeting, there will be special social and entertainment events, the National Business School, the National Technical School, a golf tournament, addresses and discussions with government and industry spokesmen, the annual trade show "The Magic Kingdom of Electronics," and many other events.

The $40 registration fee includes admission to all meetings, workshops and functions. The following special fees will be charged: A $15 golf tournament fee for carts and refreshments; the Profitable Service Management School requires $20 for members and $40 for nonmembers; and a fee of $10 is required for the Technical Schools, including the luncheon.

Registration will be on Tuesday, August 15. The rest of the day can be devoted to social activities with family, friends or business associates.

The Profitable Service Management School and the Technical School are scheduled for Thursday. The PSM School features business management, and will cover typical business-related problems. Attendees will have an opportunity to tell how they confronted such problems, and will participate in round-table solution-finding discussions.

The Technical School (College of Service Knowledge) will hold ten simultaneous sessions to be repeated four times during the day. Several subjects will be covered. "Servicing CB" will be discussed by Forest Belt, and "Fundamentals of Logic Circuits," by Ken Parese. The national service managers and field representatives of Quasar and Sony's Betamax will instruct on the special features and peculiarities of their products. Precision Tuner Service will examine tuner problems. Larry Steckler, editor of **Radio-Electronics**, will address the noon luncheon on the subject, "Outlook for the Service Business for the Next Five Years."

The special Trade Show on Friday will be a top feature of the convention. In addition to manufacturers' booths, displaying new product lines, service and test equipment, there will be 25 booths devoted to NESDA projects, troubleshooting contests, serviceability inspections and "How To" exhibits.

A Licensing Seminar is planned for all involved in or interested in state or local licensing programs. Service dealers and technicians will find out how registration and licensing work in their areas.

For further information and details, contact NESDA, 1715 Expo Lane, Indianapolis, IN 46224.

CB license applications number nearly one million per month

The Federal Communications Commission reports that CB license applications received during last January numbered close to one million, breaking all monthly records and approaching the annual record of only a few years ago.

John Sodolski, head of the Communications Division of the Electronic Industries Association, hailed the addition of 17 new channels to the band as "coming just in time." These, said Sodolski, provide CB'ers with "74% more channel availability than the old 23 channels. Without the additional channels, congestion in urban areas would have become first annoying, then intolerable."

But even with millions of CB sets being added each year, be believes that "almost everyone agrees it will take a long time to crowd the additional channels to the same extent as the original 23."

Buyers are getting bargains in 23-channel CB radios

Many first-time CB purchasers are rushing to take advantage of the low prices on 23-channel CB models, according to John Sodolski, staff vice president of the Communications Division of the Electronic Industries Association (EIA). Dealers must close out their stocks of 23-channel radios which do not meet the higher standards that apply to 40-channel radios before January 1. Therefore some fantastic bargains are available in the 23-channel models.

"There's never been a better time to buy a new CB radio," says Mr. Sodolski. He also notes "a growing demand for the new 40-channel units, particularly in urban areas where the lower 23 channels have been overloaded." R-E

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letters

MICROCOMPUTER WORKSHOP

For those of your readers that are interested, a seminar program will be held in September at the Virginia Polytechnic Institute and State University, Blacksburg, VA. Dr. Peter Rony, Dr. Paul Field and I will direct the courses.

Featured will be two workshops: The first, held on September 13 and 14, will be based on small-scale amd medium-scale TTL integrated circuits. Many hours of lab time with individual breadboarding stations and in-depth lectures will be provided. The second workshop concerns itself with microcomputer interfacing, and will be held September 15-17. Available for participant use will be over 20 operating 8080 microcomputers.

Both workshops will be held at the Institute's Extension Center in Reston, VA (near Dulles Airport). For more information, write: Dr. Norris Bell, Virginia Polytechnic Institute and State University, Blacksburg, VA 24061, or call (703) 951-6328.

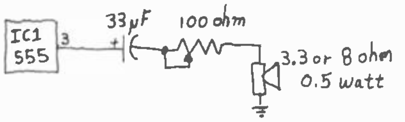
DAVID G. LARSEN
Blacksburg, VA

MORE ON THE LOGIC PROBE

I built Larry Fort's probe for testing logic circuits ("Tone Probe for Testing Digital IC's", March 1977 issue) and would like to anticipate some letters you may get on the specified 100-ohm speaker. Use any speaker. I used an unmarked 4- or 8-ohm speaker, a 100-ohm resistor and a 25-µF capacitor. If you want to get fussy, replace R1, R2 and R6 and R5 with 100K and 500-ohm pots adjusted for optimum performance. They'll run about 70K to 80K and 350 to 400 ohms. However, I built mine with the values specified and only a speaker change. Everything worked fine.

L. G.
Pompano Beach, FL

Larry Fort's digital probe can be modified to include a volume control as shown



in the schematic. As a high school physics teacher, articles on building digital equipment are most appreciated. Keep it up!

PHILIP REHBERGER
Oshkosh, WI

NEW FORCE EXPLAINED?

Peter Lefferts very effectively answered some of the easier questions in "A New Force Answered" (Letters Column, April 1977 issue). He did not inform us of a permanent magnet that has a magnetic field similar to the field around a current carrying conductor.

By using a solder gun and a flexible copper wire he correctly points out the AC energized copper wire will be pulled toward the iron bar or sheet. If he reduces the iron bar to an iron wire, such as described in "A New Force" (Letters Column, Oct. 1976 issue) he could have found a new force. If DC is fed to the flexible wire the wire would not only be pulled to the iron wire but also the copper wire would twist so it was at right angles to the iron wire.

More important than either letter, if we insert any iron, be it wire, bar, ball or sheet, into a magnetic field there is no longer a magnetic field beyond the iron. A permanent magnet causes a field to appear and inserting iron into this field causes the field to disappear from a given space so we can make magnetic waves. We know of no wave phenomena from which we can't extract energy. We may not have an energy crisis if today's magnets are truly permanent or have infinite energy and we can make waves by inserting and removing iron from the magnet's static field.

JOHN W. ECKLIN
San Martin, CA

2650 CORRECTIONS

With regard to my construction article on the 2650 Computer System (**Radio-Electronics;** April, May and June 1977 issues) I have the following corrections:

1. In the timing chain and sync generator section of the schematic, the center pin of IC61-a is hooked to 5 volts rather than $\overline{\text{A11}}$. On the same diagram, R9 should be labelled as 330 ohms rather than 100.
2. On the cassette interface diagram, there is no connection between IC74 pins 6 and 1. Also, to improve the cassette's reliability, IC25 was changed to a 74132 (a Schmitt trigger) and C4 was removed. Also, IC73-b was disconnected from pin 10 of IC76. This allows the removal of C13 and R20.
3. On the parts list, IC26 is listed as a 9344. Its actual part number is 9334, which is a bit-selectable output port, not the multiplier listed.
4. The cost of the predrilled and etched circuit board is actually $40 instead of $30. Also there is a $3 postage fee.
5. The third paragraph under "Theory of Operation" explains how the processor and the display share the same RAM. Instead of this arrangement, the OPAK pin of the processor is grounded, and it is allowed access to the display RAM anytime. The processor, therefore, has

continued on page 16

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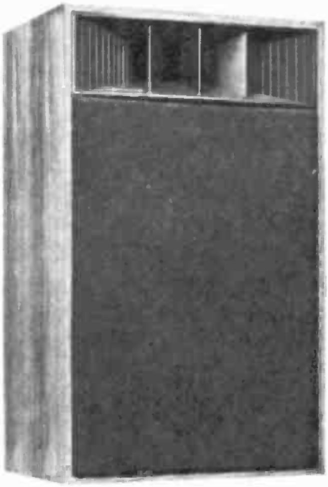

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LETTERS
continued from page 14

priority over the display as far as accessing the on-board RAM is concerned.

6. In the parts placement diagram of the article, the lower potentiometer should be marked R22 rather than R20. Also, a D8 is on the diagram; it should be R18.

Many thanks to all those readers who helped me find these errors.
JEFFREY ROLOFF

PROJECT SUGGESTIONS

I've built some of the projects that appeared in **Radio-Electronics** and found them rewarding and useful. However, there are some other projects that I'd like to see appear that I think would be of interest to your readers:

1. An intercom system that uses the AC power line as the carrier and can be plugged into any AC receptacle. Although there are some similar intercoms available, what I was thinking of is circuitry that would enable several apartments or homes to use their respective units without interference with each other;

2. A battery charger that could charge several battery sizes simultaneously;

3. A circuit monitoring the AC line that would be sensitive to a power failure. During a failure, it would automatically switch the attached circuit to battery, and then back to AC when power was restored;

4. A 6- and 12-volt battery charger that could be adjusted for a specific voltage range and left connected all the time. This battery could be connected to the previous circuit and be used only during power failure.
NORBERT BACTOWSKI
Los Angeles, CA

ELECTRONIC JOURNAL

I have an announcement that should be of interest to both you and your readers. The Washington D.C. Amateur Computer Society has announced publication of the first "electronic journal" available via a computer link to anyone in the U.S. having a computer terminal and a phone coupler. No "password" or account number is necessary.

The Journal is published once a month on the DEC System-10 of the Catholic University of America and is stored in the university's computer center as a "free access" text file. To get it, dial 202-635-5710 for a 110 Baud line, or 202-635-5730 for a 300 Baud line.

The DEC System-10 responds with its answer tone. Activate your modem, then hold down the control key and type a "C." The computer should echo an up-arrow and a "C." If it doesn't, try doing it several times; if nothing happens, perhaps the computer is either down for maintenance or has "crashed" due to some problem. Try calling again later. If you get the proper echo (the up-arrow and "C"), then type "I," followed by a carriage return. The system monitor will tell you who, what, when and where it is; something like this:

CATHOLIC U. 507B20 19:39:01 TTY60
SYSTEM 95

The monitor will then type a period on the next line, indicating that you're talking with the timesharing monitor and that it's waiting for instructions. To get the Journal, type "HELP WACS" followed by a carriage return, and the computer will proceed to type it out.

If you're going to read the Journal on a TV Typewriter display instead of printing on a hardcopy device, just tape the phone output so you can replay the Journal when you want. You can stop the output any time—just type "Control-O" (hold the control key down and type "O.")

In this "electronic mail service," the program runs on a timesharing system that moves the information stored in a disk file to a serial communications port. Since the service uses computer time made available by the university, it would be a good idea not to use it during regular business hours—late at night (using WATS lines, perhaps) or weekends would be preferable.

You can also get the Journal in printed form. It differs from the on-line version slightly—if a picture of "Snoopy" is on the cover page, it is omitted from the electronic version.
ROBERT JONES, Director
Washington Amateur Computer Society
4201 Massachusetts Ave.
Washington, D.C. 20016

R-E

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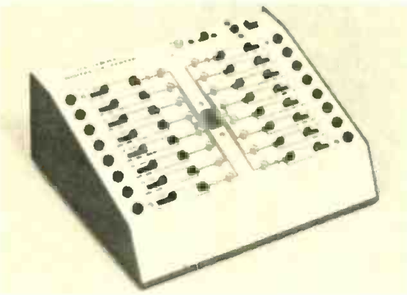
equipment report

Heathkit IT-7400 Digital IC Tester



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WHEN YOU HAVE TO SERVICE EQUIPMENT THAT contains IC's, it is very convenient to be able to remove a questionable IC from its socket and run an out-of-circuit test. The *IT-7400* tests RTL, DTL, TTL, ECL, and CMOS IC's in dual-inline packages with up to 16 pins.

An IC test socket is mounted in the center of the front panel. The user pulls the upper section of the 16-pin socket up to open the contacts. IC's are then easily inserted, even if their pins are somewhat out of alignment.

Each one of the 16-pins is directly connected to banana jacks that can, in turn, be connected to external equipment or to other jacks on the tester with jumper leads.

Two switches control each IC terminal. One switch has three positions and the other has two positions. Each position of the three-position switch serves one of two functions. The function is selected with the two position switch. For example, the three-position switch will select either 5V, STEP or OFF. However, moving the two-position switch to the other position allows the three-position switch to select either GND, GND or GAS DISC.

When the switches are positioned so the 5-VOLT function is selected, the corresponding IC terminal is connected directly to the power supply. Though labelled 5 volts, the power supply bus can be set to either 3.6 or 5.0 volts by a single switch located at the top of the panel.

The STEP function connects the IC terminal to a bus that originates from a single mercury-wetted pushbutton STEP switch. Mercury-wetted switches do not bounce and debouncing circuitry is unnecessary. The STEP switch is in series with a resistor divider made up of two 100-ohm resistors. Depressing the switch generates a voltage-step equal to half the supply voltage (2.5 or 1.8 volts respectively). All IC pins that you have selected for step function are stepped simultaneously because of their common-bus hookup. Inadvertently selecting the STEP function for an IC output-pin will cause that pin to drive all other pins similarly connected. At times this might be useful to jumper an output to an input without external wiring.

The OFF function disconnects the IC pin from the supply and step buses. However, in all three positions (5V, STEP and OFF), the IC pin is connected through a 22K resistor to the base of an indicator-driver transistor in parallel with a 68K resistor to ground. This is particularly significant when testing CMOS circuits since the resistors effectively hold the pin at ground potential.

Each IC terminal has its own neon indicator driven by a high-voltage indicator driver transistor. This transistor is required to interface

continued on page 24

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GTE SYLVANIA

EQUIPMENT REPORT
continued from page 22

the low-voltage IC's being tested to the high-voltage neon indicator.

When the two-position switch is slid into its other position, the three-position switch can select the GND, GND or GAS DISC functions. When the GAS DISC function is selected, the driver transistor is cut off and the neon indicator is connected directly to the IC terminal for testing high-voltage IC's such as gas-discharge drivers. The two redundant GND functions ground both the IC terminal and the banana jack.

The user must be thoroughly familiar with the operation of the two slide-switches. Positioning both switches so that the GAS DISC function is selected will place up to 60 volts on the IC terminal. **This can cause permanent damage to a low-voltage IC. Heath's recommended procedure is to move the three-position switch before the two-position one.**

The *IT-7400* power supply contains an isolation transformer for safety purposes. The primary can be connected so 120- or 240-volt AC power sources can be used. One secondary winding feeds a voltage doubler and μA7805 regulator to produce the 5 volts that supplies power, the step switch and the high logic-levels to the IC under test. Regulation holds the voltage to ±5% at currents under 300 mA.

The testing procedure is simple and obsolescence proof. Signals are applied to exercise the functions of the IC that are described in the data sheet associated with the IC. To check a simple gate, the various input combinations are applied and the outputs checked against the truth table.

Counters are checked by connecting the appropriate pins to ground and the power supply, and then stepping the counter input while observing the state of the various output terminals.

The *IT-7400* cannot precisely check specification limits because such things as rise and fall times and input and output levels are not adjustable or metered. But the *IT-7400* adequately verifies that the circuit is capable of its basic functions. If a circuit problem relates to speed such as the frequency at which a counter is clocked, more sophisticated (and expensive) testing is called for.

Used along with digital texts, the Heathkit *IT-7400* makes an excellent learning tool and remains useful later in its intended role as a tester.

Power consumption of the *IT-7400* is 10 watts and the unit weighs 4.5 lbs. An SN7400 quad NAND gate (TTL) is provided for initial familiarization.

Hickok model 388 CB In-Line Tester

CB-TRANSMITTER TESTING CAN BE VERY TOUGH or very easy. This depends on the test instruments. Hickok Electrical Instrument Co. has come out with a CB-test unit that can make some previously hard tests look very easy. This is the *model 388* In-Line CB Tester. Connect the *model 388* to the CB transmitter, connect a 50-ohm dummy load or the CB antenna to the other jack, turn it on, push the button and there you are.

You can read the four most important things about a CB transmitter instantly: Operating frequency on a seven-digit LED display, down to ±10 Hz; RF output power on two ranges, 10 or 100 watts; voltage standing-wave ratio (VSWR) and the modulation percentage. All you have to do is set the FUNCTION switch and push the transmitter button.

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Frequency is read out on a 7-digit display. The *model 388* has an ECL oscillator timebase with an accuracy of ± one count ± the timebase accuracy which is 10 parts-per-millions (PPM). A version of the *model 388—model 388X*—is identical but has a temperature-compensated crystal oscillator (TCXO) accurate to within 1 PPM. RF output power is read out on a 3-digit display. (Same display, of course, but only the three right-hand digits are
continued on page 26

EQUIPMENT REPORT

continued from page 24

lit to avoid confusion.) On the 10-watt range, the display reads "00.0". On the 100-watt range, the display reads ."000." The readout has a resolution of 0.1 watt.

VSWR is displayed with four digits—same reason VSWR's of up to 10:1 can be read. (But if you see a reading of about 5:1, let go of the button, quick. Something definitely needs fixing in the transmitter or antenna. Running a transmitter more than a few seconds with such a high reflected power level can blow up the final RF transistors.)

Modulation percentage is read out on a 3-digit display. This can read from 0 percent to 110 percent. (More than 110 percent indicates trouble, too.) By the way, you must use an undistorted sinewave signal for the modulation. If it is distorted, the harmonics will cause inaccuracies and a bouncing count. A voice signal won't do, of course. In this area, before we go, remember that when you're reading the frequency, the transmitter *must* be unmodulated—with one exception, which we'll get to. If there is modulation, the frequency counter will try to read the sideband frequencies and skip counts. This is normal. These instruments will work with the new 40-channel sets, of course.

All of these goodies are accomplished by state-of-the-art IC technology. They can do some cute tricks. The *model 388* has two coaxial jacks on the back panel; one INPUT, the other OUTPUT. All you need is a short coaxial cable with a PL-259 (sometimes called a UHF plug) on each end, to hook the CB-antenna output to the INPUT connector. An accurate 50-ohm dummy load must be connected to the OUTPUT—the set's own antenna may be used. Do not key the transmitter without one of the loads hooked up. This can damage the transmitter, especially if the transmitter is a solid-state type.

You'll find a BNC jack on the back of the *model 388*, along with a TIMEBASE slide switch. With the switch in the INTERNAL position, it runs on its own built-in timebase. The *model 388X* doesn't have the switch, but does have the jack. The TCXO timebase of the *model 388X* may be used for greater accuracy, by connecting it through a jumper cable to a *model 388* set on *External* timebase. In fact, several *model 388's* may be timed from only one *model 388X*, if desired. You can do a trick with the *model 388*: If you want to hold the display for any reason, just slide the switch to EXTERNAL while the transmitter is keyed. The display will freeze and hold until the instrument is turned off or the switch set back to INTERNAL timebase.

The *model 388's* can be used as a straight frequency meter. There is a BNC jack on the front panel for this, with a high-impedance (1.0 megohm) input and a sensitivity of 100 mV. A push-push selector switch lets you choose front panel operation of the frequency meter or the in-line operation from the back-panel jacks. The modulating signal can be checked on a scope connected to the AM MONITOR jack on the left side. This displays the detected AM modulation and may be used to check for possible clipping, distortion, etc.

The exception we mentioned, about not using modulated signals for frequency readings, is in the testing of single-sideband CB transmitters. These have *no* RF power output at all *without* modulation. Here again, an accurate 1-kHz audio signal is needed. Set the transmitter switch to UPPER SIDEBAND and key it. The display will read out the carrier frequency plus the modulating frequency. Setting to LOWER SIDEBAND reads the carrier minus modulating frequency. VSWR can be read on SSB systems with the same ease. RF power measurements must be corrected by a formula given in the instruction manual, for SSB *only*.

Percentage of modulation is read in somewhat the same way. One circuit reads the peaks and another reads the average value of the modulation envelope after detection in a special two-step circuit. More math, and there you are.

The timebase accuracy of the *model 388* may be checked by comparing it to the 10-MHz signal from WWV or to a frequency standard. If it needs correction, an adjustment is provided to make the display read exactly 10.00000 MHz and there you are. The aging rate of the *model 388* is given as 5 PPM-per-year, and the *model 388X* as 1 PPM-per-year. The "setability" is given as "to ±0.1 ppm," for both units. For this adjustment, the instrument must be warmed up for 30 minutes to allow all parts to reach normal operating temperature, which is 25°C.

Both models are powered from the 120-volt AC line. All of the DC power supplies are stabilized by several solid-state voltage regulators. If you want to use them in cars, etc., it is easy to hook up a connection to the power supply so that they can be used from any 12–14 volt DC-supply. **R-E**

equipment reports

Infinite UC1800 Microcomputer

CIRCLE 78 ON FREE INFORMATION CARD

INFINITE, INC., TAKES TWO DIFFERENT APproaches to the microcomputer learning/development system. First, they produce a training-and-use package that leads the uninitiated unfalteringly into the world of the computer. For example, their *model UC1800* microcomputer is a completely assembled and self-contained microcomputer system. It avoids construction pitfalls and the futile troubleshooting that often follows. To determine whether a problem is in the microprocessor IC or elsewhere can be very difficult without the necessary skill and sophisticated equipment.

On the other hand, Infinite has also developed the *model UC1800HK Hobbyist Kit* for the experienced kit builder. The kit contains only special components that are not widely available.

The *UC1800* is a completely assembled microcomputer system built around the RCA COSMAC *model CDP1802* microprocessor. Four printed-circuit boards are mounted in a console-type cabinet that resembles a desk-type calculator.

The central processor board holds the CPU IC, the CPU control logic, 256 words of NMOS RAM and the 5-volt power supply (except the power transformer mounted separately in the cabinet). The CPU board has a 72-pin gold-plated edge connector for system expansion.

The readout board has four 7-segment LED displays and the associated decoder-driver IC's. Two displays function as the address readout, and the other two as the instruction and input/output readouts. The LED's display the hexadecimal (base 16) representation of the computer's binary numbers. After 0 through 9, A, C, E and F are displayed and "b" and "d", using the available segments. The board contains its own 5-volt regulator IC to supply the substantial 400-mA current drain.

The third board is the switch-control module that interfaces with the six control switches. They are RESET, SINGLE STEP, START/EF1, POWER, MODE and SINGLE STEP/ENTER. The board has outputs that connect to the $\overline{\text{EF1}}$, $\overline{\text{CLR}}$, $\overline{\text{WAIT}}$, and $\overline{\text{DMA IN}}$ terminals on the microprocessor IC.

The keyboard module holds the 16 hexadecimal keys and the necessary debouncing and decoding components. Two LED's indicate whether the most or least significant of the two hex digits in each word is ready for loading.

To load a program, set the MODE switch to LOAD, then RESET, enter the first word, press ENTER and continue. The loading starts at 00 and proceeds sequentially. If you make a mistake along the way, you must either start all over or enter a short program that allows you to change a particular memory location.

After the program is loaded, the MODE switch is then placed in the RUN position and the SINGLE STEP switch can be turned either ON or OFF. With the switch OFF, the computer executes the program automatically. With the switch ON, the computer executes a single instruction for each push of the SINGLE STEP/ENTER button.

The START switch shares the EF1 input function that you can use to interact with your program. Input and output instructions permit you to enter data from the keyboard and readout into the two LED's.

The POWER switch maintains power to the memory only in the STANDBY position to preserve the program with minimum power consumption. You can also purchase a nickel-cadmium battery and charger to keep the memory alive for about four hours after loss of primary AC power.

The DMA (*D*irect *M*emory *A*ccess) design of the *model CDP1802* facilitates program loading without using a ROM utility program. There is an advantage in not requiring this extra component, but it does make the system cumbersome to use.

Infinite addresses this problem by including a listing and instruction for using KEYBUG as part of the *UC1800* package. This program takes one-half of the available 256 memory words, and of course it must be successfully loaded starting at address 00.

KEYBUG has five commands that help in loading, examining and changing memory contents. After the program is loaded, a RESET-START sequence gives control to KEYBUG, which is acknowledged by displaying "db" (debug).

The DC command will display the contents of a single memory location. Press the D and the C followed by EF1, which serves to enter the command. Then key in the address of the location to be displayed and press EF1 again. The program responds by displaying the memory contents. The CC command changes the contents of memory. After the command and

continued on page 32

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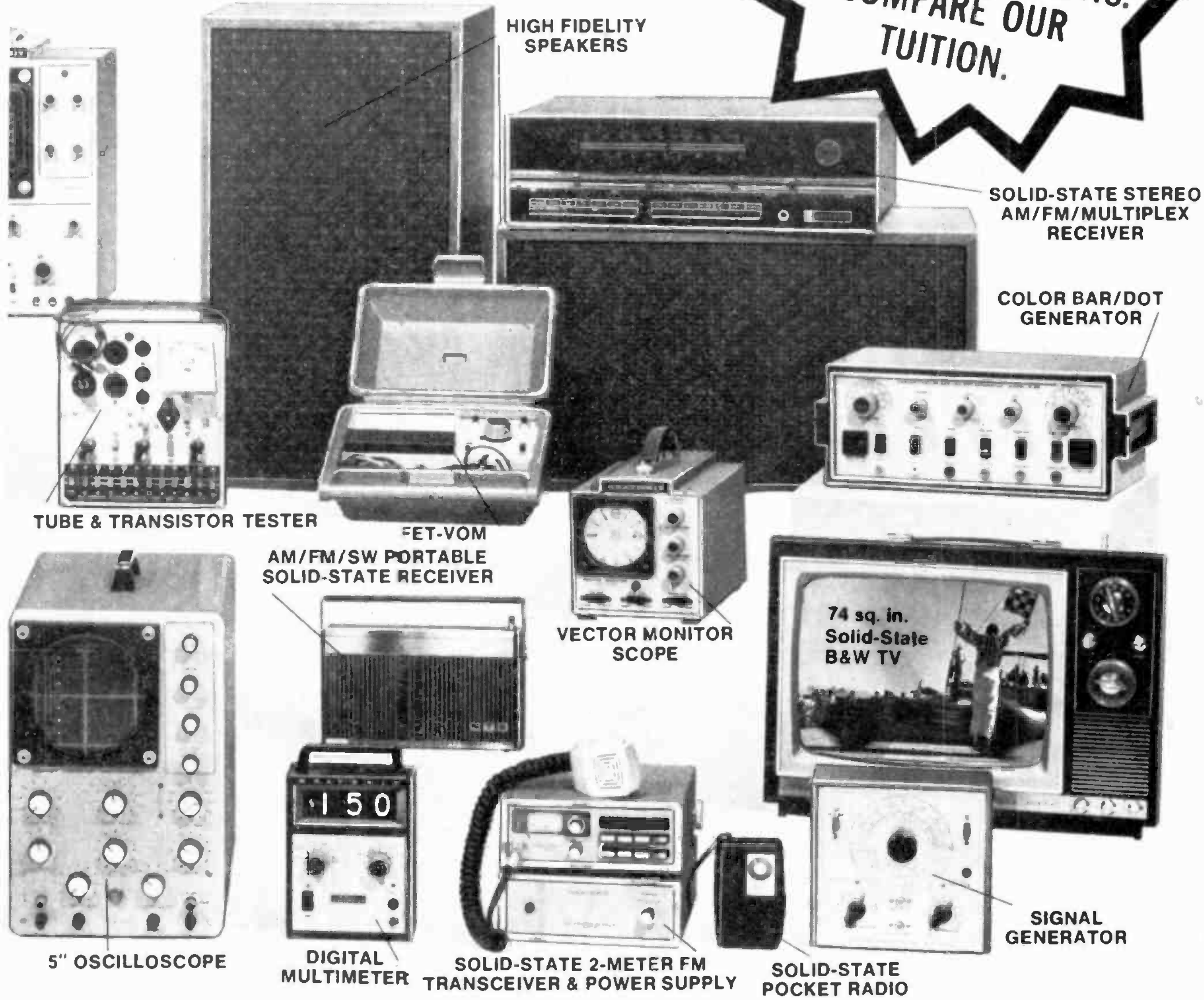

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EQUIPMENT REPORT
continued from page 27

the memory-location address are entered, the new contents are keyed in and EFI depressed. Since only a single memory location is accessed by the DC and CC commands, the system can return to KEYBUG automatically and be ready for a new command.

To examine a series of memory locations without entering memory addresses sequentially use the FD (forward display) command. The computer displays the address and its contents; then increments the address and displays its contents each time EFI is pressed. Similarly, the FC forward change command sequentially loads the memory by pressing the EFI switch after each data entry. These last two commands are self-looping; the only way to exit the loop so that a new command can be executed is to reset and restart KEYBUG.

The remaining command is EE for execute. The EE command is keyed in, EFI pressed, the program-starting address entered and EFI pushed again. Because KEYBUG starts at 00 and a program cannot be written there, EE is the only way to activate a program.

To debug your program, set breakpoints by inserting a branch to 00; this causes a "db" readout when KEYBUG is reached. You can then examine memory to see what has taken place so far. A more sophisticated approach would be to examine the processor registers when the breakpoint is reached, restarting the program and continuing to the next breakpoint.

So far KEYBUG is not available on PROM or ROM and must be loaded manually into RAM. A defective user program may destroy the utility program. This happened several times while I was experimenting with some simple programs. Some wipeouts did not completely annihilate the system, and it was possible to use KEYBUG to find the destroyed memory locations and restore the full capabilities. Some wipeouts were total.

The Infinite computer is available in four versions:

The completely assembled and documented *UC1800* package includes computer, instruction manual, RCA *MPM-201A CDP1802* Users Manual, KEYBUG program and Cardiac. Cardiac (*Card*board *I*llustrative *A*id to *C*omputation) was developed by Bell Telephone Laboratories to simulate the operation of a simple computer. Cardboard slides simulate the instruction decoding, and calculation is done with pencil and paper. The package is priced at $495, plus $8 for shipping and handling. Option 001 is the battery backup and recharger and sells for $22.50. Option 002 enables you to use the microcomputer with either 120 or 230 VAC 50-500-Hz input power and costs $15.

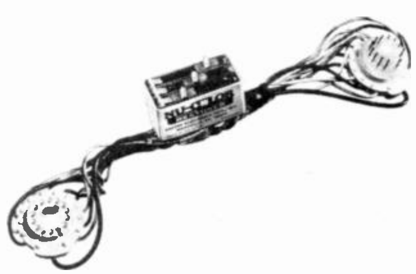
The *UC1800* kit includes everything but the cabinet and power cord. The four modules are factory-assembled and burned-in. This version sells for $389, plus $4 for shipping and handling.

The economy model (*model UC1800HK*) contains four unwired boards, keyboard, 1802 CPU, readouts, cable and Users Manual. It is priced at $129.95, plus $2 for shipping and handling. If you already have a CDP 1802, Option 003 subtracts $18 from the price.

The last version is just the assembled CPU board, which also supplies 500 mA of current for other system components. The *UC30001 OEM UC1800* CPU Module costs $179, plus $2 for shipping and handling.

For additional details write to Infinite Incorporated, 151 Center St., Cape Canaveral, FL 32931. **R-E**

Oneida Model 90A Picture Tube Restorer



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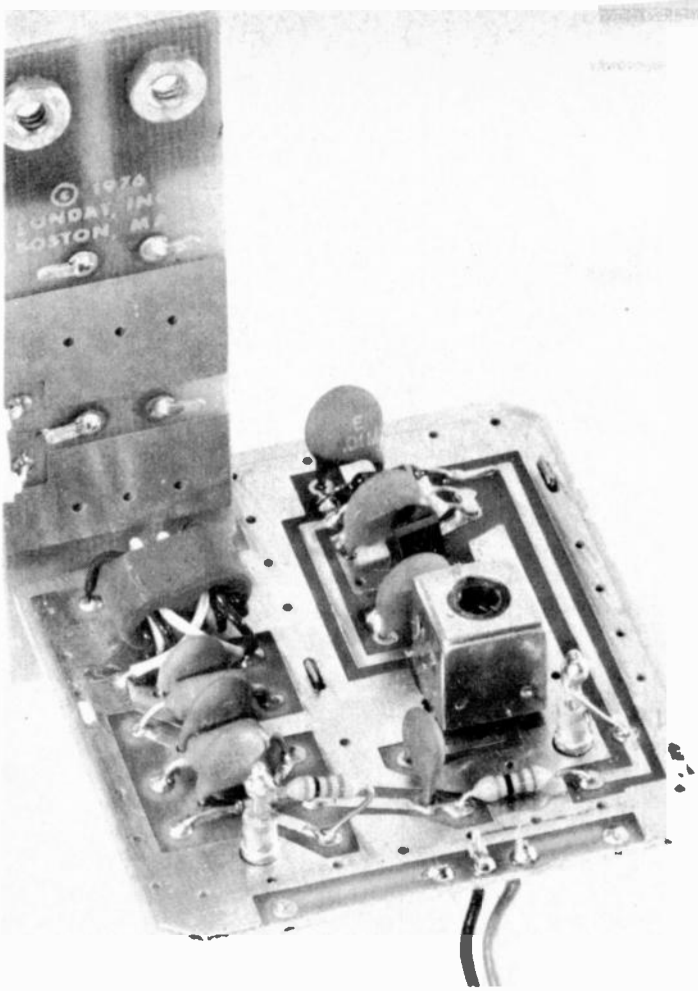
ALL THINGS COME TO HIM WHO WAITS. I HAD TO wait for quite a while, but I finally found just the thing I needed: A new device, made by Oneida Electronic Manufacturing Company. This is their *model 90A Nu-Color* picture tube restorer. This device is designed to restore color to old picture tubes with one or more weak guns.

I had a trade-in Wards TV, with a picture tube so bad it had to be seen to be believed. The blue gun read almost normal emission; the
continued on page 73



Build this Video Modulator

Permits direct connection of composite video signals from video games and microcomputers to the antenna terminals of your TV set

GLEN DASH

WITH THE ADVENT OF VIDEO GAMES AND the home computer, the ordinary television set is becoming an increasing source of interest for the hobbyist. A TV set can be quickly and safely converted for use as a display monitor using a device known as the Videocube. Basically, the device takes a composite video signal, such as the output of a TV game circuit or the 2650-based microcomputer system (**Radio-Electronics**, April 1977) and feeds a modulated Channel 3 or 4 RF-signal to the antenna terminals of the television receiver.

If we didn't have an RF oscillator/modulator such as the Videocube, the TV set could only be used as a monitor by directly wiring into its video circuit. However, finding the right point to feed in the microcomputer or TV game output often isn't easy, and most TV sets today (especially portables) are not line-isolated, which can lead to safety hazards. Also, poorly designed RF sections will radiate their signal to nearby television receivers and interfere with commercial broadcasts. The Videocube avoids these problems and offers a versatile design that can easily interface to almost any video source.

The Videocube has a 300-ohm output (the type most often used on TV receivers), a selector switch for switching between normal TV viewing and the Videocube's output, and a 3-wire input (5—12-volt power, video input and ground). The Videocube consists of an oscillator that can be tuned to Channel 3 or Channel 4, a modulation section for amplitude modulation of the RF signal from the oscillator, and an output filter for removing spurious harmonics from the signal.

NOTE

The Federal Communications Commission requires that any device to be marketed using a commercial TV receiver as its output must have FCC type approval. Use of the Videocube or other RF device does not automatically entitle a manufacturer to FCC approval.

How it works

The schematic diagram of the Videocube is shown in Fig. 1. Transistor Q1 is used in a Hartley oscillator circuit in which tunable coil L1 and capacitor C4 set the carrier frequency. Feedback to the emitter is provided by capacitor C3. Resistor R3 biases the transistor, as do resistors R1 and R2. The base of the transistor is grounded by C2 for high-frequency signals, making this a grounded base configuration. A filter that prevents RF from getting into the power supply is provided and is comprised of capacitors C1, C5 and resistor R4.

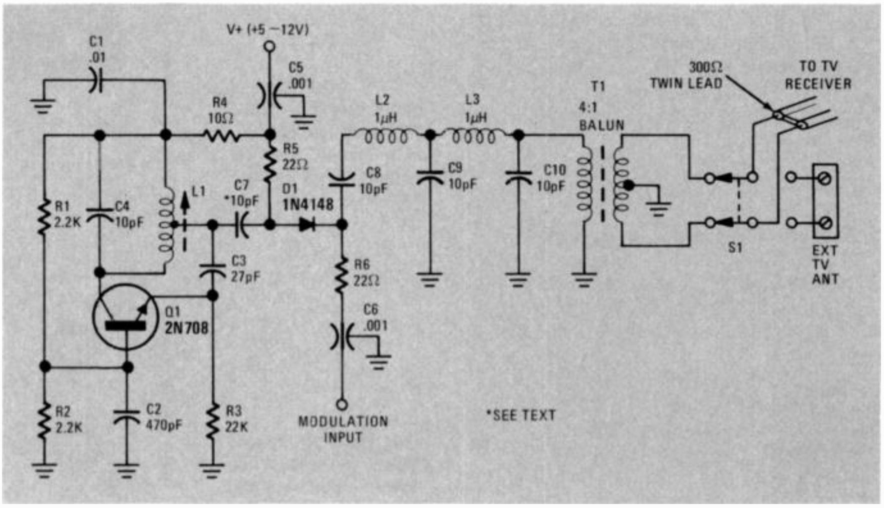


FIG. 1—OUTPUT SIGNAL LEVEL of Videocube is controlled by the modulation input.

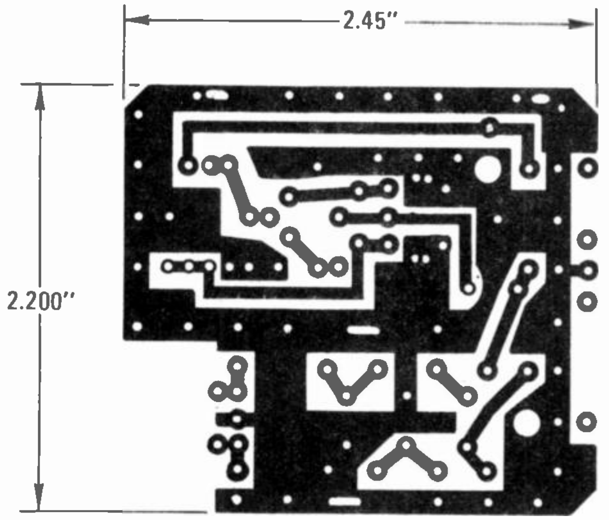


FIG. 2—FOIL PATTERN of component side of double-sided main board shown actual size.

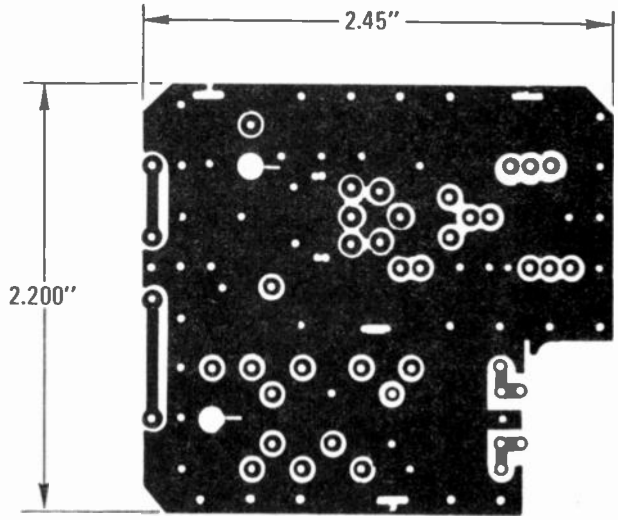


FIG. 3—FOIL PATTERN of bottom side of double-sided main board shown actual size.

The circuit uses an unusual technique for modulating the output. Capacitor C7 and resistor R5 form a voltage divider that provides about a 25-mV signal at the anode of diode D1. Since capacitor C6 (0.001 μF) is so large (its impedance is 2.6 ohms at 60 MHz), it appears as a short circuit to ground for RF signals coming from the RF oscillator. Therefore, diode D1 and resistor R6 act as a voltage divider. The forward resistance of D1, however, is a function of the current through D1, and it decreases as the current increases. Because of this, as the resistance from the modulation input to ground decreases, the current through D1 increases and the signal level at the cathode of D1 increases.

The signal at the cathode of D1 is fed to a filter network consisting of capaci-

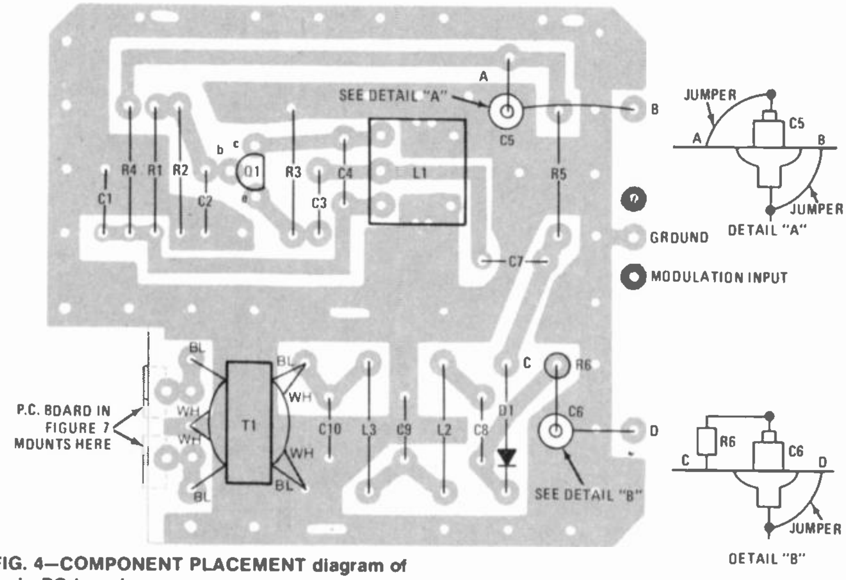


FIG. 4—COMPONENT PLACEMENT diagram of main PC board.

PARTS LIST

All resistors are 1/4 watt, 10% unless otherwise noted.

R1, R2—2200 ohms
R3—22,000 ohms
R4—10 ohms
R5, R6—22 ohms
C1—0.01 μF, 20%, 25-volt ceramic disc
C2—470 pF, 20%, 25-volt ceramic disc
C3—27 pF, 5%, 25-volt ceramic disc
C4, C7-C10—10 pF, 5%, 25-volt ceramic disc
C5, C6—1000 pF, 20%, feedthru
D1—1N4148
Q1—2N708
L1—Condat type-L1 oscillator coil (see text)
L2, L3—1 μH RF
T1—75:300 ohm Balun
S1—UID type, DPDT, 60-dB isolation

The following parts are available from Delta Electronics, Box 2, Amesbury, MA 01913.

A partial kit of parts, including S1, C5, C6, Q1, L1, L2, L3, T1, both PC boards, shields and case, for $9.95.

A complete kit of parts for $13.95.

Massachusetts residents add state and local sales taxes as applicable.

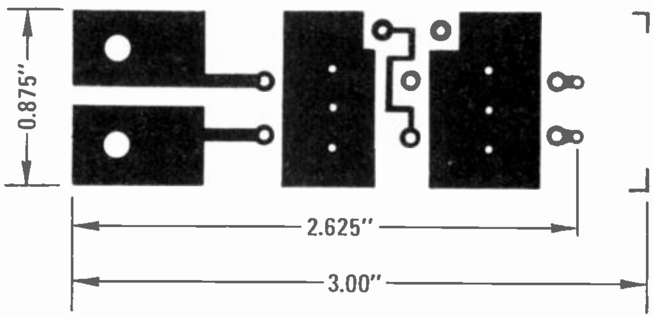


FIG. 5—FOIL PATTERN of top of double-sided switch board shown actual size.

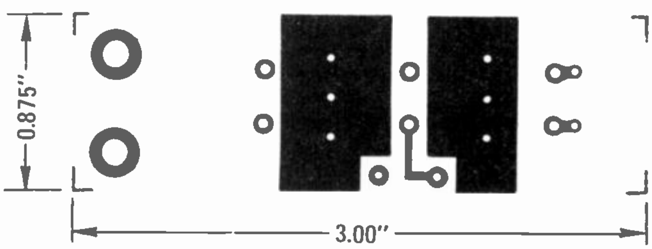


FIG. 6—FOIL PATTERN of bottom of double-sided switch PC board shown actual size.

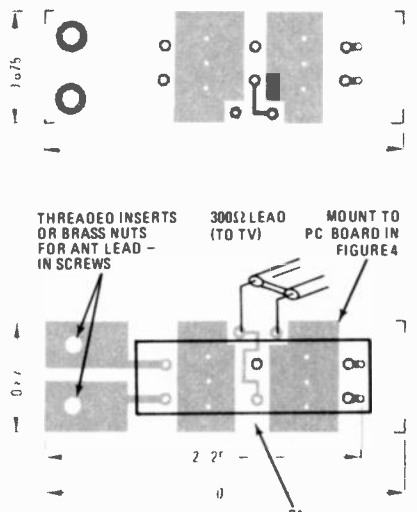


FIG. 7—COMPONENT PLACEMENT diagram of switch PC board.

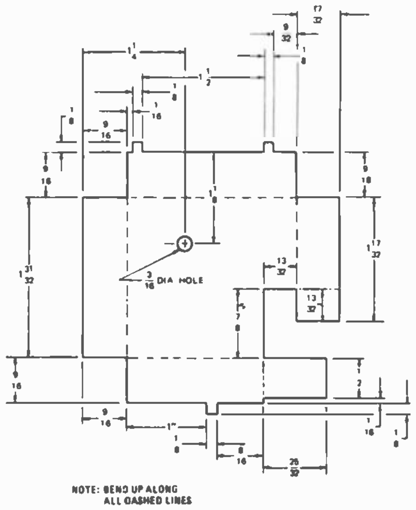


FIG. 8—TOP RF SHIELD is cut from sheet metal and soldered to component side of main board.

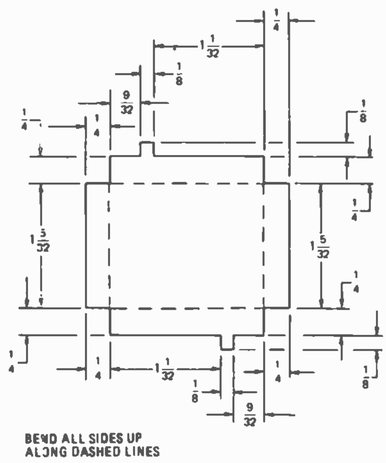


FIG. 9—BOTTOM RF SHIELD is soldered to bottom of main PC board.

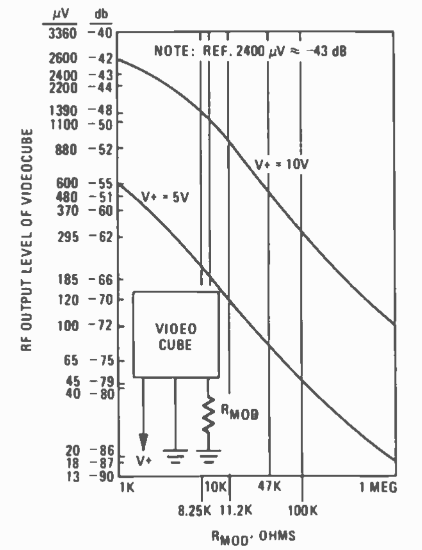


FIG. 10—RF OUTPUT LEVEL versus the value of the resistor connected to the modulation input terminal.

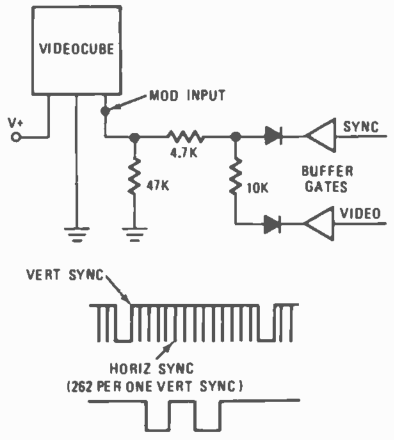
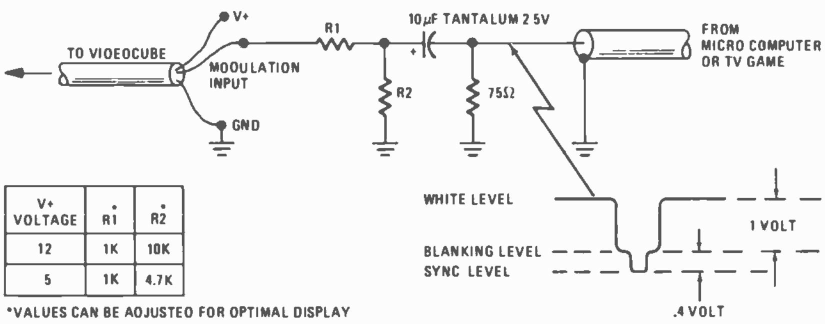


FIG. 11—VIDEO AND SYNC SIGNALS are interfaced to a TV set using the Videocube and associated components.



V+ VOLTAGE	R1*	R2*
12	1K	10K
5	1K	4.7K

*VALUES CAN BE ADJUSTED FOR OPTIMAL DISPLAY

FIG. 12—MICROCOMPUTER INTERFACE to a TV set.

tors C8, C9 and C10, and inductors L2 and L3. This filter removes harmonics from the output signal that otherwise might cause the Videocube to broadcast on more than one channel. Balun T1 matches the output of the Videocube to the TV receiver.

Assembling the Videocube

Figures 2 and 3 show the foil patterns of the double-sided main board while Fig. 4 shows the component layout. If the PC board you use does not have plated-through holes, make sure to solder all component leads on both the top and bottom sides of the board. (The PC boards supplied in the kit have plated-through holes so the second soldering operation can be eliminated.) Try to keep all component leads short.

Feed-through capacitors C5 and C6 mount from the bottom side of the board. Jumpers connect the ends of C5 to points A and B on the board, as shown in Fig. 4. Capacitor C6 has one jumper and resistor R6 to connect to points C and D. Figures 5 and 6 show the two foil patterns for the PC board that holds the switch (S1) connecting the TV receiver input to either the external antenna or to the Videocube output. This PC board (see Fig. 7) also serves as a terminal board for the antenna lead-in. I used pressed-in threaded fittings, but you can solder brasss nuts to lugs 1 and 2.

After all the components are mounted, two RF shields are soldered in place on the main PC board. These shields are cut out of sheet metal and formed as shown in Figs. 8 and 9.

Oscillator coil L1 is a non-standard type that is available in the partial kit of parts (see parts list). The tuning slug in oscillator coil L1 lets you tune the Videocube to either Channel 3 or Channel 4. Use a small plastic screwdriver or alignment tool to adjust the tuning slug through the hole in the RF shield Just be careful not to crack the slug.

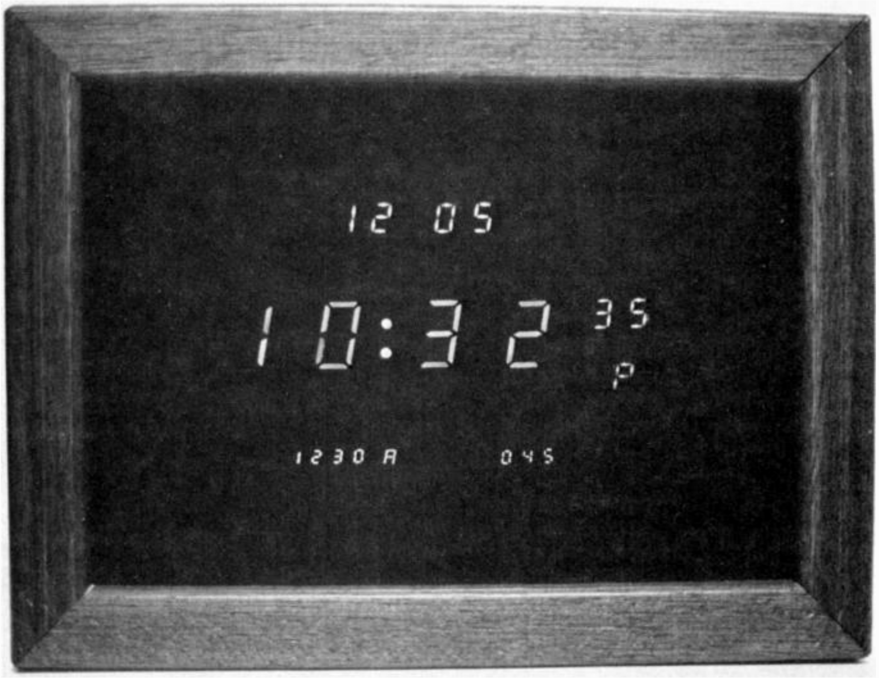
Using the Videocube

The DC voltage supplied to the Videocube should be between 5 and 12 and the current drawn is about 10 mA. The modulation input controls the output level supplied to the television set. The more current supplied the modulation input, the weaker the signal sent to the television. Since the modulation input itself always sits at about 0.8 volts less than the positive supply voltage, the output level can be set by simply connecting a resistor from the modulation input to ground. By varying this resistor, we can vary the output signal level supplied through the 300-ohm output to the TV receiver. The graph in Fig. 10 shows how this output varies with a resistor (R_{mod}) from the modulation input to ground.

Figure 11 shows a typical application. With V+ equal to 10 volts, a 47K

continued on page 69

Build This



10 Function Digital Clock

Simultaneous readout of time, date, alarm and countdown timer. Timer has three modes of operation to turn on or off appliances and the time can be readout in either a 12 or 24-hour format

JEFFREY G. MAZUR

DIGITAL ELECTRONIC CLOCKS HAVE BECOME commonplace in recent years. Mechanical movements have been replaced with split-second solid-state circuits, and the clocks are being made in a variety of styles. Small bedside and desk models are popular and low-cost. Alarm clocks and clock radios are also plentiful. You can get microwave ovens, CB sets and even TV sets with a digital time readout. The more sophisticated units feature calendar, alarm and timer circuits. They have certain drawbacks; you have to manipulate switches to display the various data. This can be cumbersome and quite inconvenient.

As opposed to mechanical clocks, electronic clocks respond uniquely to a power failure. A few start counting from some random time when the power returns, but most indicate that a power failure occurred. Still others revert to a battery backup to keep the clock running; but if the power remains off so does the alarm and you could oversleep.

The clock described here was designed to alleviate these and other problems. It was decided that the clock should have the following features:

- Constant simultaneous readout of the date, time, alarm and timer as well as status indicators
- Calendar
- 24-hour alarm
- 10-minute snooze timer
- 10-hour appliance or radio timer
- 12- to 24-hour format
- 50- to 60-Hz AC or 12-volt DC operation
- Complete battery backup including alarm and timer

Fortunately, a single clock IC is available that satisfies most of these requirements. All the timekeeping functions are performed and stored in separate registers inside the IC. The trick is to allow readout of all these registers simultaneously. To do this, a multiplexing scheme similar to that used by the clock IC itself is used.

Multiplexing scheme

Many LSI circuits requiring a multidigit display, such as calculator and clock IC's, use a multiplexing scheme to reduce wiring. The idea is to sequentially turn on each readout one-at-a-time and feed it the proper segment information to display the correct number. This permits the 7-segment leads of each digit to be paralleled together.

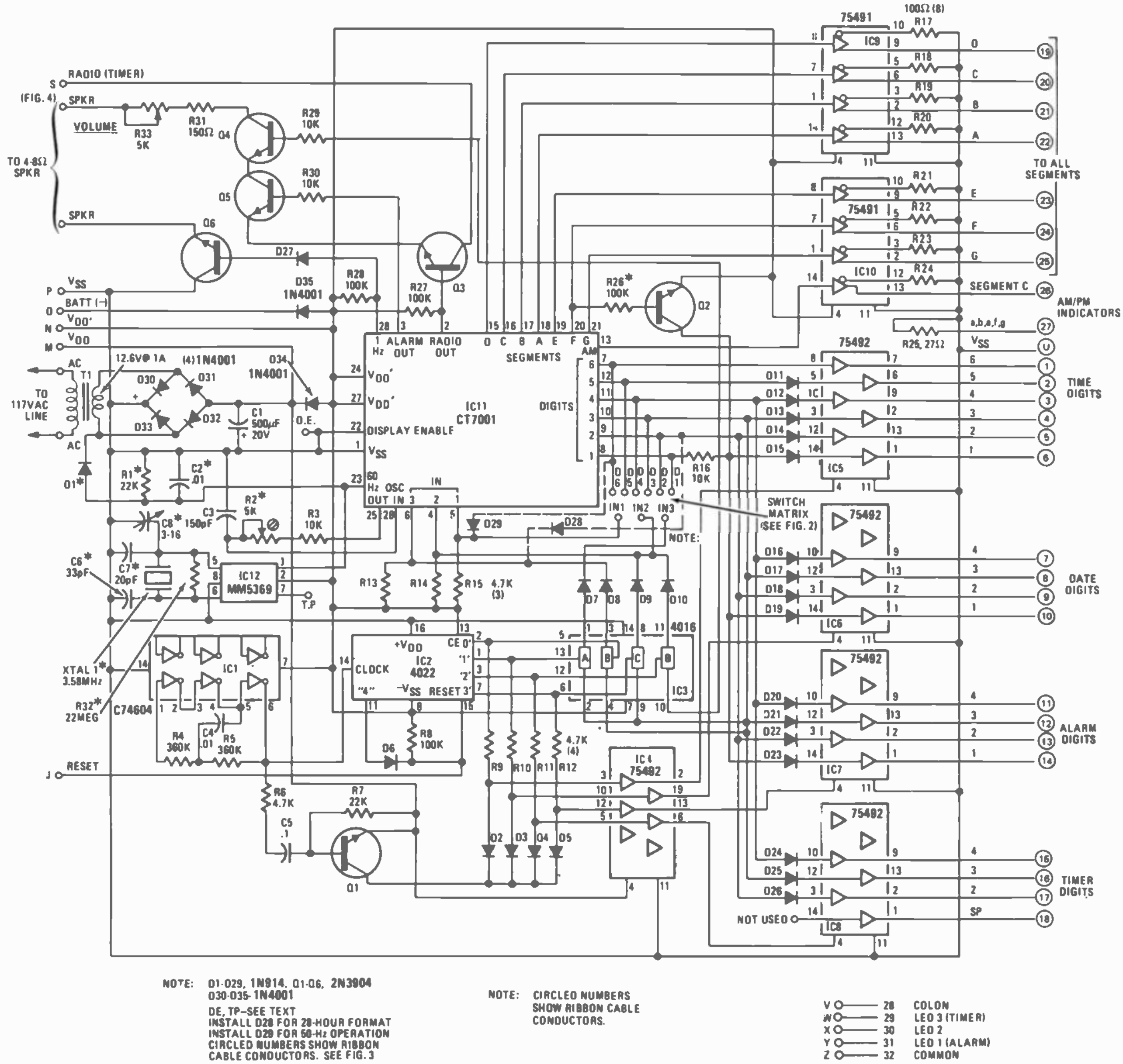


FIG. 1—CLOCK CIRCUIT provides a simultaneous display of the various functions by using a multiplexing technique.

PARTS LIST
CLOCK BOARD

All resistors are 1/4 watt, 10%, unless noted

R1*, R7—22,000 ohms
R2*—5000-ohm potentiometer
R3, R16, R29, R30—10,000 ohms
R4, R5—360,000 ohms
R6, R9-R15—4700 ohms
R8, R26*, R27, R28—100,000 ohms
R17-R24—100 ohms
R25—27 ohms
R31—150 ohms
R32*—22 megohms
R33—5000-ohm potentiometer
C1—500 μF, 20 volt, electrolytic
C2*, C4—0.01 μF disc
C3—150 pF MYLAR
C5—0.1 μF disc
C6*—33 pF MYLAR
C7*—20 pF MYLAR
C8*—3-16 pF trimmer
D1*, D2-D27, D28*, D29*, D36-D43—1N914
D30-D35—1N4001
Q1-Q6—2N3904 or equal
IC1—74C04 hex inverter
IC2—4022AE divide-by-8 counter
IC3—4016AE quad bilateral switch
IC4-IC8—75492 hex LED driver (Fairchild)
IC9-IC10—75491 quad LED driver (Fairchild)
IC11—CT-7001 clock
IC12—MM5369 oscillator/prescaler (National)
XTAL1—3.58 MHz crystal
T1—117 VAC primary; 12.6 VAC, 1-amp secondary
SPKR—4 to 8 ohm 2-inch round speaker

Then each digit is turned on, or strobed, when its 7-segment information is on the segment lines. This is called scanning. Normally a clock IC would scan each of the 6 digits in an hours-minutes-seconds display. The MTI does this with all 17 digits. Multiplexing reduces the number of leads from 136 (17 digits × 8 leads per digit) to 24 (17 digit lines + 7 segment lines). Although only one digit is on at a time, the scanning is done at a rate faster than the eye can follow. Thus, all 17 digits appear to be on at the same time.

Calendar

A 28/30/31-day calendar displays both the month and day. The calendar changes automatically to indicate the correct number of days in each month. February 29 (leap year) must be set manually.

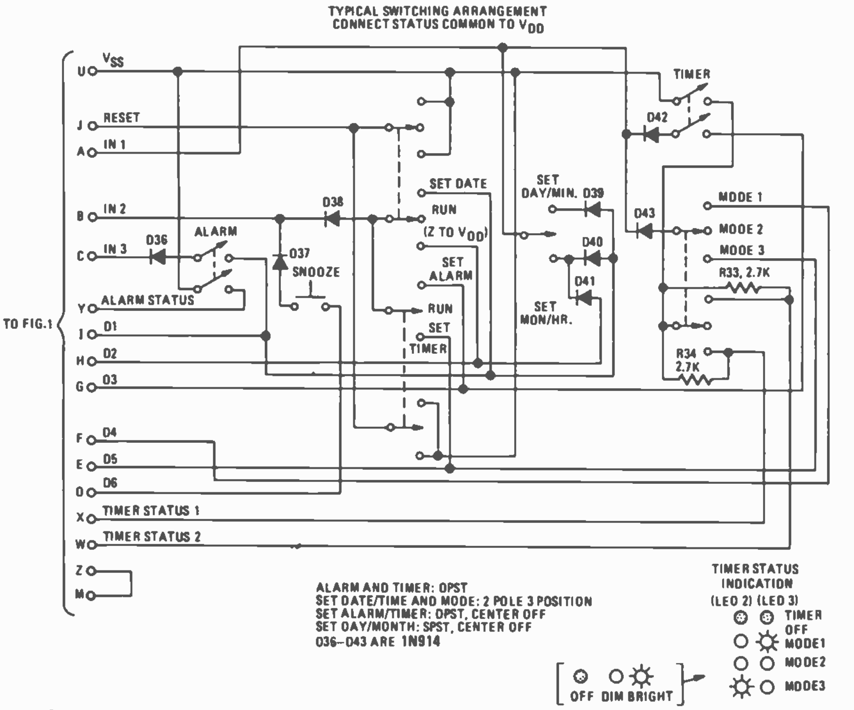


FIG. 2—SWITCH CIRCUIT selects the various functions and sets the time, timer calendar and alarm.

Alarm

The alarm is a true 24-hour device. When the hours and minutes of the alarm setting coincide with the actual time, and the ALARM switch is closed, the alarm will sound. You can turn it off at any time by opening the ALARM switch. Turning the switch back on will allow the alarm to sound 24 hours later.

A 10-minute snooze timer temporarily silences the alarm as many times as desired. A volume control adjusts the sound from a gentle "beep-beep" for a gradual awakening to a loud "BEEP" that will arouse even the heaviest sleeper. An LED status light on the display tells you when the alarm is set.

Timer

The clock has a countdown timer that can be set in one-minute increments up to 9 hours and 59 minutes. This counter is used as a timer to control an external device such as a radio, TV or similar appliance. When activated, the timer will count down from the preset time until it reaches zero, and can be interrupted and restarted at any time.

The external device is controlled using one of three modes:

Mode 1: The device is turned on for the preset amount of time and then turns off when the counter reaches zero.

Mode 2: The device stays on for the preset period but turns on again at the alarm time.

Mode 3: The device is turned on at the alarm time and stays on for exactly the preset length of time.

The position of the ALARM switch does not affect operation of the timer. The time remaining on the timer is constantly displayed and three LED status lights show whether the timer is operating and what mode it's in.

How it works

The schematic diagram is shown in Fig. 1. The heart of the circuit is the 7001 clock IC. This single MOS IC contains all timekeeping and control logic. Several features are worth noting. To reduce wiring, a multiplexing scheme controls the display so that all digits can be bused together. The digit lines are also used in conjunction with three input lines to control the internal-register and switch setting. For example, if IN2 (IC11 pin 4) is connected to the digit-1 output (IC11 pin 8), the calendar can be set. If IN2 is connected to the digit-2 line, then the time can be set. Similar connections select the entire range of modes. Isolating diodes are used in series with each switch to prevent shorting the digit lines (see Fig. 2).

One-half of IC1 forms an oscillator that drives octal counter IC2 (see Fig. 1). Connecting the '4' output of the counter to its reset pin causes it to count 0,1,2,3,0,1, etc. This gives four outputs that are continually turned on and off in sequence, that is, scanned. These outputs operate the analog switches to select each particular clock function and also to turn on the respective display digits. Because of the time needed for the 7001 IC to switch from one function to another, the displays are blanked momentarily by Q1. This assures that the clock IC sends the correct information when each display is turned on. Each 7-segment display (time, alarm, etc.) has a digit driver (IC5 through IC8) controlled by a master driver (Q1) that turns it on at the proper time. Diodes D11 through D26 are needed on the inputs to the digit driver IC's because of leakage between the inputs when the ground pin is floated.

AM/PM indication is multiplexed along with the digits. Instead of a light to signal either AM or PM, a separate digit is used to display either "A" or "P." This is done by simply turning on segments *a, b, e, f,* and *g* and controlling segment *c* by the AM output of the clock IC.

To prevent false setting, the reset line of the counter IC is also connected to V_{SS} through the SET switches. Thus, when any of the functions are set, only the time display is on but it displays the contents of the register being set.

The display board holds the 17 digits and other indicators. The schematic diagram of the display board is shown in Fig. 3. All 7-segment leads are paralleled together, but resistors are added in series with the alarm and timer displays. Connections for several status and colon LED's as well as their dropping resistors are also provided using one common lead.

In the 12-hour format, blanking of the leading zero in the digit-1 position is desirable. This means displaying 1:42 instead of 01:42. Transistor Q2 does this

DISPLAY BOARD

R1-R7, R9-R13—390 ohms
R8—27 ohms
R14—Select for proper brightness of colon (330 to 560 ohms)
RD1-RD4, RD9-RD11—FND70 7-segment LED display (Fairchild)
RD5-RD8—DL750 7-segment LED display (Litronix)
RD12-RD14—NSN33 3-digit 7-segment LED display (Monsanto)
RD15—MAN3—7-segment LED display (Monsanto)
LED1-LED3—any small discrete red LED
LED4, LED5—micro-size LED
*Optional, see text.

The following parts are available from West Side Electronics, 24348 Vanowen St., Canoga Park, CA 91307.

Kit No. MT-C: Complete parts kit including both circuit boards and switches; less case. (Specify whether on-board or wall-type transformer desired.) $109.

Kit No. MT-SS: Complete parts kit for clock board only; includes board less switches, case and transformer, $50.

Kit No. MT-1: Clock printed circuit board only; double-sided, etched and drilled with plated-through holes, $16.50.

Kit No. MT-2: Display printed circuit board only; single-sided, etched and drilled, $10.

All prices include postage and handling on U.S. orders. California residents add state and local taxes as applicable.

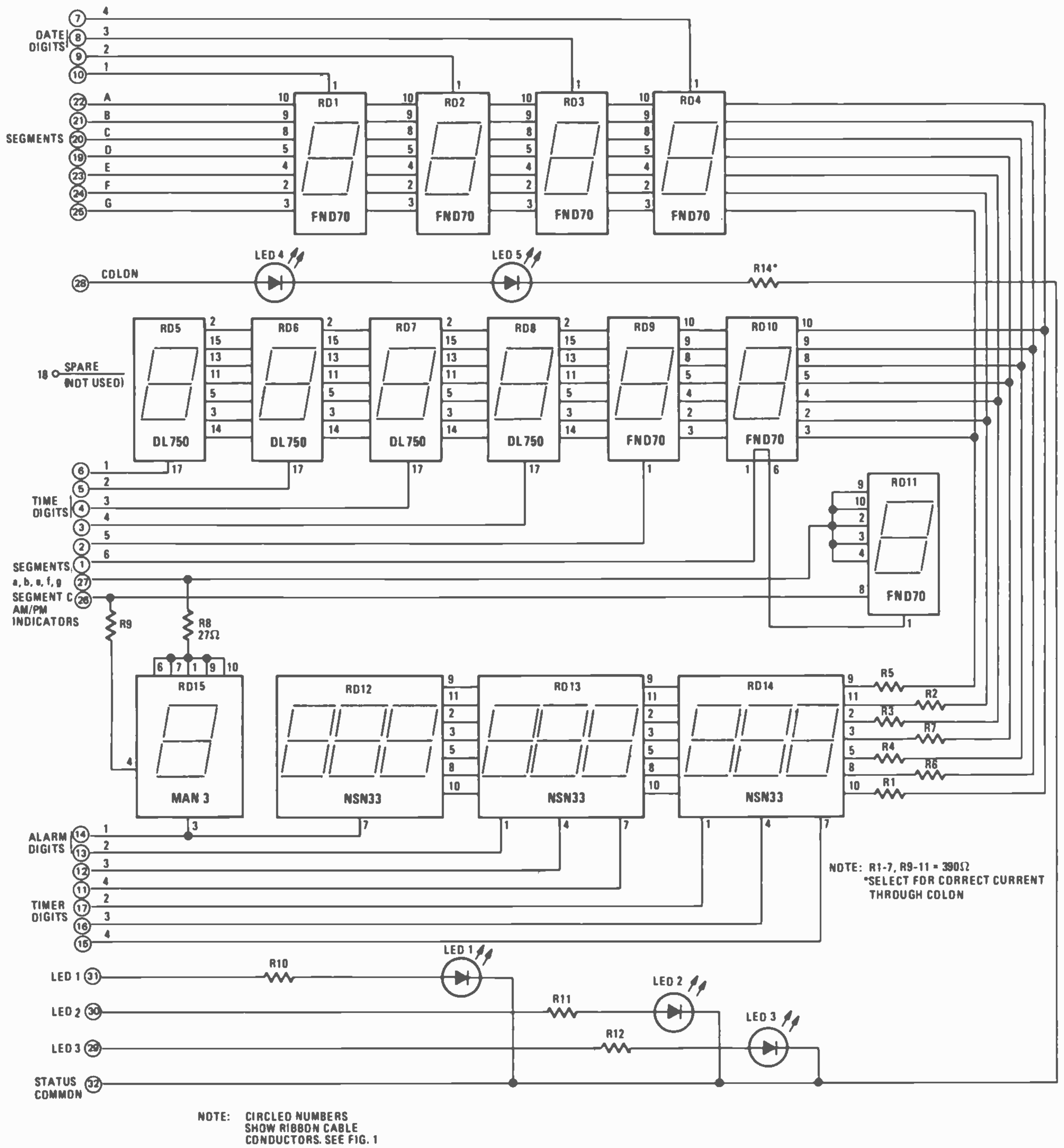


FIG. 3—DISPLAY CIRCUIT consists of 7-segment and discrete LED readouts.

by turning off digit 1 when segment *f* is on. This occurs when the first digit is a zero but not when it is a 1.

The RADIO-OUT control line from the clock IC is used to drive Q3, which can supply current to an external device such as a radio or relay. If the external device can be powered by the clock's power supply and draws less than 300 mA, then it can be connected between the RADIO and V_{SS} pins of IC11 (see Fig. 4-a). For control of a 117 VAC or high-current device, a relay is used as in Fig. 4-b.

The alarm circuit consists of Q4, Q5

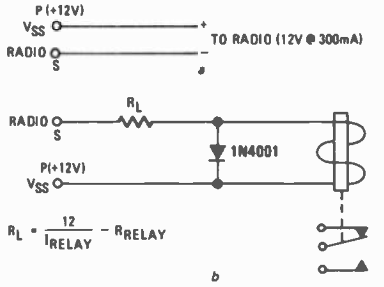


FIG. 4—TIMER CONTROLS external devices directly if current drawn is less than 300 mA as shown in *a*. For high-current devices, use relay as shown in *b*.

and Q6. Transistor Q6 turns on and off at a 1-Hz rate from pin 28 of the clock IC. Transistor Q4 is controlled by a digit line and thus has a squarewave on it at the clock's multiplex frequency (about 1 kHz). Transistor Q5 is turned on by the ALARM OUT pin of the 7001. The combined result is that when the ALARM OUT pin goes high, the speaker is fed a 1-kHz squarewave that "beeps" on and off at a 1-Hz rate.

Next month, the article concludes with the construction details, the foil patterns and the component placement diagram. To be continued.

Build This

$1 Logic Probe

This easy to build TTL logic probe is inexpensive and will save you hours of troubleshooting time when probing around digital circuits

ALEX F. BURR

WITH THE INCREASED USE OF DIGITAL IC'S for everything from inexpensive computers, through musical doorbells, to simple alarm circuits, the need for specialized equipment to test digital circuits has become apparent. The nature of two-state logic circuits—logic high or logic low—makes possible simple test equipment. It is not usually necessary to measure how much signal is present but just whether it is there or not.

This need has been met by commercial probes that range from the $65 Hewlett-Packard logic probe to a widely advertised kit for less than $10. Of course, the former is a more precise instrument than the latter but both do essentially the same thing—cause a lamp to light when the probe detects the presence of a logic high level. A voltmeter or an oscilloscope can do the same job but the logic probe is easier, quicker and more convenient to use.

Still $65 is too much for most people and even $10 is quite a lot when you consider that the TTL logic probe described here can be built for a total parts cost of less than $1.

For $1, the probe, of course, cannot be complicated. It does do the job, however, of distinguishing whether a pin of an IC is in a logic high or a logic low state. The schematic of the probe is shown in Fig. 1.

About the circuit

The schematic diagram is shown in Fig. 1. The most important design decision was to require that the wire with the alligator clip be connected to 5 volts so that the LED will light on a logic low level rather than to attach the wire to ground and have the LED light on a logic high. The latter would be preferable except that the characteristics of TTL logic prevent this.

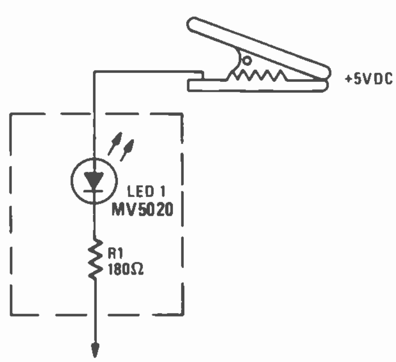


FIG. 1—SIMPLE LOGIC PROBE uses only two components.

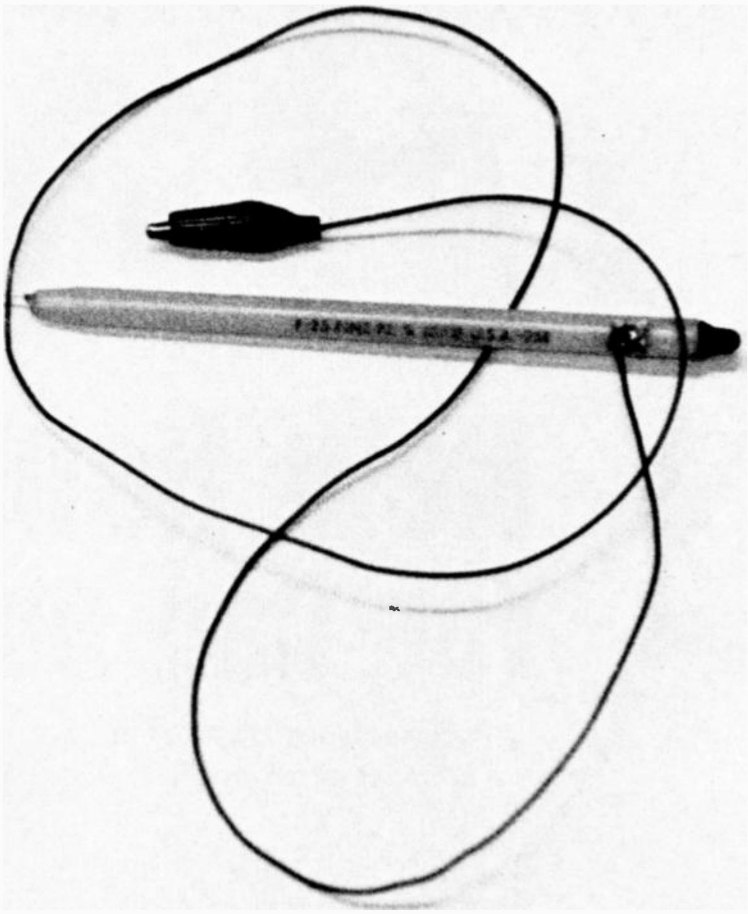
PARTS LIST

R1—180 ohms, 1/4 watt, 10%
LED1—red LED (MV5020 or equal.)
24-inches No. 20 stranded wire
straight pin
insulated alligator clip

TTL logic is designed so that logic low is any voltage below 0.8, while a logic high is any voltage above 2.4. In almost every case, a gate in a low state will sink 16 mA. That means that you can supply up to 16 mA to the output of a gate without causing its voltage to rise above 0.8. Unless an external pull-up resistor is used, the output of a gate in the logic high state will usually be about 3.5 volts. However, in practice a gate need only supply a few microamps, so any attempt to draw a significant amount of current from logic high output will pull down the output level.

In our case, if we tried to light an LED (which requires about 20 mA) from a logic high output, the voltage would drop from the usual 3.5 to about 1.8. The LED would light up in many cases, but the stages connected to that output would be disabled since the level is now not high enough to be identified as a real logic high. In other words, the probe would upset even those parts of the circuit that were working correctly and if there is anything you don't want it is test instruments that upset the circuit being tested.

The probe is designed so that it draws no current from a high output and it supplies only about 18 mA to a low



output. This current level raises the typical voltage at a low output by only 0.1 or 0.2 volt, not nearly enough to cause any disturbance in most circuits.

A green LED can be used instead of the more common red because most commercial probes use a lighted red LED to indicate the presence of a high. You can, of course, use the red LED specified in the parts list in your probe; but you must remember that, when your LED is lit, the probe is touching a logic low.

When you consider that the lowest priced commercial probe kit costs 10 times as much, this probe has to be pretty cost effective. Of course, at this price it does have a few disadvantages.

Perhaps the biggest one is that it does not distinguish between a logic high and an open circuit. Both of these conditions cause the LED to remain off. When it is connected to a gate without pull-up resistors, the LED will glow dimly on a logic high.

The probe has no overvoltage protection. If the clip is accidently attached to a voltage greater than 10 or if the tip accidently touches a point greater than 6.5 VDC, the LED will likely burn out.

Construction

The probe is easy to build. First collect the parts. The ballpoint pen is one of the inexpensive disposable types. It is approximately the same size and shape as a lead pencil and just right for the probe. Remove the point and the ink holding tube attached to the point and throw them away. Also, discard the plastic plug on the top of the pen.

Just about any LED can be used, just so long as it is small enough to fit in the top of the pen. I used an MV5020, which is a red LED. This one draws about 20 mA, has a 0.185-inch diameter lens, a 0.230-inch diameter base and a 0.10-inch lead spacing. If you prefer to use a green LED, try one that is similar in size to the MV5020. An MV5253 has a slightly larger lens but the base and the lead spacing is the same.

You will find that if the LED is the MV5020 size, it will just fit into the top of the pen. Drill a $\frac{1}{16}$-inch hole in the side of the pen about $\frac{3}{4}$-inch down from the top. You should just be able to see the end of the anode lead of the LED through the hole when the LED is set into the top of the pen. Connect the resistor to the other lead of the LED and connect a straight pin to the other end of the resistor with a wire long enough so that the pin sticks out of the pen about $\frac{1}{2}$-inch where the ballpoint used to be.

Now feed a wire 24-inches long into the hole drilled in the side of the pen and out the top. Solder the wire to the anode lead of the LED with as small a joint as possible. Tape that connection then insert the whole assembly into the top of the pen, pin first. Push on the LED gently while pulling the wire back out through the side. When the LED is set into the top of the pen, you will have a probe with the tip of a straight pin sticking out the bottom, an LED set on the top, and a length of wire coming out the side. Fill the pen near the pin with epoxy and apply a little around the LED to make sure it does not fall out. Connect an alligator clip to the free end of the wire and the probe is complete.

Using the probe

The probe is simple to use. Just hook the alligator clip to any 5 VDC point in the circuit and touch any pin of the IC to be tested. If that pin is at a logic low level, the LED will light up brightly. If the pin is at a logic high level, the LED will remain dark. Thus, you can trace the levels throughout the entire circuit until you find the spot where the levels are not correct.

The probe will even indicate the presence of pulse trains. If the repetition frequency is less than about 25 Hz, the individual pulses will be indicated. If the frequency is greater than about 25 Hz, the individual pulses will blur and the LED will glow at about half intensity. **R-E**

New Hobby You Can Build

Two machines: one an 8080A, the other an
a long list of peripherials, accessories and

On May 30, 1977, Radio-Electronics was invited to preview the new computers at the Heath plant in Benton Harbor. This is our preliminary report on what we were shown. At a later date, after we have had the opportunity to construct our own machines we will update this report.

The new line, and it is a full line, consists of two computers, the H8 and the H11. The H8 is an 8-bit system based around the 8080A microprocessor. It features an intelligent front panel with octal data entry and display, and a resident monitor with built-in bootstrap for one-button program loading or storage.

The H11 is a much more sophisticated machine. It is a 16-bit computer that uses the D.E.C. (Digital Equipment Corporation) LSI-11 with 4K memory, a built-in backplane and a regulated switching power supply.

Peripherials, that are compatible and can be used with either system include a video terminal, paper-tape reader/punch/duplicator. System dedicated peripherials include a hard-copy printing terminal and a cassette recorder. I/O (input/output) interfaces, additional memory and supplimentary software paclages complete the initial products and additional hardware and software will be added later.

Both systems are backed with complete documentation—assembly and user manuals, schematics and pictorial diagrams, printed circuit board layouts—all the great aids that Heath had traditionally provided its kit builders. There is even a Heath Users group already being formed and Heathkit H11 owners are automatically eligible for membership in DECUS, the Digital Equipment Corp. users group.

The H8—an 8080A machine

This is the basic hobby computer in the newly announced Heath line. The 8080 is a well-known stardard microprocessor. In the H8 it comes with a built-in 1K ×8 ROM (Read Only Memory) that contains a monitor program for controlling the front panel and load/dump operations. The H8 cabinet is designed to accomodate up to 32K of memory and has a total capacity for 65K of addressable memory.

The intelligent front panel has a 9-digit 7-segment octal display that permits the user to dynamically display register and memory contents while programs are running. A 16-digit keyboard allows quick and accurate data entry. A built in programmable audio circuit and speaker makes possible a wide variety of special audio effects while a set of LED status lights make it possible for the operator to monitor important machine states.

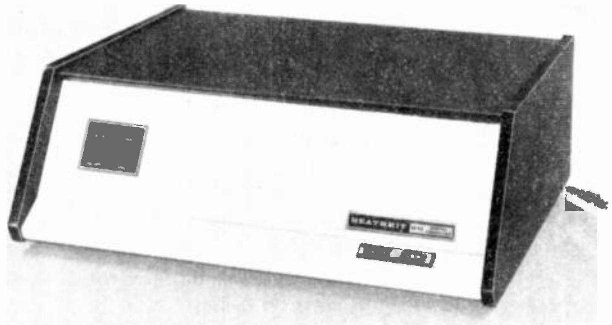
The CPU board that houses the 8080A comes factory-wired and tested to eliminate the most common source of errors that a kit builder might encounter. The system bus that Heath is using is a 50-line bus that is not compatible with any other 8080 bus currently in use. This means that any accessory items you may have for the Altair or S-100 bus *cannot* be used in the Heath computer. A built-in convection-cooled power supply completes the main frame. It can handle up to 32K of memory and two I/O interfaces. The basic H8 kit includes the wired and tested CPU, complete assembly and operations data as well as all systems software in audio cassette for,. It sells for $375 in kit form.

Memory cards for the H8

Additional memory, a must if you are going to do anything with your H8 is available. Model H8-1 is an 8K memory board kit that comes with 4K of static RAM for $140. An additional 4K expansion memory IC set (Model H8-3) is $95. Each static memory card uses TI4044 4K × 1 static memory IC's. Memory PC boards are available only as a part of a memory kit. All IC's are in sockets, and each memory card contains additional on-card power-supply regulation. The memory is addressable throughout the entire memory range and comes complete with a memory test program.

Parallel I/O card for the H8

To interface with outside peripherals you must have an I/O, preferable several. Heath offers their model H8-2 for this purpose. This I/O card kit offers 3-input/3-output 8-bit ports. It is completely compatible with the serial I/O port used to inerface a cassette recorder with the machine. The parallel I/



Computers From A Kit

LSI-11 are available in kit form from Heath—plus software

O has complete interrupt control and independent addressing is available. Output polarity is selectable and pulsed or transparant handshaking is included. Like the memory board, on-card power-supply regulation is provided. The H8-2 kit is $150.

Serial I/O card for the H8

When you want to interface a cassette recorder to your H8 computer you must have a serial I/O board. In the H8 system you need the H8-5. It has a 1200 baud rate and sells for $110.

Video terminal kit

The H9 video terminal kit can be used with either the H8 or the H11 computer. It costs $530 and has a 12-inch screen that displays up to 12 lines of 80 characters and contains enough built-in memory for one page of data. It offers long- or short-form display. Long-form is full lines of data 80 characters long. Short form is 4 columns of 20-character lines—quite handy during programming as you can then look at 48 lines of program at a time. Baud rates are variable from 110 to 9600. Editing features are built in. This terminal also includes a parallel interface for the H10 tape reader/punch/duplicator.

Tape reader/punch/duplicator

Like the video terminal, this unit can be used with either computer. It costs $350 as a kit and can read, punch or duplicate paper tape. This multi-purpose device is a 50-CPS high-speed reader; a long life 110-baud 10-CPS punch and has a copy mode duplicating tapes. It uses a parallel interface with handshakes and can accomodate either fan-fold or rolls of paper tape. The unit comes with a chad tray for catching the punched out paper scraps and a fan-fold tape tray.

H11, a 16-bit computer

This powerful machine is designed around the DEC LSI-11, a 16-bit CPU. The CPU board is supplied completely assembled and tested with 4K × 16 dynamic RAM. Memory is expandable to 20K. The unit includes a built-in backplane, power supply with switching regulators and full circuit protection, and flexible I/O interface accessories. A complete DEC system software package is also included. It contains editor, PAL-11 assembler, linker, on-line debug package, input/output executive, BASIC and FOCAL. Mail order price of the H11 is $1295.

The mainframe has no front-panel keyboard or readouts. It does feature a tilt-up removable card cage and a built-in cooling fan.

Static memory for H11

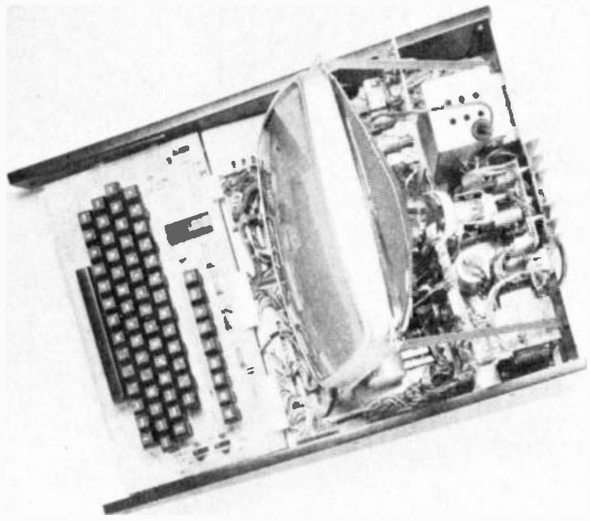
As many as four additional 4K static memory cards can be added to the H11. Heath calls these model H11-1 and cost $275 each. The cards use 1K × 4 static RAM memory (no refresh is required). They are fully compatible with the H11 bus and the PDP 11/03 bus. Only a single jumper is needed for bank selection and maximum read/write time is 500 nS.

Parallel I/O for H11

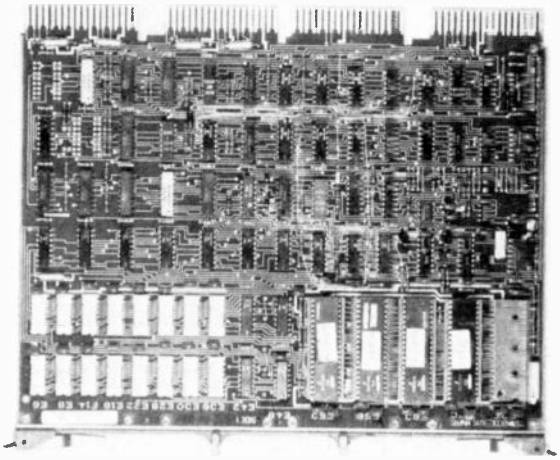
The H11-2 is a parallel I/O for the H11. It costs $95. It offers 16 diode-clamped data input lines. Inputs and outputs are latched. 16-bit words are on 8-bit byte programmed data transfers. Also provided are jumper-selectable address and vector generation. Four control lines go to each peripheral device—reader enable low, data valid low, new data valid low and punch ready low. The logic lines are TTL compatible.

Serial interface for the H11

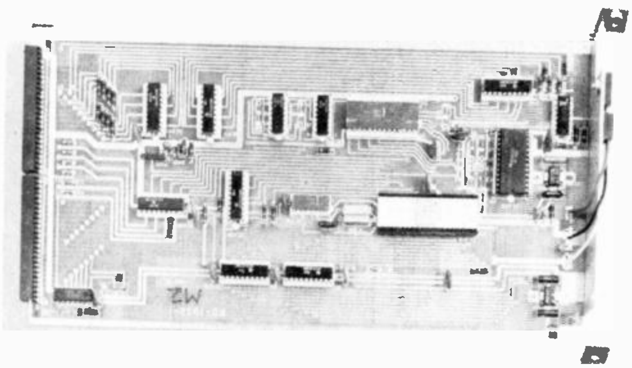
Labeled as the Heath model H11-5 this serial interface card can be either EIA or optically isolated. It offers selectable crystal-controlled baud rates of 50, 75, 110, 134.5, 150, 200, 300, 600, 1200, 1800, 4800, and 9600. Also provided are jumper-selectable stop-bit and data-bit formats and H11 bus interface and control logic for interrupt processing and vector generation. Interrupt priority is determined by the electrical position along the H11 bus. All control/status register and data registers are compatible with H11 and PDP-11/03 software.



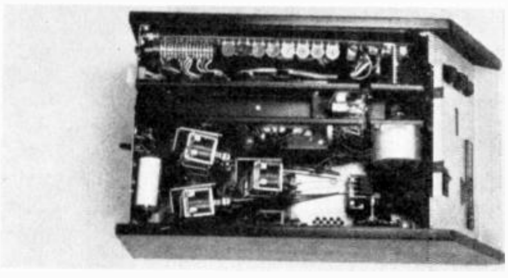
INSIDE THE VIDEO TERMINAL you'll see the CRT, keyboard, electronics and power supply that make it work.



CPU CARD FOR THE H11 includes the LSI-11 microprocessor and comes completely assembled as you see it here.



CPU CARD FOR THE H8 includes the 8080A microprocessor and is supplied with the kit as a fully assembled board.



WITH ITS COVER REMOVED you can see the works of the paper tape printer/punch/duplicator. It can be used with both computers.

Printing terminal

To complete the system Heath is offering an LA36 DEC writer. The price of this unit has not yet been announced. It offers a tractor paper feed, a maximum line width of 132 characters and baud rates of 110 and 300. In addition there is auto line feed.

Software systems

Two entirely separate software systems are provided. The H8 software goes with the H8 machine, the H11 package with the H11 machine.

The H8 software is made up of BH Basic (BH stands for Benton Harbor), expanded BH Basic, TED-8 (a text editor), HASL-8 (an assembler), BUG-8 (debug), PAM-8 (panel monitor). These programs come in cassette tape form and are supplied with the H8.

For the H11 the following software is now available: PTS Basic-11, 8K Focal-11, 4K Focal-11, Edit-11, Link-11, PAL-11S

All software for the Heath H11 computer is completely compatible with the DEC PDP-11 and can run on any operating PDP-1103 system.

Heath software will be supplied in three forms: cassette magnetic tape, paper tape and read-only memory (ROM). The panel monitor for the H8 (PAM-8) is supplied in a ROM and like all ROM, cannot be modified by the user.

BUG-8, TED-8, HASL-8 and BASIC are provided with the H8 computer in cassette form and are available as an option in paper tape form. Both the cassettes and the paper tape are compatible with the required error checking and synchronising characters used by the front panel monitor system.

Also packed with the H8 is a six-section software manual. This is, however, a reference manual and is not intended to teach the owner how to use the software. If you have never used a text editor and an assembler, for example, it would be best to obtain an introductory text in that subject.

Conclusion

As you can see there are two great systems here with more accessories still to come. There will be more I/O interfaces more memory, a floppy disc, and printers. **Radio-Electronics** will present more details on all of these new systems as we get them. **R-E**

THE LA-36 DEC WRITER II keyboard printer terminal. The price of this unit has not yet been determined.

Add Sound To Your Home Movies

Making home movies is a popular hobby throughout the world. Here are details on one moviemaker's approach to adding sound to his movies with the aid of a stereo tape recorder

ANDREW JAREMKO

EVER SINCE THE INVENTION OF MOTION pictures and sound recording, attempts have been made to give pictures a voice. Edison experimented with talking films in his Kinetophones, using his cylinder recorder. Commercial films, with Hollywood leading the way, eventually evolved a set of reliable but cumbersome techniques for adding sound to the movies. Magnetic recording simplified sound film production tremendously and also made it possible for the amateur film maker to add sound to his films. A great number of gadgets and systems have been constructed for this purpose over the years, beginning with mechanical gadgets and eventually using electronics. Many of these were designed to allow the hobbyist to run a sound track on a tape recorder, unlike the professional system that puts both picture and sound on the one strip of film.

The problem of making a circuit that would reliably synchronize a movie projector and a tape recorder to produce sound movies has occupied me for some time. I worked through a couple of very bad discrete component designs and a couple of versions using RTL logic IC's, one of which worked fairly well. My latest version uses CMOS logic throughout and represents my state-of-the-art. The movie projector has to be modified to allow the synchronizer to work, but after that any stereo tape recorder can be used to provide fully synchronized soundtracks. It should be possible to build the circuit for under $75, depending on where you shop.

The problem in playing a tape recorder and projecting a film so that the result is a talking picture is *synchronization*. This means that the sound that matches a particular image in the film should always match that image every time the film is projected. We are used to seeing voices match lip movements, and talking is the main thing that people expect from sound films. At the normal home movie speed of 18 frames per second (fps), lip movements will appear to be out of sync if the sound comes in more than one frame early or late.

All we really need is a system in which both the tape and the film run at a speed accurate enough so that at the end of a reel they haven't drifted apart by more than one frame. With a 400-foot reel of super-8 film, this is an accuracy of one part in 28,800, or about 33 parts per million. If our projector and recorder can run this accurately, allowing for all the factors that can affect their speed—tape stretch and slip, motor warmup, line voltage variations, etc.—the problem is solved. All we have to do is start the two in sync and they will stay in sync. This procedure has been a part of professional filmmaking for some time and is called "crystal sync" (since accurate crystal oscillators are used to regulate running speeds). But that kind of accuracy is expensive.

The professional method of making talking pictures is of course to put the soundtrack on the film. Sound-on-film (SOF) has always been around in home movies, and Kodak's recent entry into the market with SOF super-8 equipment will of course make it much bigger. Relatively recent improvements in projectors have resulted in sound on 8-mm film that is often superior to the sound on 16-mm film. But putting the sound on the film as it is shot and leaving it there creates many serious problems in the editing stage. Trying to make a film without editing is roughly comparable to trying to paint a picture without removing the brush from the canvas.

In professional productions the sound is virtually always recorded separately and handled separately through the editing process. It gets onto the film only at the final stage, when the print is made. The main use for SOF is news, and even here it is frequently taken off the film for editing. Once it is removed from the film, the problem of getting it back on in the right spot comes up.

We can get around the need for extreme accuracy by recording a signal on a tape that will tell the projector how fast it is to run. (The tape should be allowed to run free, since any interference with its speed is likely to cause wow and flutter.) This means that the stereo recorder will be carrying a mono soundtrack in one channel and sync information in the other. Since the two tracks are on the same piece of magnetic tape, anything that affects the soundtrack will affect the sync track and the sound will remain in sync.

The most logical method to use is simply to record one signal of some sort (usually a pulse) for every frame of film that should go through the projector. The synchronizer would keep track of how many pulses have gone by on the tape and make sure that the same number of frames of film are displayed. For live sync sound all that has to be done is to obtain a pulse from the camera every time a frame goes through it and record this signal along with the sound. When the film and sound are run together using the synchronizer, each frame will go past at its correct moment relative to the soundtrack, and the result is talking pictures.

Some specifics

So far the circuit is pretty vague, with only its main function specified and absolutely no notions about other duties or about how to put it together. Based on my previous experience with synchronizers, I had decided on several other characteristics. I wanted to put it inside the projector where it would always be ready to use and would have no cables to fail in the middle of a show. It had to have the smallest possible number of adjustments, ideally zero, and should require no adjustment or other attention during projection. Many earlier mechanical and electrical synchronizers required the projectionist to make adjustments continually during the show, which is annoying for him and a distraction for the audience.

There should be an indicator or indicators to prove to the projectionist that it is running properly, especially if there are no adjustments he can make. It

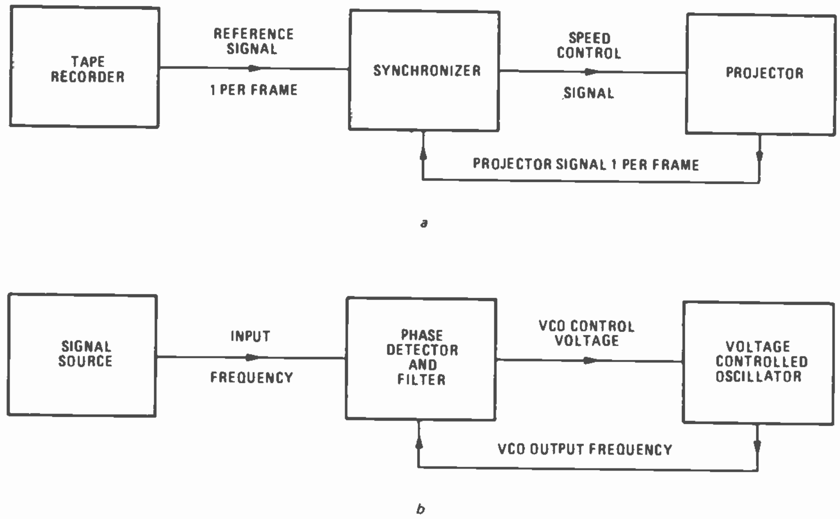


FIG. 1—SOUND SYNCHRONIZATION CIRCUIT is based on synchronizer and is shown in *a*. For comparison, system based on phase-locked-loop is shown in *b*.

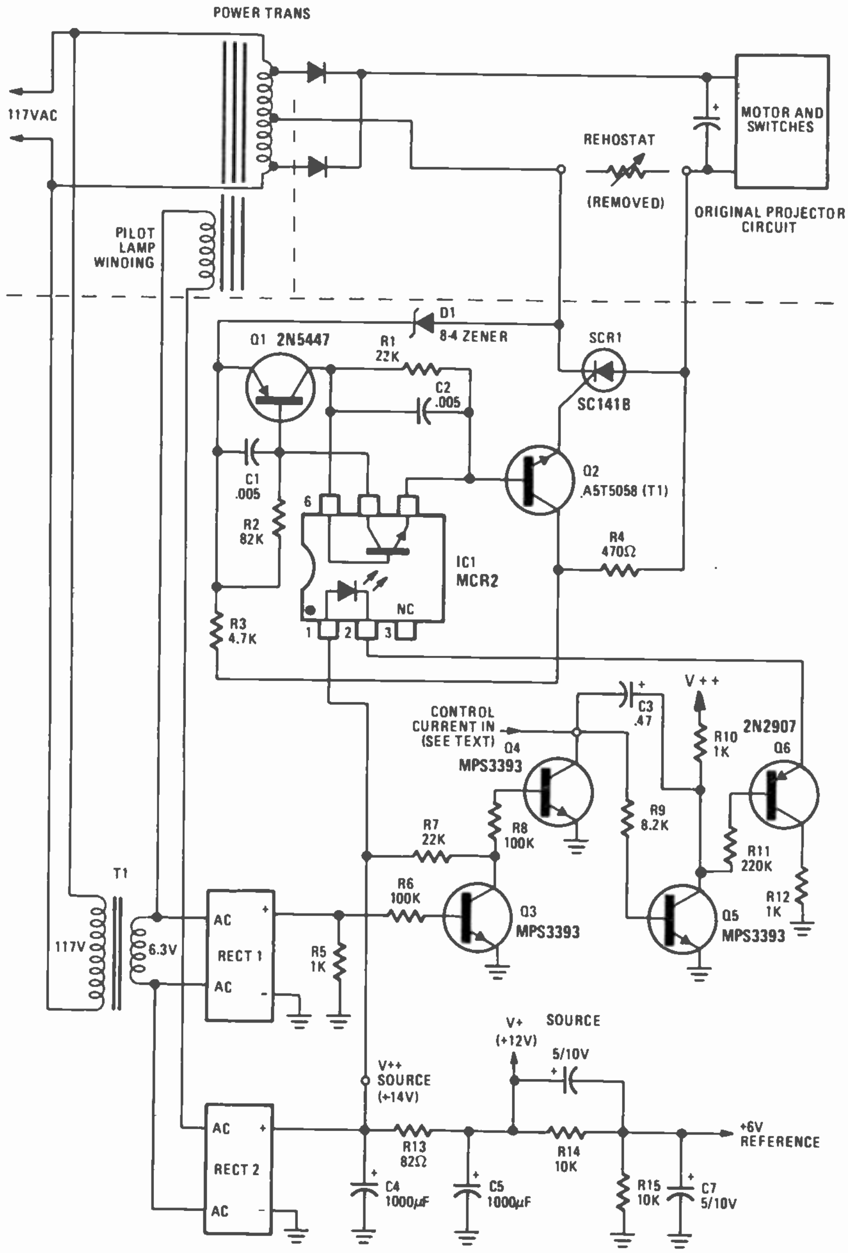


FIG. 2—MOTOR SPEED CONTROL AND POWER SUPPLY. Control current would normally come from synchronizer circuit, not shown in this article.

PARTS LIST

All resistors ¼ watt, 10%, unless otherwise noted
R1, R7—22,000 ohms
R2—82,000 ohms
R3—4700 ohms
R4—470 ohms
R5, R10, R12—1000 ohms
R6, R8—100,000 ohms
R9—8200 ohms
R11—220,000 ohms
R13—82 ohms, ½ watt
R14, R15—10,000 ohms
C1, C2—.005 μF, 50V
C3—0.47 μF, 35V
C4, C5—1000 μF, 16V, electrolytic
C6, C7—5 μF, 10V, electrolytic
D1—8V, 1W, Zener
Q1—2N5447
Q2—A5T5058 (Texas Instruments), (Radio Shack 276-2012 or equal)
Q3, Q4, Q5—MPS3393 or equal.
Q6—2N2907
IC1—MCT2 opto-isolator
SCR1—SC141B (G-E) or equal (see text)
RECT1, RECT2—bridge rectifier, 2A, 50 PIV (Radio Shack 276—1151 or equal)
T1—Filament transformer, primary 120 V 60 Hz, secondary 6.3 V

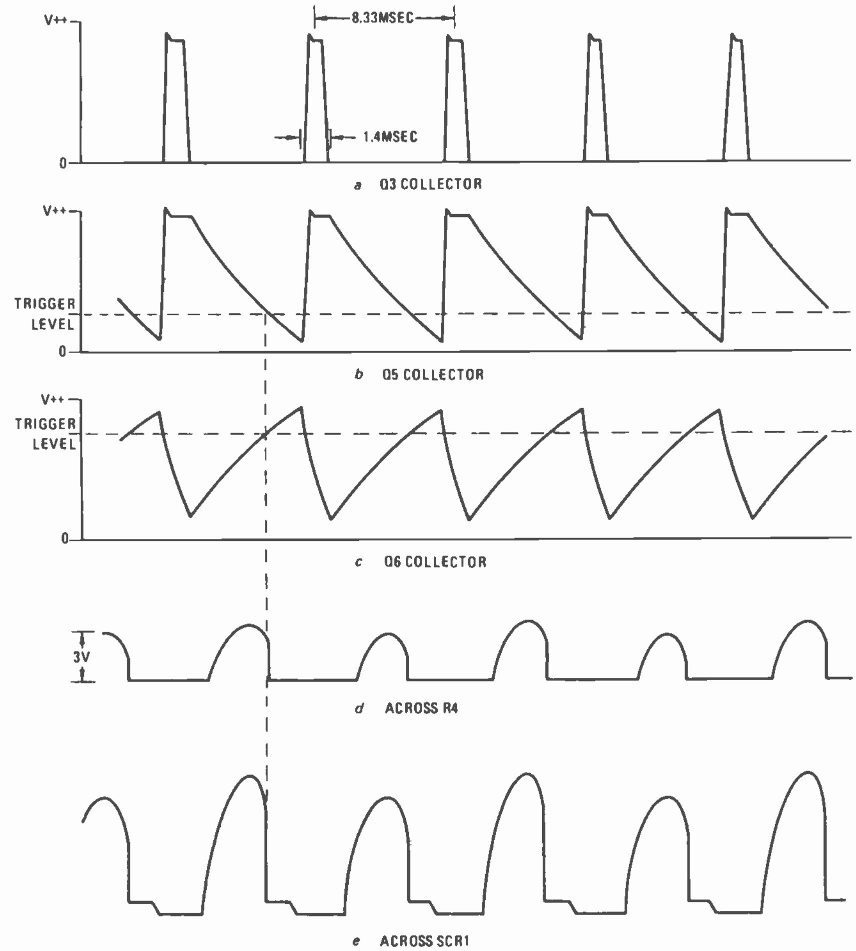


FIG. 3—WAVEFORMS for the motor speed control and power supply circuit.

should be able to cope with small starting errors and still maintain sync to the desired ±1 frame. The fact that the film is to have synchronized sound implies that picture and soundtrack have to be in sync right from the start, which is asking a lot from human reflexes. My circuit will find and maintain synchronization as long as the film and tape are started within about one second of each other.

Finally, the most important consideration for the circuit is that under no circumstances can it allow the projector to damage the film. In practice, this means that it cannot allow the projector to stall, since if it did the lamp would quickly burn a hole in the film. The motor also usually cools the lamp; a stalled motor would overheat the lamp and shorten its life—no laughing matter at the present price of lamps.

If the circuit is to go inside the projector and be permanently connected it has to be able to let the projector run without an external control input, as for projecting silent films. The original speed control (if any) could be left in operation when required, or the synchronizer could use an internal control signal when the external one is not present. I decided to use an internal signal and replace the projector's original speed control entirely. I gained some speed accuracy from this, since the internal oscillator is more stable than the rheostat control was. With the projector fully under the synchronizer's control one must be careful to see that it can deal with all the circumstances that can arise.

The circuit is getting to sound quite complex, with no hints as to how it can operate. A rough block diagram of it appears in Fig. 1-a. If the external reference signal disappears, the circuit will replace it with one of its own. For comparison, Fig. 1-b is a rough block diagram of a phase-locked-loop (PLL) circuit. The two are very similar and show a very basic application of negative feedback. Any change that occurs in any part of the feedback loop is detected, amplified and used to eliminate itself. It happens that PLL's are available as single IC's. Unfortunately, they would do only half the job—to them, any cycle of the reference frequency looks the same as any other cycle, so that they can quite happily lock anywhere. Our circuit has to lock on a particular cycle of both the reference and the controlled frequencies.

The projector

All this has assumed that the projector speed can be electronically controlled over a useful range. A digital solution to the problem is to generate a number representing how fast the projector should be going, and then convert this number to an analog signal that controls the projector's speed. The other thing that is needed is the signal that says that one frame has gone by. This signal is usually easy to come by and will be discussed later. A lot more depends on the motor.

First, a couple of warnings. Any unauthorized tampering with a projector immediately voids the manufacturer's warranty. It is best to work on a machine whose warranty has expired, or to pretend that it isn't covered at all. Modifications can also be difficult for service technicians to understand, since the manufacturer's manuals won't show them. Second, the modifications involve working with the 120-volt AC line. Shock hazards must be avoided or eliminated. This applies to hazards during construction and testing as well as for use.

The type of speed control used will depend a lot on the type of motor in the projector, and to a lesser degree on the range of control required. Generally speaking, induction motors (anything without brushes) can be easily controlled over a very narrow speed range, and are difficult and expensive to control over a wide range. AC or DC motors with brushes are easy to control over a wide range. If a projector runs at only one speed or has a mechanical speed change so that the motor doesn't change speeds, it is safe to assume that it uses an induction motor. A continuously variable speed over a wide range is a good indication of a brush motor. The only real way to tell is to look. Fortunately, the backs of projectors are pretty easy to remove.

The speed of induction motors depends on the line frequency, the line voltage and the load that the motor drives. The line frequency has the greater effect on speed, while the line voltage mainly affects the power that the motor can deliver. If the line voltage is reduced the speed drops until the load on the motor matches the power available from it. If it drops too far, the motor will stall. If precautions are taken against the motor stalling, the limited control available this way can be enough to allow the synchronizer to work. The control frequency shouldn't vary more than about ±5%. Since controlling the line voltage will only reduce the motor's speed, the nominal frequency of the control signal has to be less than the motor's maximum speed to allow for speeds above and below the nominal speed. The Motorola *Semiconductor Power Circuits Handbook* (1968) contains a chapter on controlling induction motors, and RCA's *Transistor, Thyristor and Diode Manual* contains a chapter "Power Switching and Control." The

RCA book says that "Speed ratios as high as 3:1 can be obtained . . . with certain types of induction motors."

A typical modification

When I bought my present projector, I was careful to get one that could be easily modified. It uses a DC motor operating from a 70-volt supply, with the speed controlled by a rheostat in series with the motor. The projector's original circuit and the circuit I replaced it with are shown in Fig. 2. The projector contains a large power transformer to supply the projection lamp with 21 volts at about 7 amperes. The primary is used as an autotransformer and is tapped at appropriate points to provide the motor with a maximum of about 70-volts DC via a full-wave rectifier. The lamp winding is not shown, and the small winding that is shown provided power to a pair of pilot lamps.

Since the rheostat comes before the filter capacitor, it has a pulsating DC waveform across it and can be directly replaced with a SCR. In this type of capacitor-input power supply, the peak currents through the diodes and SCR are about ten times the average current into the motor. (For more details on power supplies, see Don Lancaster's article on designing regulated power supplies in the December 1973 issue of **Radio-Electronics.**) Choose an SCR that has a lot of safety margin in both current and voltage, since it should never blow out. The SC141B in the parts list is actually a triac, but it works quite happily as an SCR. It had the ratings I needed and I had it on hand.

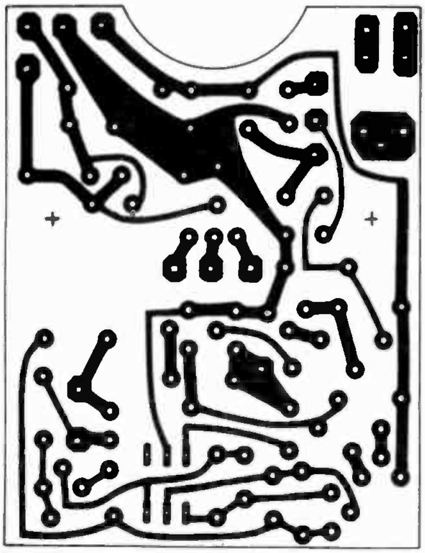


FIG. 4—FOIL PATTERN shown full-size. Top view—foil up.

In circuits using SCR's, the cathode lead usually becomes a common point, often the ground. But in this case, it would put the ground line about 50 volts away from either side of the power line and create a definite shock hazard. This voltage has to be kept inside the projector and ideally should be kept to the immediate vicinity of the SCR. IC1 provides the necessary isolation. It consists of a LED optically coupled to a phototransistor, but electrically insulated to 1,500 volts.

How the circuit works

The circuit will switch the SCR on when current flows through the LED in IC1. Whenever the voltage across the SCR goes to zero, the SCR, Q1 and the phototransistor in IC1 will all cut off. As the voltage across the SCR rises they will remain cut off, since Q1's base is connected to its emitter via R2 and the phototransistor is similarly biased by R1. With no current flowing in either of these transistors, Q2 receives no base current and deprives SCR1 of gate current.

As soon as current begins to flow in the LED, the phototransistor begins to conduct and a voltage appears across R2. This starts Q1 conducting, which produces a voltage across R1 that helps the phototransistor turn on. This regeneration, or positive feedback, continues until both transistors are fully conducting. This provides Q2 with base current and allows it to conduct, providing gate current to SCR1. As soon as the gate current reaches a high enough level, the SCR will conduct. When the line voltage goes through zero, everything shuts off again. C1 and C2 provide a low-impedance path to noise signals that might otherwise trigger SCR1 prematurely.

The combination of Q1 and the phototransistor is called a transistor switch, and has a very low impedance when it is conducting. D1 is an 8-volt Zener that prevents the voltage across the Q1-phototransistor combination from exceeding 8 volts, and in addition prevents them from ever being reverse-biased. Transistor Q2 is included so that Q1 and the phototransistor only need to carry small currents and to isolate them from the 70-volt peak that can show up across SCR1. Any component failures in this part of the circuit could cause the projector to stall, so everything is operated well within its ratings. This network will trigger the SCR on from a signal electrically isolated from it.

With this type of circuit, maximum power is delivered to the motor if the SCR is triggered just before the peak of the line voltage. If the SCR is triggered much before this, it will remain cut off until the line voltage rises above the voltage on the filter capacitor. If it is triggered later, the capacitor will not receive as much charge and the voltage across it will drop, delivering less power to the motor. With AC motors, the earlier the SCR turns on the more power will get to the motor. Induction motors need most of the cycle present just to run, so that the SCR would have to be switched on even earlier.

The current input to the LED is provided by Q3 through Q6. Transistor Q3 is driven by the output of a full-wave bridge rectifier, RECT1. Whenever the power line waveform goes through zero, the voltage across R5 goes to zero and Q3 cuts off, making its collector positive. Resistor R5 ensures that Q3 does actually cut off. When this happens, Q4 conducts, grounding its collector and forcing Q5's collector positive. This charges C3 and cuts Q6 off, which also removes the current to the LED in the isolator.

As soon as the line voltage waveform gets away from zero, Q3 saturates and Q4 cuts off, allowing the control current to start discharging C3. This brings Q5's collector toward ground, and at some point Q6 will begin to turn on. As soon as enough current flows in Q6 and the LED in IC1, the transistor switch turns

continued on page 82

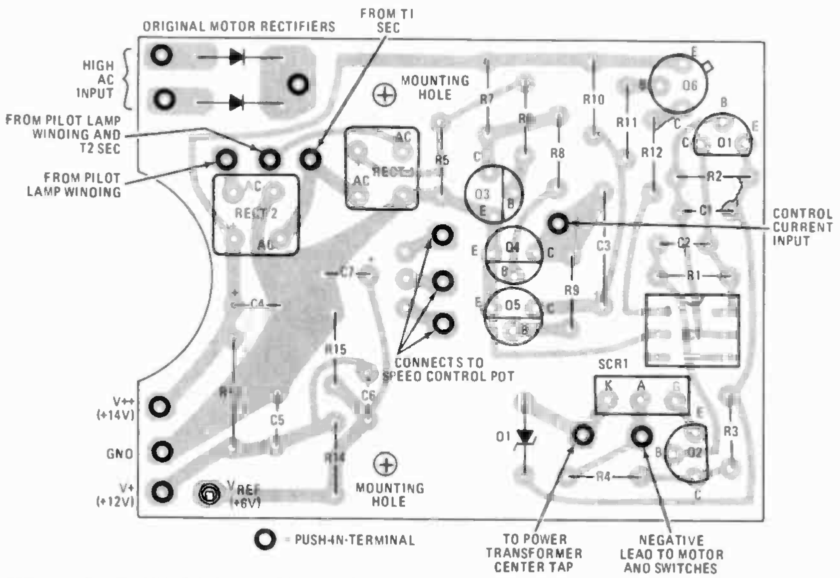


FIG. 5—COMPONENT PLACEMENT diagram.

all about RF signal generators

PART I—An in-depth look at the different types currently available, including how they work, their specifications, features and applications

CHARLES GILMORE*

RADIO-FREQUENCY SIGNAL GENERATOR IMplies a number of basic features. These include: frequency range; modulation capability; and amplitude control. The RF (radio frequency) signal generator has a frequency range (typically 50 kHz to 10MHz) whose lower frequency limit is above 20 kHz (the practical upper limit of the audio frequency range). However, the upper frequency limit of an RF signal generator can be as high as 1 GHz. Generators operating above 1 GHz fall into a special class called microwave signal sources. Modulation may be AM (*A*mplitude *M*odulation), FM (*F*requency *M*odulation), pulse, or a combination of any of the three. A wide range of output amplitude control is implied, including the ability to generate signals of 1 μV or less.

At the present time there appears to be very little middle-of-the-road pricing for RF signal generators. The truly low-cost units fall in the $200 or less area. The cost of those with moderate or great sophistication exceeds $1000 and extend to $10,000 or more. The specifications, features and applications of the generators covered in this article include generators costing as much as $2000 or $2500, as well as low-cost units.

The price level of RF signal generators has not changed significantly. There have been many generators for the past 30 years that fall into the $1000 to $2500 classification. The performance level of the generator has changed. The performance level of the generator changed with a change in need. This need is primarily concentrated in the communications industry, with secondary uses in the area of consumer product servicing, amateur radio, instrumentation and the home experimenter. There is also a need for the RF generator in related design work.

The need for better specifications and features is forced by the sophistication of the products the generators are used with. For example, the communications industry has changed VHF and UHF standards from wideband FM deviation ($\pm$5 kHz) to narrowband deviations ($\pm$3 kHz). This change necessitates generators with precise modulation capability and substantially increased frequency stability requirements.

Low-cost generators fill the needs of the home experimenter, and supply the RF signals required by the service shop for simple alignment procedures. These generators (or oscillators, as they should be known) normally lack stability, RF shielding, frequency range, and modulation capability required to verify performance specifications when servicing or calibrating communications, industrial or high-fidelity equipment.

Producing the signal

The methods for generating an RF signal cover a wide gamut of technology. The simplest generators are power oscillators that use a fixed inductor and a variable capacitor as frequency determining elements. On the other end of the spectrum are signal generators with sophisticated synthesis circuits that deliver signals of high spectral purity, extreme stability and uniform modulation capability. In between these extremes are the L–C (inductance—capacitance) oscillator with stages of buffering, modulation and power amplification. This oscillator is normally housed in a sturdy casting that provides a stable mechanical and temperature environment, as well as a high degree of shielding. Generally speaking, this type falls into the upper end of the low-cost signal generator price class.

Figure 1 is a block diagram of a basic RF signal generator using a band-switched L–C oscillator. This oscillator

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drives a buffer amplifier that helps maintain frequency stability with changes in output load. The buffer amplifier may be eliminated on lower cost RF generators. Although the signal from the basic oscillator, and therefore the signal from the buffer amplifier, may well be at (or greater than) the amplitude required of the generator output, a power amplifier is used to drive the 50-ohm low impedance lines. The output amplifier supplies the maximum possible signal, usually in the 1 to 3 volt area, to the output attenuator. The attenuator reduces the output signal level to the level selected by the operator.

As you can see in the block diagram, extensive shielding around these four sections prevents stray signals from leaking from any one of these components. Such shielding usually involves a rather complex mechanical design, often a box within a box. Shown as dashed boxes are other circuit components that may not appear on all generators.

Signal generators contain some form of modulator. Amplitude modulation is applied to either the output amplifier or to some modulator ahead of the output amplifier. A few generators modulate the oscillator directly. The modulator receives audio signals from an internal oscillator or an external source. On higher quality generators, the audio oscillator provides tones of 400 Hz and 1 kHz. Simpler generators use one tone. If the generator features FM, signals from the modulating oscillator are applied to frequency modulating components on the bandswitch oscillator. This is usually done through circuitry that maintains a constant deviation, regardless of oscillator frequency setting.

In some complex RF signal generators, frequency-control circuitry monitors the output frequency, compares it to a standard, and applies corrective signals to the bandswitch oscillator. This action maintains the desired frequency setting. Such frequency-control circuitry is only found on more costly generators.

Basics of modulation

Two types of modulation, AM and FM, are by far the most common. AM only is common on RF signal generators with upper frequency limits in the 30 MHz to 60 MHz area. Most signal generators with FM capability also have AM capability. Some generators, especially those designed for work in the high VHF and UHF region, also have pulse modulation capability. Pulse modulation is zero to 100% amplitude modulation in the form of a square wave or pulse.

There are two ways to view amplitude modulation. Figure 2-a shows an envelope presentation, as seen on an oscilloscope, for a 100% modulated RF carrier. A section of the unmodulated carrier is also shown for reference. This display presents amplitude versus time period. Figure 2-b shows a signal with less than 100% amplitude modulation. Figure 2 also shows how to measure percent of modulation using this display. Figure 2-c shows a spectrum analyzer display of an amplitude-modulated signal. This display has amplitude on the vertical axis and frequency on the horizontal axis. The centermost line represents the carrier frequency. The signal to the left represents the lower sideband; the carrier frequency (f_c) minus the modulating frequency (f_m). The line to the right represents the upper sideband; the carrier frequency plus the modulating frequency. The display of the spectrum analyzer shows the power distribution in an amplitude-modulated signal. Each of the sidebands contains one-quarter of the power.

Figures 3-a and 3-b show oscilloscope and spectrum analyzer presentations for an RF carrier frequency modulated by a single sinusoidal tone. In the oscillo-

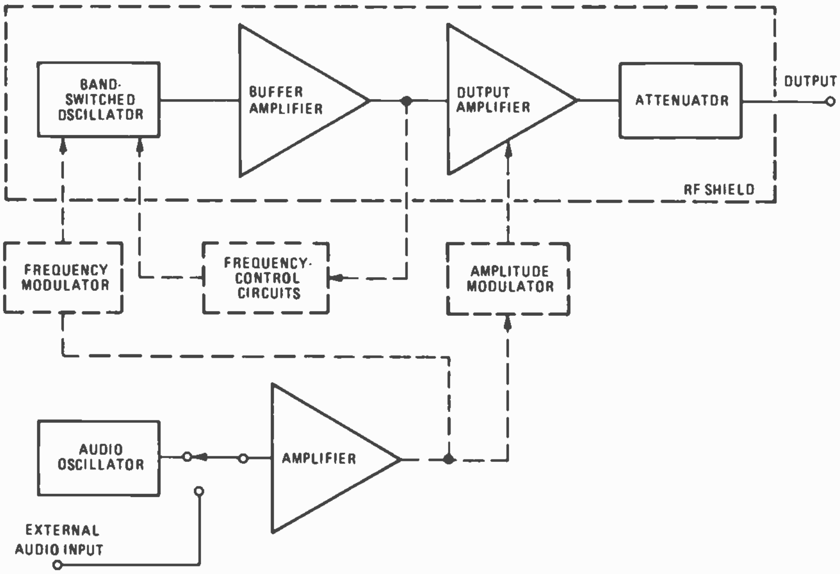


FIG. 1—BASIC RF SIGNAL GENERATOR with a bandswitched L-C oscillator.

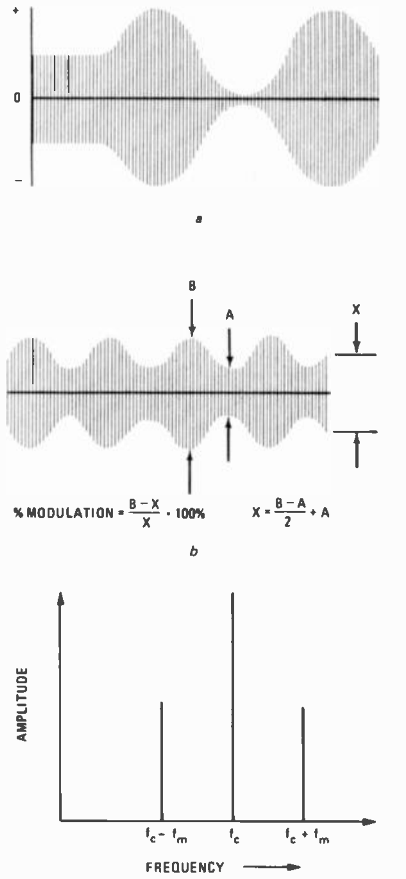


FIG. 2—AMPLITUDE MODULATION. 100 percent modulation level is shown in *a*. Less than 100 percent modulation is shown in *b*. Frequency spectrum of an AM signal is shown in *c*.

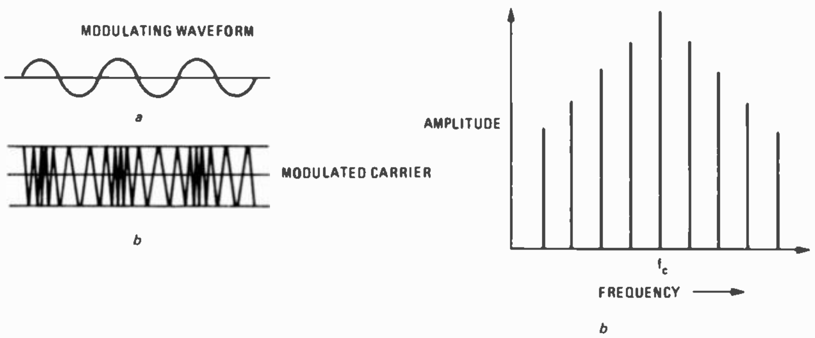


FIG. 3—FREQUENCY MODULATION. Modulating signal is shown in *a* and *b* shows modulated carrier. Frequency spectrum of FM signal is shown in *c*.

scope trace, note an increase in frequency for positive peak of the modulating waveform and a decrease in frequency for negative peaks of the modulating waveform. The difference between carrier frequency with no modulation and peak carrier frequency with modulation is referred to as the deviation. The ratio of the modulating frequency to the deviation is called the modulation index.

The spectrum analyzer display (Figure 3-b) shows a number of sidebands spaced above and below the carrier frequency at integral multiples of the modulating frequency. Note, this differs in three ways from the AM signal. First, if the modulating signal is purely sinusoidal, AM generates only one upper and one lower sideband. Second, the amplitude of these sidebands are a direct function of the percentage of modulation. Third, the amplitude of the carrier remains constant with modulation.

When FM is used, there are an infinite number of sidebands (although only the first few are strong enough to be given any real consideration). The amplitude of these sidebands and the carrier depend on the modulation index. For example, at a modulation index of approximately 2.4, the carrier amplitude is reduced to zero and increases for modulation indices greater or less than 2.4. Frequently, FM deviation is measured by modulating the carrier with a signal of known frequency. The deviation is increased until the carrier amplitude, as observed on a spectrum analyzer, goes to zero. For example, the carrier passes through zero amplitude when 5 kHz deviation is reached if the modulating frequency is 2 kHz.

As noted earlier, pulse modulation is essentially 100% amplitude modulation by a rectangular pulse. Figure 4-a shows an envelope presentation of a pulse waveform and RF carrier modulated by this pulsed waveform. As you can see, the carrier is turned on and off by the pulses. Figure 4-b shows a spectral analysis of this same waveform. The center line is the carrier frequency. There are many sidebands, each one spaced from the carrier by integral multiples of the pulse repetition rate. The amplitude of each of these sidebands depends on the duty cycle of the modulating pulse and the completeness of the modulation. As can be seen from a spectral analysis, complex signals, such as square waves or pulses, require an extremely wide bandwidth. Therefore, pulse modulation is usually confined to very high-frequency or ultra high-frequency generators where considerable bandwidth is available.

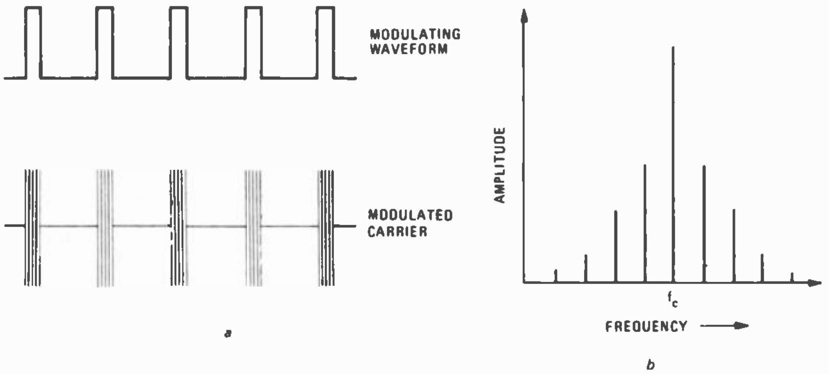


FIG. 4—PULSE MODULATION is essentially 10u percent amplitude modulation by a pulse signal. Modulating signal is shown in *a* and modulated carrier is shown in *b*. Frequency spectrum of pulse modulated carrier is shown in c.

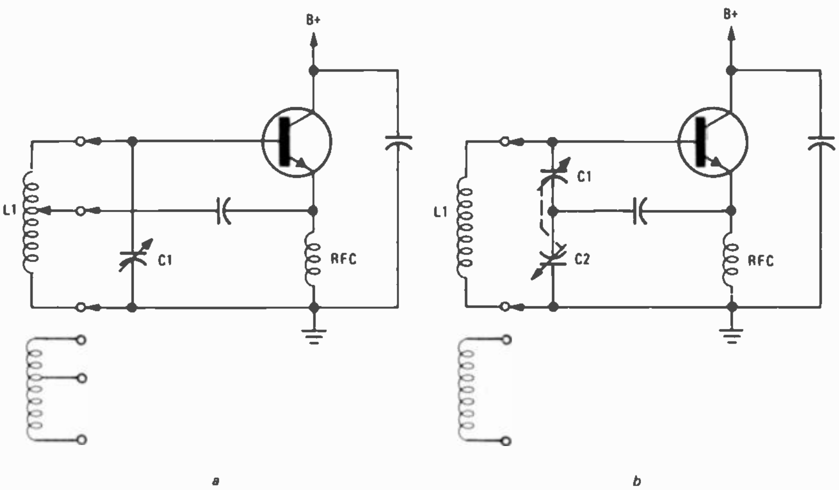


FIG. 5—HARTLEY OSCILLATOR is shown in *a*. Colpitts oscillator is shown in *b*.

Basic oscillators

The oscillator is the heart of the RF signal generator. The stability and purity of the generator is directly related to the stability and purity of the oscillator. Therefore, a great deal of design time and effort goes into the oscillator circuit. One of the most common oscillators used for generators that cover 50 kHz to 60 MHz, or even 100 MHz, is the Hartley oscillator.

The circuit in Fig. 5-a is a simplified Hartley oscillator. The frequency of oscillation is determined by the values of C1 and L1. When the desired frequency can no longer be reached by adjusting the variable capacitor, a new inductor is switch-selected. Frequency for an L–C oscillator is directly related to the square root of the capacitance and inductance. Therefore, a large capacitance change is required to obtain a reasonable change in frequency before a band change is necessary. Typically, capacitance changes of 10:1 to 12:1 are used. As a result, band ranges on most RF signal generators using L–C oscillators cover a frequency spread of about 3:1 to 3.5:1.

The stability and spectral purity of the generator output is largely dependent upon the characteristics of the L–C circuit. A high Q (quality factor) circuit designed with silver plated coils and air variable capacitors is used. Extreme care is given to the mechanics of the oscillator, and it is not uncommon to find the entire oscillator circuit housed in a sturdy box, or perhaps a hollowed out casting. This provides low susceptibility to thermal variations, mechanical shock and vibration, and external capacitances, all of which affects oscillator stability and purity.

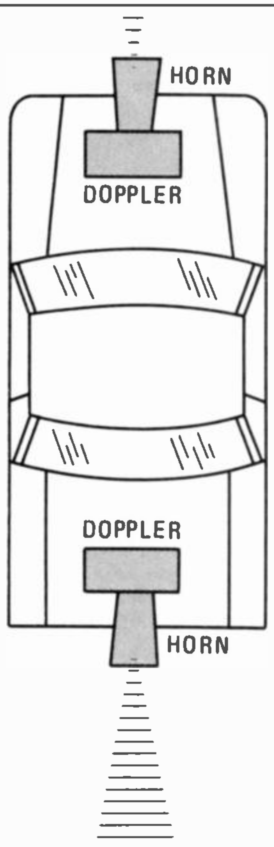
In addition to minimizing environmental effects upon the stability and purity of the oscillator, extensive decoupling circuitry is used on all power supply connections. Such decoupling serves two purposes. First; it keeps external signals from modulating the oscillator and therefore creating undesirable spurious signals. Second; it removes the desired signal from the power supply lines so the signal is not radiated except through connections to the output attenuator terminals.

An alternative oscillator configuration is shown in Fig. 5-b. It is the Colpitts oscillator. A split capacitor is used to control the ratio of feedback here, rather than the tapped coil of the Hartley oscillator. The value of capacitance that sets the frequency of the oscillator is the series value of capacitors C1 and C2.

The Colpitts oscillator does not provide as wide a tuning range as the Hartley oscillator. Tuning ratios of 10:1 are common for the Colpitts oscillator.

When UHF signal generation is
continued on page 80

How To Design



Automotive Anti-Collision Systems

Part II—An in-depth look at the different types of systems and the various design considerations, with enough information for the advanced hobbyist to build his own

MARTIN BRADLEY WEINSTEIN

Last month, in part I of this article, we discussed several different approaches to collision-avoidance systems and we looked at practical LASER modules.

This month, the article concludes with a look at SODAR and RADAR modules.

SODAR modules

Headway and tailway range information is obtained through an air-coupled version of SONAR called SODAR (*SO*nic *D*etection *A*nd *R*anging). A frequency of 40 kHz should be used for your SODAR for several reasons. One, ultrasonic energies at significantly higher frequencies dissipate rapidly, requiring too much power for useful range. Two, ultrasonic energies at lower frequencies diffuse easily, making beam definition difficult. Further, the wavelength at, say, 23 kHz, is nearly twice the wavelength at 40 kHz. Finally, 40-kHz ultrasonic transducers are readily available.

Because we are dealing with a two-way path (the transmitted signal is reflected, then received), the received echo strength drops with the fourth power of range. This can be combatted in two ways. One is through large transmit power. The other through extra receiving sensitivity.

The rest of the signal processing problem has been greatly simplified, thanks to the National Semiconductor LM1812 Ultrasonic Transceiver IC. This innovative IC is capable of producing up to 12 watts of transmitted ultrasonic power. It works on 12 volts and its output is formated to make the addition of a clock and gating circuit easy. As shown in Fig. 4 block diagram, very little circuitry outside the LM1812 is required to produce a BCD range output. The LM1812 is available from dealers for $7.50 to $10.00.

Though application notes on the LM1812 show a single transducer used for both transmission and reception, system sensitivity can be enhanced through the use of dual sensors. Furthermore, by positioning them far apart on the automobile, a lower range cutoff can be established. (See Fig. 5.) Additionally, the use of separate sensors permits the addition of a receive preamp, if desired, to further enhance received signal sensitivity and reliable system operation at the upper-range limits.

Beam shaping is accomplished for both transducers mechanically, through the use of tubing. The sensors chosen should be waterproof and highly resistant to mechanical and environmental hazards.

The Massa Corporation (280 Lincoln Street, Hingham, MA 02043) *model TR-89B Type-40* is an excellent choice as a receiving transducer at 40 kHz. Untuned with a 2-megohm load, its sensitivity is a very high–48 dB (versus a standard 1 microbar at one foot). Its directional characteristics are also excellent. They are available from Massa at $5 each, but Massa has established a minimum sample order of $25.

The high power requirements of a transmitting transducer are more than met by Linden Laboratories, Inc., (Box 920, State College, PA 16801) *model 70160*. It is capable of handling hundreds of watts of output

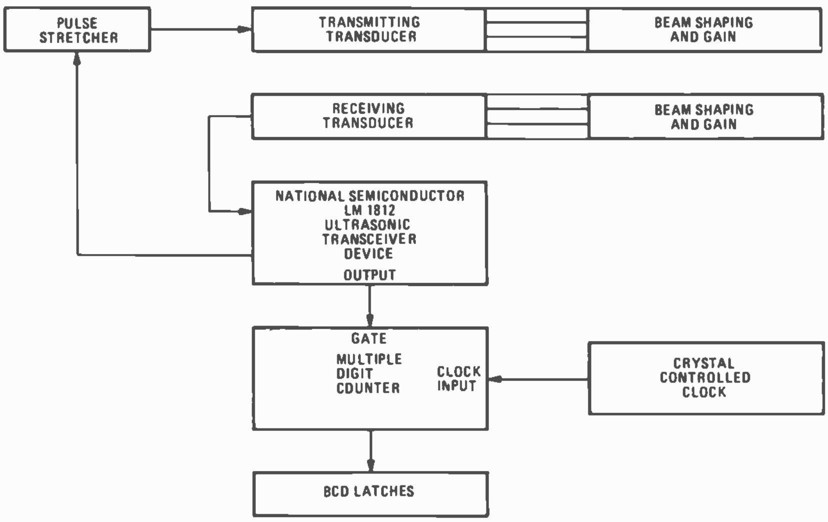


FIG. 4—SODAR MODULE uses a National Semiconductor LM1812 ultrasonic transceiver. The LM1812 provides a gating signal to a counter for accurate range information.

(properly cycled), so at 12 watts it's coasting. It comes in a molded, rugged PVC housing. Its half power (-3 dB) beamwidth is 10 degrees. It is available for only $23.50, postpaid. This is less than half the usual price of such units in these small quantities.

The entire SODAR system is duplicated twice for full forward and rearward range information. System beamwidth can be anything from 3 to 10 degrees.

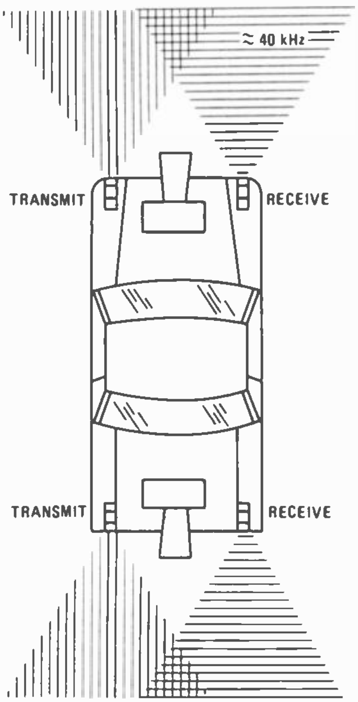


FIG. 5—SODAR MODULE PLACEMENT. Transmitting and receiving transducers are separated as widely as possible. Tubing at the mouth of each transducer can provide a narrow beam.

Doppler RADAR's

Some of the techniques for Doppler measurement have already been mentioned. Here we will take a look at the elements of a practical system that almost anyone can build, as shown in Fig. 6.

Voltage and current regulation is a must. The Doppler microwave modules available use Schottky diode detectors and Gunn diode oscillators. An overvoltage can blow both diodes. An undervoltage can keep the Gunn diode from oscillating—15% regulation is the maximum variation from manufacturer's specs permissible to assure reliable starting and safe operation. Popular, inexpensive three-terminal regulators provide sufficient regulation and help safeguard against potentially dangerous transient spikes.

If the voltage source is modulated at approximately 10 kHz, the Doppler range rate information can be further qualified with a sign, to indicate whether the target is approaching or receding.

The Doppler modules themselves are available from a number of sources. The Amperex Electronic Corp. (230 Duffy Avenue, Hicksville, NY 11802) *model DX-489* Doppler Module, at $47.50, is a very inexpensive starting point. It includes a built-in 5-dB antenna (which should be replaced with a 14-dB or more antenna), operates on 7.0 volts and delivers 8.0 mW at 10.525 GHz. As in all the modules we'll discuss, the only connections necessary are power in and signal out.

The Amperex *DX-489*, operated as delivered, is designed to meet the requirements of Part 15 of the FCC Rules and Regulations. This is also true of the other modules mentioned. Additional antenna gain, however, can violate Part 15 specifications and the designer is cautioned to observe such limitations in any modification. Amperex modules include built-in second harmonic rejection networks.

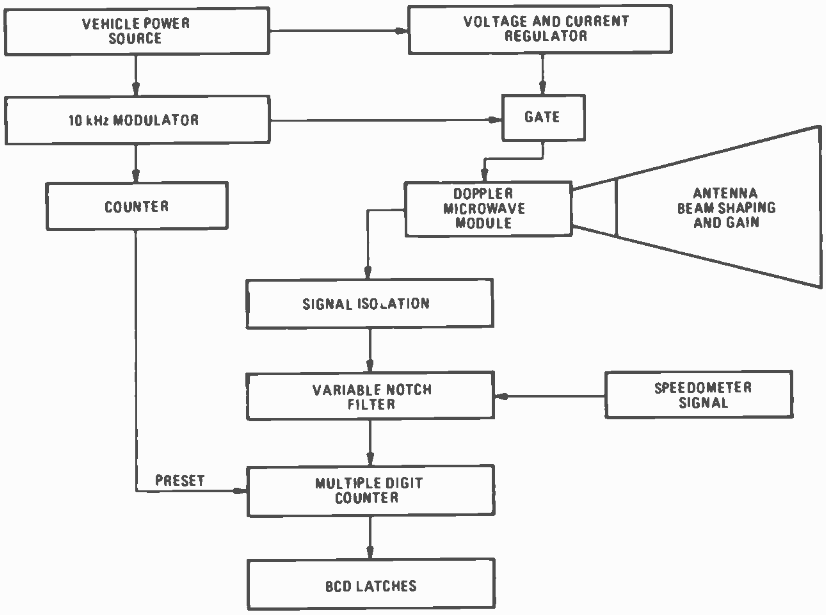


FIG. 6—RADAR MODULE. Information from the speedometer is fed to a filter to eliminate signals returned from stationary objects. The resultant signal is counted and latched for a direct readout of relative velocity.

Plessey Semiconductors (1674 McGaw Avenue, Irvine, CA 92714) offers a number of Doppler modules near 10.525 GHz (also called X-band). *Model GDM-3B* offers a 10-mW output and a frequency range of 10.2–11.0 GHz for $77.20. *Model GDM-101B* offers a 50-mW output in the same range for $88.10. The *model GDVM-3B* offers the same capabilities as the *model GDM 3B*, plus electronic tuning of plus-or-minus 25 MHz, all for $118.30. The *GDVM-101B* is a similarly-tunable model of the *GDM-101B* for $154.40.

The General Electric Microwave Devices Products Section (Owensboro, Kentucky 42301) *model C-2126A* Microwave Circuit Module Doppler Transceiver offers a 3-mW output at 10.525 GHz with an 8.0-volt operating requirement. Its flange mount mates with UG39/U flange and RG52 waveguide. It costs $59.

The audio-frequency output of the Doppler module is buffered in an isolation amplifier. Then a variable-frequency notch filter reduces returns at a frequency related to vehicle speed. A multiple digit plus-and-minus counter with resettable inputs performs the arithmetic conversion to a precise BCD range rate (relative speed) readout, which is latched for display or for software routines.

The modules are placed at the center of the vehicle in both the front and the back as shown in Fig. 7. Antenna gain and directivity is chosen to avoid clutter returns from overhead signs, roadside obstacles and adjacent-lane traffic. In some cases, thermostatically-controlled heating elements may have to be added for reliable operation in very cold weather.

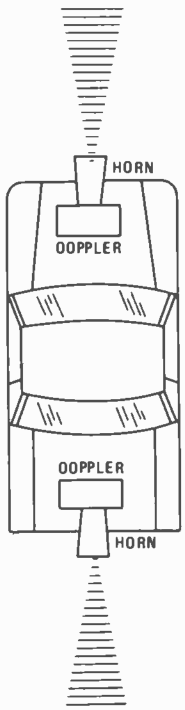


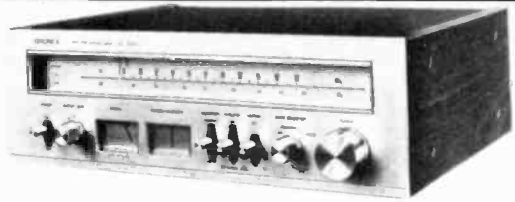
FIG. 7—RADAR MODULES are located fore and aft near the vehicles center line. Nominal 10.525 GHz operating frequency provides operation that is relatively free of bounceback-type interference from rain, snow, dust and other objects.

Microcomputers

The advantages of even simple data processing are obvious. A small, microprocessor-based system can selectively interrogate the various inputs, coordinate data, perform arithmetic and formating operations, make intelligent decisions and produce a meaningful display.

continued on page 72

Radio-Electronics Tests Optonica ST-3535 Tuner



1

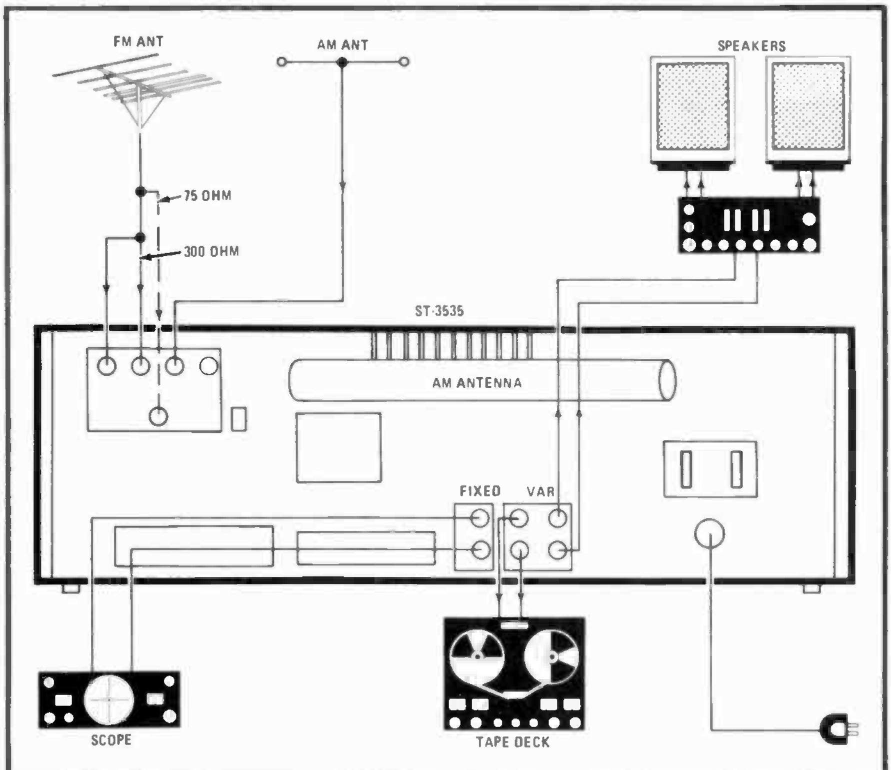
CIRCLE 99 ON FREE INFORMATION CARD

LEN FELDMAN
CONTRIBUTING HI-FI EDITOR

SHARP ELECTRONICS CORPORATION OF JAPAN markets in the US a line of high-fidelity equipment under the name of Optonica. The top tuner in this line is the *model ST-3535*. The styling is similar to that of several recent tuner and receiver entries from competing firms in that the entire front panel, including the long dial-area cutout is finished in a gold color. When power is applied to the unit, dial scale numerals illuminate in contrasting green for extremely good visibility. The FM scale is linearly calibrated, with markings at every MHz. Three light indicators to the left of the AM and FM frequency scales show which band has been selected and also denote the reception of a stereo FM signal. The dial pointer is also illuminated with a bright spot of light.

Two framed meters located along the lower section of the panel are shown in Fig. 1, along with other major controls. The meter at the left serves as a signal-strength meter for AM and FM. The meter to the right is both a center-of-channel FM tuning indicator and a multipath meter. In this latter function, minimum readings are obtained as the FM antenna is rotated, and absence of multipath is indicated by the meter needle returning to its center point, from higher readings to the right of center.

To the left of the meters are a POWER on/off toggle switch and an OUTPUT LEVEL control that alters audio output levels from the pair of variable-output jacks on the rear panel. Three lever switches are located to the right of the meters. The first is a three-position MULTIPATH switch. When moved upwards from its center position, the MULTIPATH switch permits audible detection of multipath distortion. With the lever set to this position, the antenna is rotated until minimum sound is heard. The lower switch setting introduces the meter multipath indicator just described. Next is the HI-BLEND switch that introduces a high-blend circuit for reduction of background noise during weak-signal stereo FM reception. However, this is accomplished at the expense of high-frequency channel separation. In its lower position, the HI-BLEND switch introduces a built-in 440-Hz test signal to the output jacks, which is used in setting record levels on associated tape deck equipment before recording from FM programs. The remaining two-position MUTING switch turns on interstation muting. A rotary selector switch chooses AM, FM-STEREO or FM MONO reception, while a large TUNING knob at the lower right is coupled to a smooth-acting flywheel and the frequency dial pointer.



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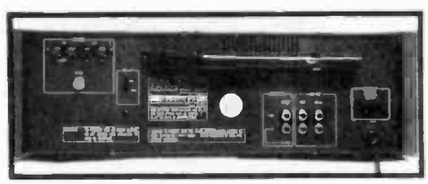

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The rear panel of the *model ST-3535* tuner, shown in Fig. 2, is equipped with the usual 75-ohm (coaxial), 300-ohm and external AM antenna terminals. An attenuator switch reduces signal input to the RF stage of the tuner in the event of signal overload. In addition to the separate pairs of output jacks for fixed and variable level output, two jacks are provided for connection to an oscilloscope for still a third method of multipath observation and antenna adjustment. An unswitched AC auxiliary power outlet and the usual pivotable AM ferrite-bar antenna plus a fuseholder complete the rear panel layout. Typical connection arrangement into a complete hi-fi system is shown in Fig. 3.

MANUFACTURER'S PUBLISHED SPECIFICATIONS:

FM SECTION:
Usable Sensitivity: Mono: 1.8 μV (10.3 dBf). **S/N Ratio:** Mono: 70 d dB. **Selectivity:** 75 dB. **Capture Ratio:** 1.0 dB. **Total Harmonic Distortion:** Mono: 0.2% at 1 kHz; Stereo: 0.4% at 1 kHz. **Image Rejection:** 90 dB. **IF Rejection:** 90 dB. **Spurious Response Rejection:** 90 dB. **AM Suppression:** 50 dB. **Frequency Response:** 40 Hz to 14 kHz, $\pm$1.5 dB. **Stereo Separation:** 1 kHz: 38 dB at 1 kHz, 30 dB from 50 Hz to 10 kHz.

AM SECTION:
Sensitivity: 200 μV/M (Internal Antenna). **Selectivity:** 29 dB. **S/N Ratio: 45 dB. Image Rejection:** 60 dB. **IF Rejection:** 60 dB. **Total Harmonic Distortion:** 1.0%.

GENERAL SPECIFICATIONS:
Audio Output Level: Fixed, FM: 0.8V; Variable FM: 0–1.0V; Fixed, AM: 0.2V for 30% modulation; Variable AM: 0–0.3V for 30% modulation. **Power Consumption:** 24 watts. **Dimensions:** 17³/₈ wide × 5⁵/₈ high × 15 inches deep. **Weight:** 22 lbs. **Suggested Retail Price:** $269.95.

TABLE I

RADIO-ELECTRONICS PRODUCT TEST REPORT

Manufacturer: Sharp (Optonica) Model: ST-3535

FM PERFORMANCE MEASUREMENTS

SENSITIVITY, NOISE AND FREEDOM FROM INTERFERENCE	R-E Measurement	R-E Evaluation
IHF sensitivity, mono: (μV) (dBf)	1.7 (9.8)	Excellent
Sensitivity, stereo (μV) (dBf)	6.0 (20.8)	Very good
50 dB quieting signal, mono (μV) (dBf)	2.5 (13.2)	Excellent
50 dB quieting signal, stereo (μV) (dBf)	32.0 (35.3)	Very good
Maximum S/N ratio, mono (dB)	76	Excellent
Maximum S/N ratio, stereo (dB)	69	Very good
Capture ratio (dB)	1.2	Very good
AM suppression (dB)	50	Fair
Image rejection (dB)	95	Excellent
IF rejection (dB)	90	Excellent
Spurious rejection (dB)	93	Excellent
Alternate channel selectivity (dB)	75	Very good
FIDELITY AND DISTORTION MEASUREMENTS		
Frequency response, 50 Hz to 15 kHz ($\pm$dB)	2.0	Fair
Harmonic distortion, 1 kHz, mono (%)	0.23	Good
Harmonic distortion, 1 kHz, stereo (%)	0.24	Very good
Harmonic distortion, 100 Hz, mono (%)	0.38	Fair
Harmonic distortion, 100 Hz, stereo (%)	0.30	Good
Harmonic distortion, 6 kHz, mono (%)	0.20	Very good
Harmonic distortion, 6 kHz, stereo (%)	0.30	Excellent
Distortion at 50 dB quieting, mono (%)	0.6	Good
Distortion at 50 dB quieting, stereo (%)	0.4	Very good
STEREO PERFORMANCE MEASUREMENTS		
Stereo threshold (μV) (dBf)	6.0 (20.8)	Very good
Separation, 1 kHz (dB)	40	Very good
Separation, 100 Hz (dB)	34	Good
Separation, 10 kHz (dB)	33	Excellent
MISCELLANEOUS MEASUREMENTS		
Muting threshold (μV) (dBf)	7.0 (22.1)	Very good
Dial calibration accuracy ($\pm$kHz at MHz)	100	Good
EVALUATION OF CONTROLS, DESIGN, CONSTRUCTION		
Control layout		Very good
Ease of tuning		Excellent
Accuracy of meters or other tuning aids		Excellent
Usefulness of other controls		Excellent
Construction and internal layout		Very good
Ease of servicing		Very good
Evaluation of extra features, if any		Excellent
OVERALL FM PERFORMANCE RATING		Very good

TABLE II

RADIO-ELECTRONICS PRODUCT TEST REPORT

Manufacturer: Sharp (Optonica) Model: ST-3535

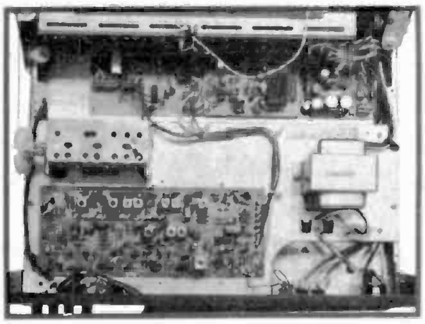
OVERALL PRODUCT ANALYSIS

Retail price	$269.95
Price category	Low/medium
Price/performance ratio	Excellent
Styling and appearance	Very good
Sound quality	Excellent
Mechanical performance	Very good

Comments: Several features included in this well-designed AM/FM stereo tuner set it apart from others in its price class. The built-in 440-Hz test tone is extremely useful in setting up record levels for FM program recording. However, the level of tone delivered is about 3-dB lower than maximum modulation levels of received FM signals would deliver and record level indicators should be set accordingly. The aural method of multipath detection, coupled with the meter indicator, combine to provide an extremely sensitive and accurate means of minimizing this form of interference and distortion. Calibration of the long, linear dial was never off by more than 100 kHz (and even that minimal error occurred only at the low- and high-frequency extremes).

The designers have carefully targeted muting threshold and stereo switching sensitivity so that they provide maximum usefulness. Quieting slope is extremely steep, which results in usable signals being received even when signal strength is under 5 μV or so for mono, 30 μV or thereabouts for stereo. The only compromises made in the interest of price are in the less-than-satisfactory distortion levels (which are nevertheless low enough so as not to intrude audibly) and a rather low AM-suppression figure. Neither characteristic impaired listening quality. At its relatively low asking price, the Optonica *ST-3535* turns out to be something of a "sleeper" from a company whose reputation was gained in other fields.

An internal view of the chassis of the *model ST-3535* is shown in Fig. 4. The separate, shielded FM front-end at the center-left contains a 4-gang capacitor for FM and uses dual-gate MOSFET's for the double-tuned RF stage and the mixer stage. A three-section capacitor is used in the AM section. Phase-linear ceramic filters and differential IC circuitry are used in the IF section (FM) to



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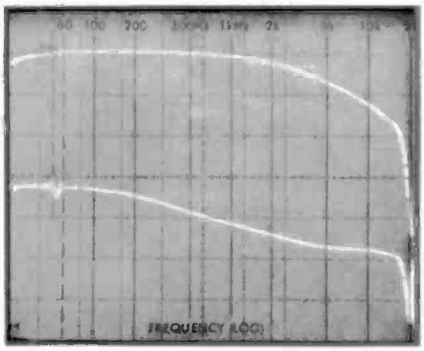
feed a conventional ratio-detector circuit. An IC phase-locked-loop circuit is used for stereo multiplex decoding, followed by a low-pass filter for subcarrier product suppression. The 440-Hz test tone is produced by a two-stage R–C feedback phase-shift audio oscillator circuit. A fully regulated power supply is used to provide operating voltages for the tuner signal sections. Total semiconductor complement includes 2 MOSFET's, 6 IC's, 26 bipolar transistors and 21 diodes. Intercircuit board wiring is neatly harnessed, and the tuner lends itself to easy servicing and parts identification.

Laboratory measurements

Results of our lab measurements, summarized in Table I, disclose that the unit generally exceeded published specifications. Of course, many of the required new mono and stereo specifications were not listed by the manufacturer despite the fact they proved to be extremely good. For example, a THD figure of only 0.3% at the 6-kHz point tells much about the excellent phase linearity of the IF section and the care with which the multiplex decoder section was designed.

The effectiveness of the low-pass filter was confirmed by the fact that subcarrier rejection in stereo measured more than 64 dB (not listed in Table I). At the point where stereo switching occurred (6 μV, or 20.8 dBf), quieting in stereo was already 37 dB and distortion was well below the 3% "minimum usable sensitivity point." While frequency response tended to roll off a bit more rapidly than preferred (-2.0 dB at 15 kHz), this is a small price to pay for the excellent subcarrier



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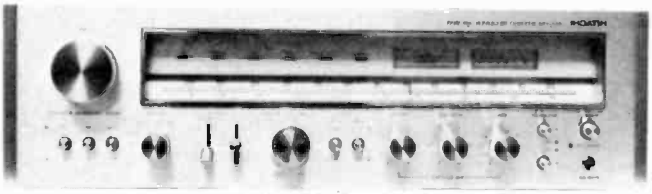
product rejection afforded. Stereo separation was plotted over the entire frequency range by means of our spectrum analyzer. Figure 5 shows the results. Note the steep roll-off action of the low-pass filter in the region of 19 kHz. The upper trace shows the output from the desired channel while the lower trace represents output from the opposite channel. Each vertical division equals 10 dB.

Our overall product analysis is found in Table II, together with summary comments. For the budget-minded high-fidelity enthusiast who prefers a separate tuner to an all-in-one receiver, the *model ST-3535* offers considerable value and an abundance of extra features not normally found in lower cost tuners. Unless you are fortunate enough to live in an area where one or more stations are taking special pains to deliver a superclean FM or stereo FM signal, it is unlikely this tuner will prove a limiting factor in determining the quality of your FM reception. **R-E**

Hitachi SR-903 Stereo Receiver



1

CIRCLE 101 ON FREE INFORMATION CARD

IN THE AUGUST 1976 ISSUE OF RADIO-ELECTRONICS, we described a new type of audio amplifier output circuit developed by Hitachi that was identified as a "Class G" circuit. Hitachi first used this innovative output circuit in their top receiver, *model SR-903* (See Fig. 1). The chief virtue of the Class-G circuit is its increased efficiency (compared with conventional Class-B push-pull output circuitry). The resulting decreased weight and heat-sink requirements, in turn, lead to a more economical design. Indeed, while the *model SR-903* is dimensionally the equal of competitive receivers in the same power class, its net weight and retail asking price suggest that the Class-G approach provides decided benefits.

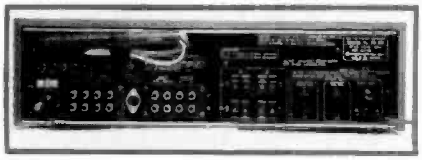
The front panel of the *model SR-903* is made of gold-anodized aluminum. Frequency numerals are printed on a sloping section behind the dial glass for better visibility, and the linear FM-scale is calibrated at every 200 kHz. Rectangular colored slits above the right section of the dial scale illuminate to show program source selected as well as stereo FM signal reception. Above the left area of the dial scale are signal-strength and center-of-channel tuning meters.

An indicator light labelled AUTO-LOCK is included with the program source indicators and works together with the large tuning knob at the right of the panel. In FM tuning, a built-in AFC (*A*utomatic *F*requency *C*ontrol) circuit is deactivated so long as your fingers engage the tuning knob. As soon as you approach center-of-channel (as indicated on the tuning meter), releasing the knob permits the auto-lock feature to pull in the station and the then AUTO-LOCK light comes on.

Rotary controls along the lower section of the control panel include BASS, MID-RANGE and TREBLE tone controls; dual concentric balance and click-stop master volume controls; and a rotary program selector switch. The switch has, in addition to its PHONO, AM and AUX positions, a separate FM position and one which combines the FM auto-lock and FM mute features. We would have preferred to see a separate FM muting switch so that the auto-lock feature could be enjoyed with or without interstation muting.

Seven individual pushbuttons take care of low and high filters, speaker A/speaker B selection, stereo/mono selection, loudness control activation and external adaptor switching. Two three-position lever switches handle twin tape-monitoring circuits and tape copying or dubbing. Phone jack and power on/off pushbutton are located at the lower left of the front panel.

Figure 2 is a rear-panel view of the receiver. Antenna terminals at the left handle 75-ohm, 300-ohm and external AM antenna connections. A swing-out ferrite AM bar antenna is located above the usual input and tape-out pairs of phono-tip jacks with a DIN



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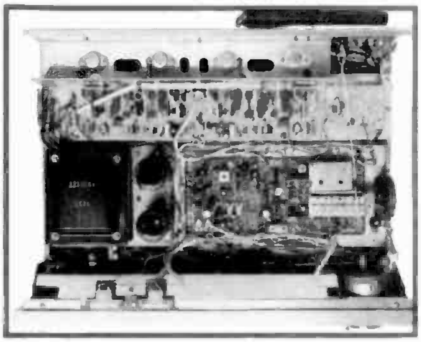
connector also provided for the TAPE 1 in-and-out connections. Spring-loaded speaker terminals are vertically oriented. One switched and one unswitched AC receptacle, a fuseholder and a chassis ground terminal complete the rear-panel layout. Adaptor in-and-out jacks provide the equivalent of a third tape monitor circuit interruption point.

Circuit features

Four major circuit boards (two are visible in Fig. 3) contain the majority of components used in the receiver. The tuner PC board (see Fig. 3) includes a 4-gang linear tuning capacitor for FM and a 3-section AM tuning gang. A MOSFET is used in the RF amplifier stage. The FM-IF section uses a 4-stage IC differential amplifier with three ceramic filter elements and an IC limiter-quadrature FM detector stage. Phase-locked-loop IC circuitry is used in the multiplex decoder section. Ceramic filtering and IC's are used in the AM tuner section and an IC phono equalizer is used in the low-level preamp stage.



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An electronic protection circuit protects speakers and power transistors in the event of a fault, with a relay used to disconnect power applied to the speaker terminals. In the event that the protection circuitry is activated, a

MANUFACTURER'S PUBLISHED SPECIFICATIONS:

FM TUNER SECTION:
Usable Sensitivity: mono: 1.6 μV (9.3 dBf); stereo: 14 μV (28 dBf). **50-dB Quieting:** mono: 3.1 μV (15 dBf); stereo: 34.5 μV (36 dBf). **S/N Ratio:** mono: 74 dB; stereo: 68 dB. **THD:** mono: 0.15% at 1 kHz; 0.2% at 100 Hz; 0.25% at 6 kHz; stereo: 0.25 at 1 kHz, 0.3% at 100 Hz, 0.3% at 6 kHz. **Frequency Response:** 30 Hz to 15 kHz, ±1.0 dB. **Capture Ratio:** 1.0 dB. **Image Rejection:** 85 dB. **IF and Spurious Rejection:** 100 dB. **Selectivity:** 80 dB. **AM Suppression:** 55 dB. **Stereo Separation:** 45 dB at 1 kHz. **Subcarrier and SCA Rejection:** 65 dB. **Muting Threshold:** 14 μV (28 dBf).

AM TUNER SECTION:
Sensitivity: 300 μV/M (internal antenna); 20 μV (external antenna). **Image Rejection:** 70 dB. **IF Rejection:** 90 dB. **Selectivity:** 40 dB. **S/N Ratio:** 50 dB.

POWER AMPLIFIER AND PREAMPLIFIER SECTION:
Power Output: 75 watts-per-channel, minimum continuous, 8 ohms, 20 Hz to 20 kHz. **Rated THD:** 0.1%. **Rated IM:** 0.1%. **Damping Factor:** 45. **Input Sensitivity:** phono: 2.5 mV; high level: 200 mV. **S/N Ratio** (A-weighted): phono: 75 dB; high level: 87 dB. **Tone Control Range:** bass: ±10 dB at 100 Hz; treble: ±10 dB at 10 kHz; mid-range: ±6 dB at 1 kHz. **High Filter:** −8 dB at 10 kHz. **Low Filter:** −8 dB at 50 Hz. **Frequency Response:** high level: 10 Hz to 30 kHz, ±1 dB; phono: RIAA, ±0.5 dB.

GENERAL SPECIFICATIONS:
Power Requirements: 120V, 60 Hz, 250 watts. **Dimensions:** 19¼" wide × 5¹¹⁄₁₆" high × 15¾" deep. **Weight:** 29.8 lbs. **Suggested Retail Price:** $499.95.

TABLE I

RADIO-ELECTRONICS PRODUCT TEST REPORT

Manufacturer: Hitachi — Model: SR-903

FM PERFORMANCE MEASUREMENTS

SENSITIVITY, NOISE AND FREEDOM FROM INTERFERENCE	R-E Measurement	R-E Evaluation
IHF sensitivity, mono: (μV) (dBf)	1.7 (9.8)	Very good
Sensitivity, stereo (μV) (dBf)	16.0 (29.3)	Fair
50 dB quieting signal, mono (μV)	2.6 (13.5)	Excellent
50 dB quieting signal, stereo (μV)	32.0 (35.3)	Very good
Maximum S/N ratio, mono (dB)	76	Excellent
Maximum S/N ratio, stereo (dB)	70	Excellent
Capture ratio (dB)	1.2	Excellent
AM suppression (dB)	55	Good
Image rejection (dB)	86	Very good
IF rejection (dB)	100	Excellent
Spurious rejection (dB)	100	Excellent
Alternate channel selectivity (dB)	82	Excellent
FIDELITY AND DISTORTION MEASUREMENTS		
Frequency response, 50 Hz to 15 kHz (±dB)	1.0	Very good
Harmonic distortion, 1 kHz, mono (%)	0.12	Excellent
Harmonic distortion, 1 kHz, stereo (%)	0.19	Very good
Harmonic distortion, 100 Hz, mono (%)	0.12	Excellent
Harmonic distortion, 100 Hz, stereo (%)	0.25	Good
Harmonic distortion, 6 kHz, mono (%)	0.14	Excellent
Harmonic distortion, 6 kHz, stereo (%)	0.3	Very good
Distortion at 50 dB quieting, mono (%)	0.6	Good
Distortion at 50 dB quieting, stereo (%)	0.38	Very good
STEREO PERFORMANCE MEASUREMENTS		
Stereo threshold (μV) (dBf)	16.0 (29.3)	Fair
Separation, 1 kHz (dB)	50.0	Superb
Separation, 100 Hz (dB)	40.0	Excellent
Separation, 10 kHz (dB)	42.0	Superb
MISCELLANEOUS MEASUREMENTS		
Muting threshold (μV) (dBf)	14.0 (28.0)	Fair
Dial calibration accuracy (±kHz at MHz)	100	Very good
OVERALL FM PERFORMANCE RATING		Very good

TABLE II

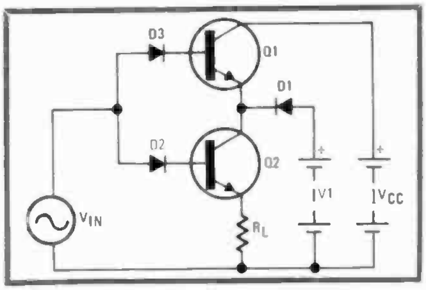
Manufacturer: Hitachi — Model: SR-903

AMPLIFIER PERFORMANCE MEASUREMENTS

POWER OUTPUT CAPABILITY	R-E Measurement	R-E Evaluation
RMS power/channel, 8-ohms, 1 kHz (watts)	102	Excellent
RMS power/channel, 8-ohms, 20 Hz (watts)	75	Good
RMS power/channel, 8-ohms, 20 kHz (watts)	77	Good
RMS power/channel, 4-ohms, 1 kHz (watts)	N/A	
RMS power/channel, 4-ohms, 20 Hz (watts)	N/A	
RMS power/channel, 4-ohms, 20 kHz (watts)	N/A	
Frequency limits for rated output (Hz-kHz)	20-22	Good
DISTORTION MEASUREMENTS		
Harmonic distortion at rated output, 1 kHz (%)	0.035	Excellent
Intermodulation distortion, rated output (%)	0.07	Excellent
Harmonic distortion at 1-watt output, 1 kHz (%)	0.01	Excellent
Intermodulation distortion at 1-watt output (%)	0.01	Excellent
DAMPING FACTOR, AT 8 OHMS	45	Very good
PHONO PREAMPLIFIER MEASUREMENTS		
Frequency response (RIAA ± dB)	0.2	Excellent
Maximun input before overload (mV)	110	Very good
Hum/noise referred to full output (dB) (at rated input sensitivity)	70	Very good
HIGH-LEVEL INPUT MEASUREMENTS		
Frequency response (Hz-kHz, ± dB)	10-32, 1.0	Very good
Hum/noise referred to full output (dB)	90	Excellent
Residual hum/noise (min. volume), (dB)	90	Good
TONAL COMPENSATION MEASUREMENTS		
Action of bass and treble controls		Good
Action of secondary tone controls		Good
Action of low-frequency filter(s)		Fair
Action of high-frequency filter(s)		Fair
COMPONENT MATCHING MEASUREMENTS		
Input sensitivity, phono 1/phono 2 (mV)	2.6	
Input sensitivity, auxiliary input(s) (mV)	210	
Input sensitivity, tape input(s) (mV)	210	
Output level, tape output(s) (mV)	210	
Output level, headphone jack(s) (V or mW)	62 mW	
OVERALL AMPLIFIER PERFORMANCE RATING		Excellent

small front-panel light located near the power ON/OFF switch becomes illuminated. This light also comes on for the first few seconds after turn-on—the relay prevents output to the speakers, eliminating warm-up thumps and pops from reaching them.

For those who may not have read the earlier description of the Class-G output circuit, here is a brief review: A simplified Class G circuit is shown in Fig. 4. Two transistors are used in each half of the push-pull arrangement for each channel (a total of four transistors in each channel). In Fig. 4, transistor Q2 is powered by the lower of two supply voltages (V1) and amplifies the incoming signal V_{in} until the amplitude of the



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incoming signal exceeds the value of V1. During this time, transistor Q1 is cut off. As the crest of the incoming waveform is reached, signal amplifying is taken over by Q1, powered by the higher supply voltage V_{cc}, and transistor Q2 is then cut off. Thus, each transistor operates over its most efficient range, thereby increasing efficiency far beyond that attained in conventional Class-B operation. This increased efficiency results in decreased thermal dissipation and decreased heat-sink requirements.

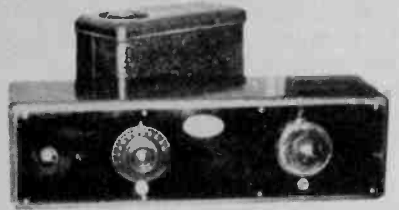
FM tuner measurements

Table I lists the measurements made for the FM tuner. Generally, results equalled or exceeded published specifications, although stereo usable sensitivity was limited by the rather high switching threshold provided between mono and stereo reception. Signal-to-noise ratios at high input signal strengths in both mono and stereo were excellent, and well above ratings. Mono and stereo distortion was as low as in some expensive "separate" tuners. More important, the lowest distortion points were observed with the auto-lock feature engaged, indicating good correspondence between the indicated "perfect" tuning point and actual center-of-channel.

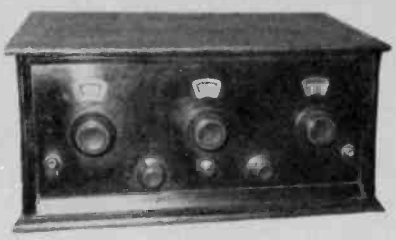
There was good correspondence between the center-of-channel meter indications and the true, lowest-distortion tuning point from one end of the dial to the other. Calibration of frequencies was also extremely accurate. Stereo separation was particularly impressive, especially at the more difficult high-frequency test point of 10 kHz, where it remained above 40 dB!

We would have preferred to see a somewhat lower muting threshold setting than the 14 μV observed, especially in view of the good steep quieting slope of tuner circuit. Of course, for weak signal reception one can always defeat the muting feature, but since it is tied in with the auto-lock setting of the program selector switch, you would also have to forego that feature as well during FM DX'ing.

continued on page 77



ATWATER KENT model 36, 1927



FRESHMAN MASTERPIECE, 1925

FRESHMAN MASTERPIECE, 1925

Restoring Antique Radios

Antique radios have gained popularity in recent repairing and modifying and how to go

MORGAN E. McMAHON*

THE OLD RADIOS ARE COMING BACK. THOUSANDS of collectors and nostalgia hounds are dragging old sets out of attics, basements and junk shops. You can be the one to make them play again. If you have an old-line repair shop, you can revitalize your business. If you're a hobbyist, you can discover real fun in renovating antique sets. Chances are you'll become an enthusiastic collector yourself.

AC radio sets from 1927 to 1950 are now very popular with collectors, and are in demand by almost everyone as conversation pieces for den or rumpus room. Prices for early AC sets in playing condition run from $25 to over $200. Battery sets from the early 1920's command even higher prices, even pre-1951 TV sets are fair game.

Getting Started

What does it take to jump into the hobby or business of renovating antique sets? If you're experienced at repairing tube sets you've already got a start. How far you go depends on skills such as refinishing and machine tool operation.

There are really three levels of renovation: **Restoration** requires that the set be brought back to its original condition in every respect, except that the rich luster of the finish, accumulated over the years, is not disturbed unless required. The restorer puts new transformer windings into the old transformer cans, and places new dry electrolytic capacitors in the old wet-filter capacitor cans. The set should be indistinguishable from new, except for the richness of the finish. A true restoration job involves using skills in cabinetry, refinishing, metalworking and electronics.

Repair means to get the set working as it once did, but with possible short-cuts such as hanging electrolytics under the chassis and substituting R–C networks for those hard-to-get transformers. **Modification** involves substituting modern modules, such as transistorized tuners, for the original (an unpardonable sin to the purist!).

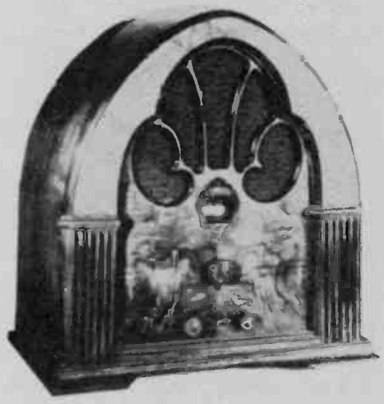
How do you get started? First, you must be competent to do the work. Just because the sets are many years old doesn't mean they're a snap to fix. Next, you need the tools—workbench, testers, circuit references, etc. You must know where to get obsolete tubes and parts. You also have to find the best way to ship sets, as you'll want to work beyond your immediate locale if you want to set up a business. You must advertise your talents and services and set up channels for finding old sets to renovate and sell at a profit.

It's not hard to sell sets to incidental buyers. Try local antique and collectibles dealers, and the new "funky things" shops. An exhibit of your own helps. However, your best bet may be with more serious collectors who don't have the time or resources to restore their acquisitions. If you become *the* restorer for collectors in your area, you're pretty well set.

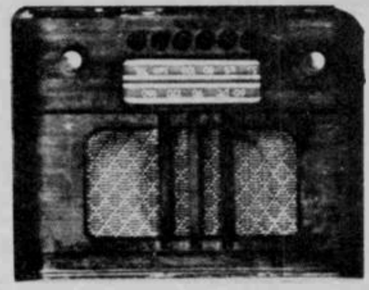
*Author-publisher, Vintage Radio Company.

1933 AUDIOLA

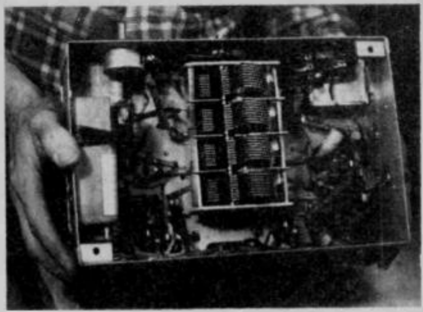
ATWATER KENT model 55, 1929



PHILCO CORP. model 90B, 1931



RCA model 95T5, 1938



JACKSON BELL CHASSIS, 1932

ZENITH model 75 Radio Phonograph, 1930

-How to get started

ears. Here's a look at what's required in restoring,
ibout obtaining parts and schematics

Clubs and periodicals

To tap the collector community, start by reading the same books and periodicals as they do, and by getting to know the local or regional collectors' clubs. Start with the Vintage Radio Company books; write to Vintage Radio, Dept. P, Box 2045, Palos Verdes, CA 90274 for information. The volume of key interest to you is *A Flick of the Switch*. The 1887-1929 counterpart to this book is *Vintage Radio*.

There are some periodicals devoted entirely to radio collectors. *The Horn Speaker*, 9820 Silver Meadow Dr., Dallas, TX 75217, is a monthly newspaper for collectors and historians. Other collector newsletters are: *Radio Age*, 1220 Meigs St., Augusta, GA 30904; *Antique Radio Topics*, Box 42, Rossville, IN 46065; and the *Classic Radio Newsletter*, Box 28572, Dallas, TX 75228. A good directory of publications and of hard-to-get parts and services is available from Historical Radio Services, Box 15370, Long Beach, CA 90815.

Historical radio clubs are your best doors into the collector community. The Antique Wireless Association and the Antique Radio Club of America are national, and there are also regional clubs. In Canada the Canadian Vintage Wireless Association is the key organization.

Your other main need is for circuit-diagram references. Rider's *Perpetual Trouble Shooter's Manuals* cover sets from the mid-1920's to the 1950's. Howard W. Sams' *Photofacts* give detail on sets built after 1945. Morris Beitman's *Most-Often-Needed Circuit Diagrams* books are still available from Supreme Publications, 1760 Balsam Rd., Highland Park, IL 60035. Gernsback Publications' *Official Radio Service Manual* covers the period from the mid-1920's through 1935. Vintage Radio Company provides a circuit research service in which the schematic diagram and other available information on any pre-1951 radio set will be sent for $3.50.

You can help preserve radio history and have some fun at the same time; and if you're interested, earn some money in the process. R-E

ANTIQUE RADIO CLUBS

Antique Radio Club of America
c/o Mr. Bill Denk
81 Steeplechase Rd
Devon, PA 19333

Antique Wireless Association
c/o Mr. Bruce Kelley
Main St.
Holcomb, NY 14469

Buckeye Antique Radio and Phonograph Club
c/o Mr. Ken Longenecker
1937 Stoney Hill Dr.
Hudson, OH 44236

California Historical Radio Society
c/o San Jose Historical Museum
635 Phelan Ave.
San Jose, CA 95112

Canadian Vintage Wireless Association
c/o Mr. Sid Prior
102 Parkhurst Blvd.
Toronto, Ontario, M4G 2E6
Canada

Indiana Historical Radio Society
c/o Mr. Ed Taylor
245 N. Oakland Ave.
Indianapolis, IN 46201

Mid-America Antique Radio Club
c/o Dr. Robert Lane
2301 Independence Ave.
Kansas City, MO 64214

Northwest Vintage Radio Society
Box 13544
Portland, OR 97213

Rocky Mountain Antique Wireless Association
16500 W. 12th Dr.
Golden, CO 80401

Southern California Antique Radio Society
c/o Mr. Alan Smith
6712 Bisby Lake Ave.
San Diego, CA 92119

Southwest Vintage Radio and Phonograph Society
Box 19406
Dallas, TX 75219

ATWATER KENT model 35, 1926

service clinic

Double, double, toil and trouble. *Overlook the obvious and don't believe the evidence.* JACK DARR, SERVICE EDITOR

THIS IS A GOTHIC TALE, OF MYSTERY, HARDship, frustration and suffering. There is a happy ending, but one that would amaze Alfred Hitchcock. What? Certainly; it's an intermittent; what else could it be?

Synopsis. Technician makes house call on Quasar TS-941. Complaint: raster folds over in center, darkens and goes out, after about 15 minutes. Tapping on cabinet will bring it back. Verified by observation. So, technician installs new FC panel.

Symptoms remain exactly the same. Take set to shop. On the way, pick up another set, same chassis. Hook set No. 2 up, and it shows exactly the same symptoms. (******* This denotes lapse of two days.)

Concentrating on first set, the problem seems to be in the flyback, since the FC module has been replaced, and it contains all of the rest of the circuitry. Tapping the flyback, moving the leads, etc., does nothing. Bending the endplate of the chassis up and down will make the raster go out, or come back if it's out. Tapping the module will make it go out sometimes. (***** Two more days, not continuously, half an hour at a time.)

During this time Visiting Expert (sic!) has been passing through shop, observing (but not helping much). Temptation too much; V. E. breaks down and says "Drive this thing into my place and let's see what's going on." No sooner said than done.

Now both of us start in on it. We agree that it has to be a bad solder joint *somewhere*, since it has all of the typical symptoms. Also it is thermal, since it will show up by itself after a short time. However, we are unable to locate that place where only a very light tap will make it act up. To make life more interesting, now it develops a new failure mode. In this one, the raster goes out instantly. Once again, tapping or bending the chassis will bring it back.

Transcription of V.E.'s bench notes (somewhat edited and highly expurgated).

"Two failure modes with same result. Has to be bad solder joint from symptoms. Monitor things. The scope shows that the base drive waveform on the horizontal output transistor does not disappear, but just changes shape slightly. Perfect square wave in fault condition, 15 volts p-p (Fig. 3-a); in operation, normal waveform as shown in Fig. 3-b.

"However, different reactions on collector current of output transistor. Monitored by reading DC voltage drop across R805/R806, 5 ohms each, in the +73 volt supply that feeds the flyback primary. In Mode 1, foldover and fade, the collector current rises slowly from the normal 700 mA to 1.0 amps or more (at which time the plug is pulled!)

"In Mode 2, instant disappearance of raster, the collector current drops to zero

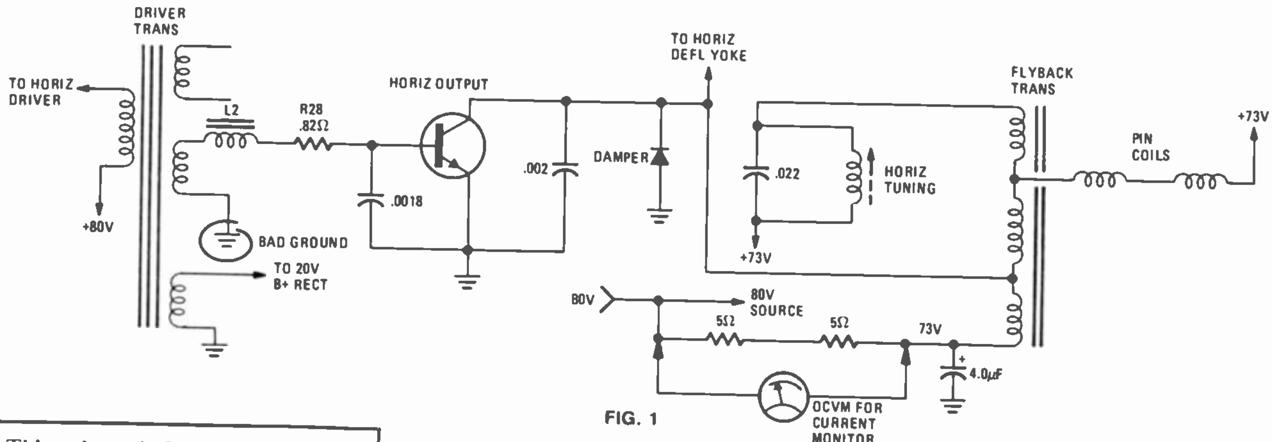


FIG. 1

This column is for the service technician's problems—TV, radio, audio or industrial electronics. We answer all questions submitted by service technicians on their letterheads individually, by mail, and the more interesting ones will be printed here.

If you're really stuck, write us. We'll do our best to help you. Don't forget to enclose a stamped, self-addressed envelope. If return postage is not included we cannot process your question. Write: Service Editor, Radio-Electronics, 200 Park Avenue South, New York, NY 10003

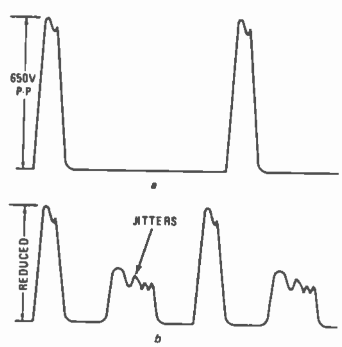


FIG. 2

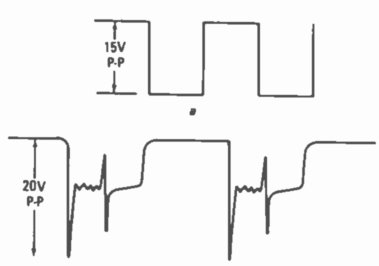


FIG. 3

and the collector voltage rises to the supply value of +80 volts. In Mode 2 (using the other channel of the scope) the collector pulse drops to zero. In Mode 1, the height of the pulse drops, and another smaller pulse shows up halfway between the normal pulses; this jitters very badly (Fig. 2). Either condition can be induced by bending the end-plate of the chassis.

"Now, some conclusions were made. From the complete loss of the collector current in No. 2, we decided that the emitter of the output transistor could be opening. This was eliminated by grounding the emitter with a clip-lead in the fault condition. No result. The flyback was still suspect, since a new module had made no difference at all.

*"Resistance tests showed nothing out of order. Reading primary resistance from B+ to collector showed no change when the chassis was tapped or the plate bent. Since this circuit uses a three-branch parallel-feed for the collector circuit, this one was discarded as unlikely. (**** One more day.)*

"The output transistor was not conducting at all in fault condition, Mode 2. This was not a loss of drive, since the monitor showed no change at all. That is, aside from the change from a normal waveform to the square wave. We could tell when it was in or out by watching this. We still could not find that sensitive point where a slight tap would make it cut in and out.

"A belated reading of the base *voltage of the output transistor showed that in operation it was normal at a –1.2 volts. In fault condition this jumped to a –6 volts. Now we knew! The complete loss of collector current was due to the transistor being firmly* cut *off. At this point, Colleague happily went out on a service call, saying that he had to do* something *to make a living.*

"So try something new; think! *This wasn't loss of drive, but it was something that affected the* bias. *The base circuit was very simple (Fig. 1). The socket terminal (which had been cleaned and checked, with the rest, as the first step), a 0.82-ohm resistor, a tiny choke, and the secondary winding of the driver transformer. Taking the module out, this circuit was checked. All solder joints looked good, and the continuity checked out.*

"Keep thinking: If the hot end of this winding opened, we'd lose the drive waveform on the base. However, if the ground end was opening, this would leave the base floating, and could result in the kind of bias change we were seeing. Replace module. Turn on. Works. Using long thin plastic screwdriver, carefully move the two terminals of the secondary, which

continued on page 66

Should your career in electronics go beyond TV repair?

CREI prepares you at home for broader and more advanced opportunities in electronics— plus offers you special arrangements for engineering degrees

There is no doubt television repair can be an interesting and profitable career field. TV repair, however, is only one of the many career areas in the fast growing field of electronics.

As an indication of how career areas compare, the consumer area of electronics (of which TV is a part) makes up less than one-fourth of all electronic equipment manufactured today. Nearly twice as much equipment is manufactured for the communications and industrial fields. Still another area larger than consumer electronics is the government area. That is the uses of electronics in such areas as research and development, the space program, and others.

Just as television is only one part of the consumer field, these other fields of electronics are made up of many career areas. For example, there are computer electronics, microwave and satellite communications, cable television, even the broadcast systems that bring programs to home television sets.

As you may realize, career opportunities in these other areas of electronics are mostly for advanced technical personnel. To qualify for these higher level positions, you need college-level training in electronics. Of course, while it takes extra preparation to qualify for these career areas, the rewards are greater both in the interesting nature of the work and in higher pay. Furthermore, there is a growing demand for personnel in these areas.

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SERVICE CLINIC

continued from page 61

were barely reachable from outside. There it was! Only a very small movement would make it cut in and out. Here was the sensitive point we'd been looking for so long.

"Remove module; disassemble. Take out large electrolytic capacitor that blocked access to terminals of driver transformer. Check solder joints; look good. Resolder anyhow. Replace capacitor, reassemble. Look at solder joints on PC board, for same winding. These too looked good; resolder them anyhow. Replace module; turn on. Bend board; hit terminals. Nothing; it works. Leave note for colleague, telling what had been done, then go home and feed horse." (End of bench note transcriptions.)

Next morning; came into shop, and (being a realist) asked "When did it cut out?" Colleague says;" It didn't!" Complete amazement. Then he said "Come here. I've got something to show you." He handed me the other two FC modules and my 6-power loupe. "Look at the ground pin joint on that secondary winding." A very close examination showed that *both* of these had an almost invisible crack around the transformer-lead joint. Obviously, the one in the set had had one too.

There's the Alfred Hitchcock aspect. By an amazing combination of coincidences, three modules had developed exactly the same fault. This included the one in his kit! So, when the module was changed with no results, the other assumption was quite normal.

Conclusion, using perfect 20-20 hindsight: by taking readings, and observation, we *had* arrived at the point where the fault was located; the base circuit of the horizontal output transistor. Due to the drive waveform, we had been a day late in checking the DC voltage on the base.

This, of course, was the key clue, along with the drive waveform. It was pointing directly to the solder joint that was causing the trouble. Back-checking, with one of the bad modules, we found that while the peak-to-peak voltage and waveform did stay the same, the *DC level* of the *top* of the waveform was zero volts. We were driving an NPN transistor with what actually was a series of negative-going pulses. This caused the transistor to cut off completely.

We accounted for Mode 1, where the extra pulses appeared and the current increased, by deciding that this could be due to the bad joint arcing intermittently, so that the stage was double-triggering; some sort of screwball feedback loop, and it was trying to go into parasitic oscillation.

Such a combination of contradictory symptoms, plus the unbelievable coincidence of having three modules with identical defects made this one a little hard to pin down. The defect in this set certainly isn't typical of Quasar sets, and it was finally located by persistence and logic. If there is a moral, it would probably be "Keep on keeping on"!

R-E

reader questions

TRACE OFF-CENTER

The trace is way off center in this scope. It's one I built some years ago from a correspondence course. It is an RCA. The trace is far too high and I can't get it down. If I disconnect the vertical deflection-plates on the CRT, the trace centers. The tubes seem to be OK. I get +400 volts on one plate of the 12AU7 vertical output tube, and only +200 volts on the other plate. At this point I don't know what to do. It's probably simple.—A.A. San Diego, CA.

You have found the cause: the DC plate voltages on the output tube must be the same, and they're not. Note that the plate voltage of the pentode section of the 6BL8 is also off. Since this is directly coupled to the grid of one triode in the 12AU7, this is upsetting the bias. Try a new 6BL8 tube and check *all* of the resistors in this circuit for drift in value. Be sure to read the grid and cathode voltages; these are clues.

WEAK COLOR

Here's a cute one. This Admiral 2K2084 had very weak color. All of the color circuitry voltages and resistances were within tolerance. Even the chroma amplifier stages looked OK on a sweep test though the chroma curve had an extra hump at a higher frequency.

Turning the chroma take-off coil core produced nothing. Checking the coil showed it was open; the wire had been pulled too tight when it was soldered. Repaired this, and everything went back to normal.

Thanks to Louis R. Supek, Brunswick, OH, for this one.

continued on page 68

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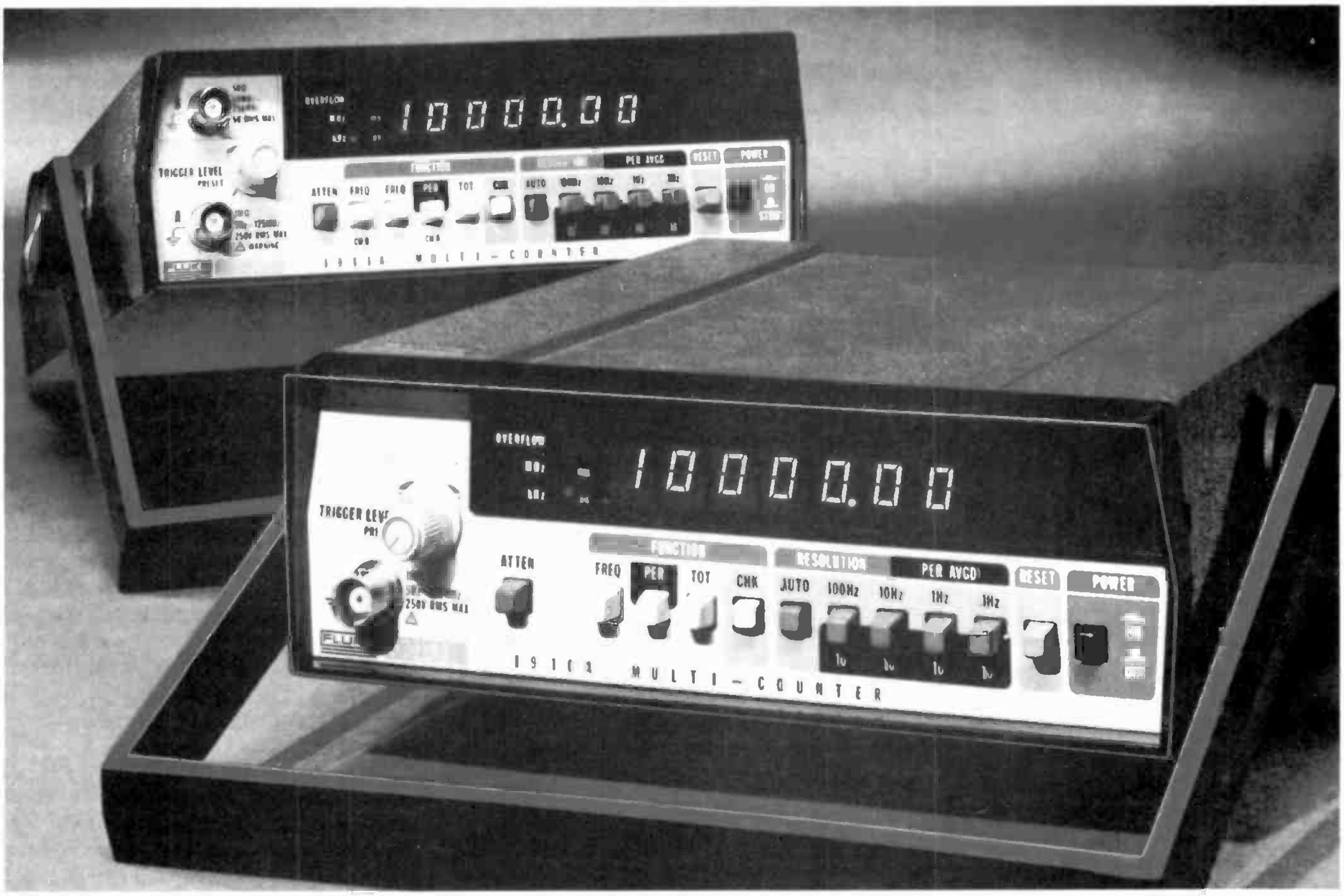

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• Autoranging:	Yes!	vs.	(sorry)	Yes!	vs.	(sorry)
• Battery Option:	Yes!	vs.	(sorry)	Yes!	vs.	(sorry)
• Multi-function:	f, p, pa, tot.	vs.	f only	f, p, pa, tot.	vs.	f only

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READER QUESTIONS

continued from page 66

MISMATCH

I got this Admiral 1K2084-2 chassis with a vertical problem; half of the deflection yoke had opened. I replaced it with a Thordarson Y-109. Now I have other problems. There's a damped sinewave look to the scanning lines on the left side. The high voltage is low and the width is narrow. Vertical linearity at the top isn't good. I've checked several things with no luck. Any suggestions?—H.G., Hudson, MA.

Your new set of symptoms are the classical symptoms of horizontal deflection yoke *mismatch*. According to the Thordarson catalogue, the correct deflection yoke for this one should be a Y-131. The Y-109 is listed as an RCA replacement. The Y-131 is shown as an exact replacement.

COLORED LINES

The vertical sweep and sync are good on this Zenith 19FC45, but I see several horizontal lines of various colors at the very top. I don't think these are retrace lines. Can't find a way to get them out.—A.T., Roseville, MN.

These probably are the VITS reference signals, which do have assorted color signals in them. The most likely cause for this would be some kind of oddball problem in the retrace blanking. Check the vertical blanker transistor. If it checks good, try a new one just for luck. May not be cutting off as sharply as it should.

(Feedback: "This transistor tested good in and out of circuit. So, I replaced it and cured the problem. How about that?")

THIN VERTICAL LINE

All I can get on this Broadmoor TV set, sold by K-Mart, is a bright, thin vertical line in the center of the screen. No sound. Can't find a listing on this is Sams.—W.D., Mission Viejo, CA.

The latest Sams Index shows a Broadmoor 7212WA. 1543-1. This should be close to the one you have. The thin vertical line could be due to an open *yoke-return* capacitor. Since the deflection yoke and high-voltage supply in solid-state TV sets are usually in *parallel* across the horizontal output transistor, should this capacitor open, you'd still have high voltage but no horizontal deflection. This is a 0.22 μF capacitor.

The sound problem could be due to a bad IC or audio output transistor. Check all of the DC voltages around the IC. If any of them are quite a bit off, chances are that the IC is bad.

GREEN SCREEN

The screen on this RCA CTC-59 has a greenish tint, both on color and b-w pictures. The screen and drive controls act very oddly. I can't get the blue to react properly.—C.K., Kenmore, NY.

See if you can get setup lines on all three colors in with the service switch in the service position. If so, then the picture tube is good. A greenish tint can be due to excess green or not enough blue. If your blue setup controls do not show a normal reaction, try this: All three of the MAD-1 video drivers are the same. Try swapping the blue one with either the red or green and see if your symptom changes color. If it does, you have a bad transistor or some problem in that MAD-1 module.

OLD RASTER

The bottom corners of the raster on this Zenith 20Y1C48 pull in. If I turn the brightness and contrast all the way up, they almost fill the screen. The high voltage is OK and the tubes have been substituted. Any ideas?—E.C., Los Angeles, CA.

There's one thing that might do this. Check the 30-μF capacitor on the screen grid of the 6HE5 vertical output tube. This is *not* the screen bypass capacitor; that's the 10μF unit. The 30-μF is actually part of the pincushion correction circuitry. If it opens, you will see what looks a good deal like a keystone raster. (Quite a few good deflection yokes have been replaced for this symptom!) **R-E**

VIDEO MODULATOR

continued from page 35

resistor sets the white level on the TV screen, that is, the intensity of the light portions of the screen. When the sync input and the video input are both high, the modulation input is connected to ground through a 47K resistor, which according to Fig. 10 will cause a 480-μV signal to be sent to the TV. If the sync input goes low (sync signal is present), an equivalent resistance to ground of 8.25K is formed (10K in parallel with 47K). This will produce an output of approximately 1390 μV. Likewise, when the video input goes low and the sync input is high, a 920-μV output is produced. With the waveforms in Fig. 11 applied to the sync and video inputs, two dark horizontal bars will be produced on the TV screen. Changing the values of the resistors will vary the relative brightness of the light to dark areas on the TV receiver.

The Videocube can also be used on a home microcomputer, such as the Signetics 2650-based system (**Radio-Electronics**, April 1977). Using the circuit in Fig. 12 to interface with the "video output" of the system, a standard TV receiver can be used as a monitor. Resistors R1 and R2 can be adjusted for the best contrast and brightness. **R-E**

hobby corner

Homebrew breadboard that's inexpensive, easy to build and versatile. The basic design can be easily modified.

EARL R. SAVAGE, *K4SDS.*

EXPERIMENTERS AND HAMS ARE FAMOUS for their well-stocked junk boxes. When they build something, many if not most or all of the parts come out of those junk boxes. If a part is not quite right, *maybe* it will be OK so use it anyway.

Well, I got tired of soldering in and then unsoldering one part after another until a circuit would finally work. As transistors, IC's and all kinds of miniature parts came along, the task became worse and worse. What I needed was an easy and non-destructive way to wire and unwire circuits.

I looked longingly at those fancy breadboarding outfits but the old wallet would not stand the strain of the ones that would do what I wanted. I settled for a few of the breadboard strips. Things worked well but every time I built the simplest circuit, my bench was covered with power supplies, switches, indicators and all kinds of things that added up to a mess.

No more! I finally stuffed everything into one box. The result was the homebrew breadboard shown in Fig. 1. It will do what the commercial units do—a great deal more than most—and is much less expensive. Even if you have no junk box and buy everything at regular prices, the cost is under $65. Between my junk box and bargain sales, my cost was considerably below that.

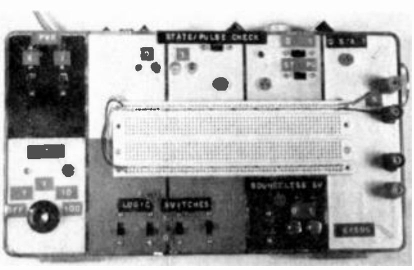


FIG. 1—HOMEBREW BREADBOARD contains facilities for developing and testing all types of solid-state circuits.

This homebrew breadboard is used for all types of solid-state circuits: TTL, DTL, RTL, MOS, CMOS, *et cetera*, digital and linear IC's as well as discrete transistors. It contains the following circuits.

1. logic switches (4)
2. state checkers (4 visual, 1 audible)
3. pulse/state checker
4. pulse generator (clock)
5. pulser switch (bounceless)
6. power supply for internal circuits
7. power supply for external circuits

You may want to put more or less into your homebrew breadboard. It is easily tailored to suit your special needs.

About the circuit

The breadboard contains two power supplies (See Fig. 2). Both are regulated and have thermal and over-current shutdown. Each has an LED pilot light. One is a light-duty 5-volt supply for the internal circuits. It is not affected by any errors or bad components in your experimental circuit.

The second power supply produces 5 volts at 1 amp and is fully regulated and protected. This comes out at two of the binding posts on the top panel for use in the experimental circuits. I chose this output because most of my work is with TTL and CMOS. Other supply voltages can be brought to the panel via the two uncommitted binding posts or directly to the distribution strips.

If you usually work with other voltages, the second power supply can easily be changed to the value you need. Alternately, it can be made variable or a third supply can be built in (there is plenty of space).

Pulse checker

Figure 3 shows a very special type of state checker. When switch S2 is in the STATE position, the LED glows in the presence of LO or HI just like the four state checkers previously described, except that switch S1 changes it from a "glow on a logic HI" to a "glow on a logic LO" checker.

When S2 is in the PULSE position, the LED *continues* to glow once the presence of LO or HI (depending on the setting of S1) has been detected. Thus,

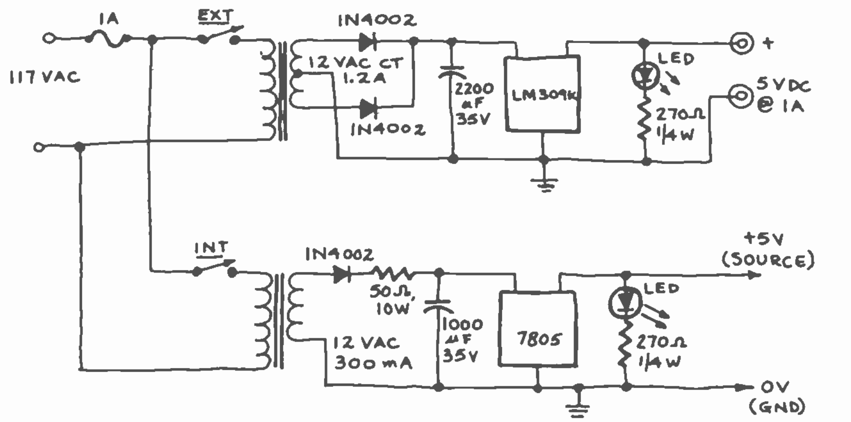


FIG. 2—HEAVY-DUTY POWER SUPPLY provides 1 amp to the circuit under development. Second supply powers internal circuits within the breadboard.

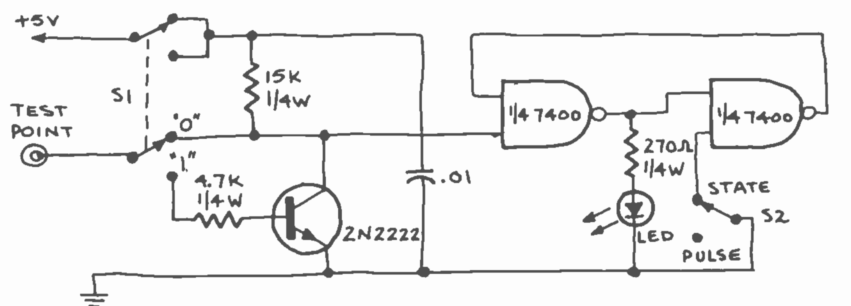


FIG. 3—PULSE CHECKER indicates presence of a low- or high-pulse as it occurs or it can "lock" on in the presence of a short duration pulse.

pulses too short and fast to be seen or heard with the other checkers will lock the LED on so you know that the pulse *was* there!

This circuit uses two gates—one-half of a 7400 quad 2-input NAND gate IC. The other half of the IC (two gates) is used in the pulser-switch circuit.

State checkers

The state checkers (See Fig. 4) are simple LED indicators. They are used to indicate whether a given part of a circuit is in a logic HI (1) or LO (0) state. Two LED's are wired to be turned on by logic LO and are shown in Fig. 4-a. The other two LED's are wired to be turned on by a logic HI and are shown in Fig. 4-b. For convenience of use, the four LED's are different colors.

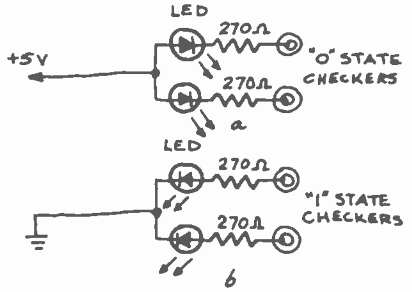


FIG. 4—VISUAL STATE INDICATORS are used 12345to dene logic levels. The low-state indicators are shown in *a*, and the high-state indicators are shown in *b*.

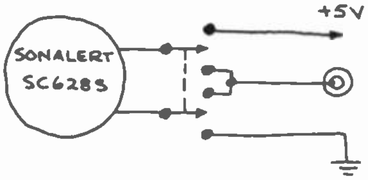


FIG. 5—AUDIBLE STATE CHECKER uses a high-frequency transducer to indicate logic levels.

Audible state checker

A Mallory *Sonalert* is used as an audible state checker (See Fig. 5). At times it is convenient to be able to know without looking at an LED whether a pin is HI or LO. The *Sonalert* does this very nicely by emitting a sound in the presence of a HI or LO depending upon the setting of the switch. (The prototype does not have this switch. Both *Sonalert* connections are brought directly to the front panel.)

A less expensive audible state checker can be made with a small speaker driven by a 555 timer connected as a multivibrator. I just happened to have the *Sonalert* in my junk box.

Logic switches

The four logic switches are nothing more than SPDT switches wired to bring a HI or LO to the front panel. They are very handy for circuits requiring frequently changed levels on one or more inputs.

To be continued.

ANTI—COLLISION SYSTEMS
continued from page 53

Originally, the large temperature range of the CMOS RCA COSMAC 1802 microprocessor made it a likely candidate. Additional memory, however, can become quite expensive. And because the architecture is non-traditional, it required a ground-up system design.

The very fast 6502 microprocessor has many advantages and only one disadvantage—temperature operating range. This can be solved by placing the entire electronics compartment in a large, thermostatically-controlled "oven." The oven keeps the ambient temperature from falling below 3°C.

OSI (Ohio Scientific Instrument, 11679 Hayden Street, Hiram, OH 44234) offers a rather complete family of microcomputer products with remarkable capabilities at a really low price. Even if you don't plan on using a microprocessor in your collision-avoidance system, I strongly recommend the OSI 440 Video Board as an excellent way of presenting a very flexible, readable display. The 440 is available for $29 unpopulated, plus $4 for shipping and handling. A complete kit, OSI *model 445*, is available for $99, plus $4 for shipping and handling.

System outputs

A passive system can offer a plethora of warnings. These are left to the ingenuity of the designer. Just remember, the time a warning is needed most is the time when attention can least be afforded to it.

Active systems can take over braking, steering, acceleration and more. But the driver proceeds at his own risk. A capacitor shorting out can send a child through a windshield. Double fail-safe and safeguard any system you allow to actively participate in your driving. There hasn't been a system yet intelligent enough to pass a driver's license exam.

One active output you can pursue is the air bag. Many agencies cite the air bag as a positive force in saving lives and reducing injuries. Some foreign cars now offer the air bag. Visit a dealership and talk to the guy at the parts counter about how difficult it is to retrofit one into your vehicle. It shouldn't be too hard. And be on the lookout for a do-it-yourself kit that allows you to install an air bag on your shoulder belt.

An invitation

We have undertaken here to describe some of the elements of a realizable electronic automotive collision-avoidance system you can begin building yourself. Even the individual elements of the system can go a long way toward providing you with the information you need to improve the safety of the driving environment.

We invite your response to the information printed here. Send us your ideas, too. Home computer hobbyists are invited to come up with mathematical models of the driving situation. Then refinements to the system could be plugged in to see what improvements can be made.

Automotive collisions are one of the most costly problems facing us, both in lives and property. Anything we can do to reduce that problem is a step toward making things easier on everybody. **R-E**

EQUIPMENT REPORT
continued from page 32

green gun would come up to the bottom end of the BAD sector on the meter; and the red gun just barely wiggled the needle.

The *Nu-Color model 90A* is a plug-in device that is inserted between the picture tube and socket, like a brightener. However, it is *not* a brightener, at least in the usual sense of the word. Between its plug and socket is a little box with three color-coded slide controls, one for each color.

Starting with all controls at the OFF position, I plugged the *Nu-Color* in and turned the set on. As expected, the raster was a bright blue. I adjusted the controls of the *Nu-Color* and came up with a good-looking color-bar pattern. Twiddling the grey scale and the *Nu-Color* controls gave an excellent color picture. Reds saturated normally, with the color control all the way up and all other things looked very good! This device lives up to its claims and its name; it certainly did "restore the color" to this old dog.

As Oneida is careful to explain, the *Nu-Color* is not intended as a "cure-all" for color troubles, but it will help correct problems due to unbalanced picture-tube emission. The device can be installed and adjusted in the home with very little trouble. **R-E**

new products

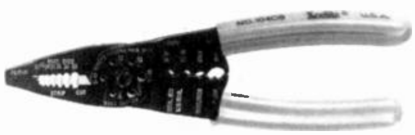
More information on new products is available from the manufacturers of items identified by a Free Information number. Free Information Card follows page 88.

ROBYN 40-CHANNEL CB PACKAGE, *model 007-140P*, is a 40-channel CB package that includes a CB transceiver with plug-in microphone, trunk/roof mount antenna, weatherproof PA speaker and all necessary hardware and cables.

The Robyn *007-140* transceiver has computer-designed phase-locked loop circuitry for top performance with full power—4 watts output and 100% modulation (FCC's maximum allowable). The *007-140* also features a two-way intercom, squelch control, power and volume switch, a new CB/PA/ANL/INTERCOM selector, illuminated dual function S/RF meter and channel selector and a wood grain front panel. Suggested list price: $179.95; without antenna and PA speaker: $159.95.—**Robyn International, Inc.,** Northland Dr., P.O. Box 478, Rockford, MI 49341

CIRCLE 80 ON FREE INFORMATION CARD

WIRE TOOL, *model 104CG*, combining stripper, cutter and crimper, has been introduced by the manufacturer for the electronics technician.



This wire tool features include a serrated-jaw plier nose, stripper and crimper gauged to wire sizes from No. 22 to No. 10, hardened pivot joint bushing for light-pressure precision use, a six-size bolt cutter, and specially formulated cushion grip handles.—**Xcelite,** Apex, NC 27502

CIRCLE 81 ON FREE INFORMATION CARD

32-RANGE HAND-HELD DMM, *model 175*, has a basic sensitivity of 100 μV, both in the DC and wide bandwidth AC-measuring functions. With 5 ranges of DC voltage measurement and 100% overrange capability per range, the 175 smoothly measures from 100V to 1000V in either polarity, displaying both the plus and minus sign. The DC function is protected to ±1000V on any range (including 100 mV) and even during switching. Basic instrument accuracy is 0.1% (± the always-present least-significant-digit uncertainty).

The unit measures resistance from 100 milliohms to 20 megohms in 6 ranges with a basic accuracy of better than 0.1% on all but the highest range and 0.2% on that. The AC range of the instrument is the same as DC, again providing a 100 mV sensitivity. A full frequency response is provided from 30 Hz up to 50 kHz on all voltage ranges, with mid-frequency accuracy better than 0.5%.

The *model 175* is protected electronically on all voltage ranges from interfering signals up to 1000V peak (just as in DC), and on the resistance ranges will withstand voltages of up to 250 VDC or RMS AC. All protection circuits allow continuous over-voltages as specified not only without damaging the instrument, but without also affecting the calibration. Powered internally by a rechargeable NiCad battery module, it will work for up to 6 hours without requiring a recharge. The 0.433-inch LED display provides bright, easily readable information under most normally expected types of external light conditions. This unit includes a low-battery-voltage indicator which gives approximately 10 minutes of warning before the battery level goes down to the point where the reading may not be reliable. Priced at $189.—**Data Precision Corp.,** Audubon Rd., Wakefield, MA 01880

CIRCLE 82 ON FREE INFORMATION CARD

40-CHANNEL REMOTE CB TRANSCEIVER, *model 10 (2710)* is an advanced phase-locked-loop system that transmits and receives on all 40 channels. It employs automatic noise-limiting circuitry to help eliminate both atmospheric and man-made noise. As in the *model 9*, the *model 10* has also been designed for separation of transceiver and MSR (Microphone, Speaker and Radio) control unit.

All *2710* controls are located on the MSR control unit for hand-held operation of microphone, speaker and radio. There are a 40-channel selector switch plus lighted channel readout; push-to-talk button; volume and

squelch controls. The *2710* MSR control unit is linked by coiled cord to an under-dash connector. From there an optional cable *model 1179)* runs to the transceiver which may be located beneath the seat, in the trunk or any other protected area. Suggested retail at $199.95.—**Hy-Gain Electronics Corp.,** 8601 Northeast Highway 6, Lincoln, NE 68505

CIRCLE 83 ON FREE INFORMATION CARD

AEROSOL PULSATING DEVICE—the *Vibra-Jet*, when connected to an aerosol cleaner or degreaser, will provide the mechanical force necessary to dislodge hard-to-remove contaminants with its pulsating action. This action will also remove dirt from horizontal surfaces, increase solvent penetration of surface pores and remove contaminants not normally removed by the cleaning products themselves. *Vibra-Jet* comes complete with a 26-inch flexible polyurethane hose and 12-inch probe for reaching inaccessible areas. The *Vibra-Jet* probe reaches easily into very tight places and sprays effi-

ciently in any position. Designed to work with all the manufacturer's products, this device is intended primarily for use with electronic cleaners and degreasers that leave no residue. It is especially useful in enhancing the cleaning action of the manufacturer's *Tun-O-Wash*. To introduce the *Vibra-Jet*, the manufacturer is offering this device to electronic technicians with the purchase of two cans of *Tun-O-Wash*.—**Chemtronics, Inc.,** 45 Hoffman Ave. Hauppauge, NY 11787

CIRCLE 84 ON FREE INFORMATION CARD

continued on page 76

NEW PRODUCTS

continued from page 75

CORDLESS SOLDERING STATION *No. 2000* consists of a rugged rechargeable iron with a quick-charge nickel-cadmium battery. The unit

is designed to accept two rigid interchangeable tips, and the charging holder with tip cleaning sponge completely recharges the battery in 4 hours. The unit is molded in high-impact plastic. Charging holder is rated at 120 volts AC input, 3.2 volts DC at 285 mA.—**Ungar**, Div. of Eldon Industries, Inc., 233 East Manville, Compton, CA 90220.

CIRCLE 85 ON FREE INFORMATION CARD

FREQUENCY COUNTER, *model 1827* offers full 6-digit LED display and guaranteed operation to 30 MHz with 1-Hz resolution. Operation to 50 MHz is typical. The unit features 1-ppm resolution on a 6-digit scale with ±0.25-ppm stability. The input circuitry is sensitive enough to display a 100-mV sinewave signal, but is protected against an input signal of up to 200 volts (peak AC & DC). A broad range of optional accessories gives the unit unequaled versatility. An optional signal tap allows the *1827* to continually monitor the output frequency of a 23- or 40-channel CB transceiver without affecting normal set operation. Signal tap is rated at 100 watts.

The *model 1827* is also fully compatible with the manufacturer's 40-channel CB service bench. Other optional accessories include rechargeable batteries and an AC adapter/charger, an under-shelf or under-dash mounting bracket, 27-MHz pickup antenna, general-purpose input clip-lead and vinyl carrying case. The *1827* can be powered for more than 8 hours of normal use by ordinary AA batteries or rechargeable nickel-cadmium batteries. The optional AC adapter/charger allows overnight charging of nickel-cadmium batteries, so the unit can be ready for daily field service. The unit weighs less than 1 pound and measures only 1.75 × 3.75 × 6.6 inches. Priced at $120.00.—**B&K-PRECISION, Dynascan Corp.**, 6460 W. Cortland Ave., Chicago, IL 60635

CIRCLE 86 ON FREE INFORMATION CARD

R-E TESTS HITACHI SR-903
continued from page 57

TABLE III

RADIO-ELECTRONICS PRODUCT TEST REPORT

Manufacturer: **Hitachi** Mode': **SR-903**

OVERALL PRODUCT ANALYSIS

Retail price	**$499.95**
Price category	**Medium**
Price/performance ratio	**Excellent**
Styling and appearance	**Excellent**
Sound quality	**Very good**
Mechanical performance	**Excellent**

Comments: In evaluating this receiver, it is easy to concentrate on the novel power amplifier circuitry to the exclusion of the other fine features. The chief virtue of the Class-G circuitry is increased efficiency, which results in a product that is both well priced (in its power and feature class) and less bulky than its competitors. The tuner section of the receiver is also well designed, as is the preamplifier control section. The extra midrange tone control is a welcome addition, as is the extremely effective auto-lock tuning method that offers all the virtues of conventional AFC without any of its measurable disadvantages.

As for the Class-G "double power supply" system, we searched carefully for any audible or measurable notch distortion (resulting from the switching action from the low-level to the high-level transistor pair) and could find none. The distortion-versus-power output curve was similar to any conventionally designed Class-B amplifier circuit; any transitional problems in switching from one power supply level to the other seem to have been successfully overcome by adding "smoothing" components which make this transition undetectable. Higher efficiency and lower heat dissipation (under actual operating conditions) are, therefore, the *only* consequences of the novel output circuit approach as far as actual performance is concerned.

Hitachi claims regarding the greater margin between "continuous" and "dynamic" power are justified—both in bench measurements and in listening tests. We drove this unit to considerably higher levels with musical signals than one would normally expect with a "nominally rated" 75-watt-per-channel receiver. We consider the *model SR-903* to be even more of a bargain when judged on a cost/performance ratio basis.

Amplifier measurements

In view of the novel Class-G output circuit, the performance of the power amplifier section of this receiver was tested. Results listed in Table II indicate a great deal of reserve power at mid-frequencies while just making "spec" (under continuous power testing) at the frequency extremes of 20 Hz and 20 kHz. FTC preconditioning tests were particularly revealing, in that the heat generated at the one-third power point was noticeably lower than for similarly rated power amplifier sections on competitive receivers. While Table II lists THD readings at 1.0 watt and at full power output, we specifically measured distortion at intermediate levels to see if any notch distortion occurred at or near the transitional point between the "low-level" and "high-level" transistors. No such increased distortion was detected at any operating level below clipping.

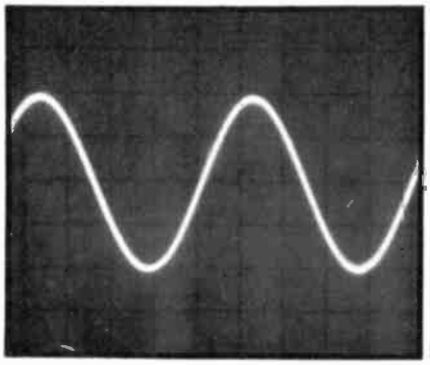
Federal Trade Commission ratings notwithstanding, Hitachi stresses the fact that the Class-G arrangement offers actually greater dynamic power output capability than is possible for similarly rated (on a continuous power basis) competitive units. They maintain that under actual music listening conditions, the amplifier section is capable of delivering greater short-term power than Class-B amplifiers having the same FTC power ratings. In investigating this claim we devised an additional test. Figure 5 is a scope photo of a 1-kHz output signal whose amplitude has been increased just to the point of clipping (an output of 102 watts).

turn page

R-E TESTS HITACHI SR-903

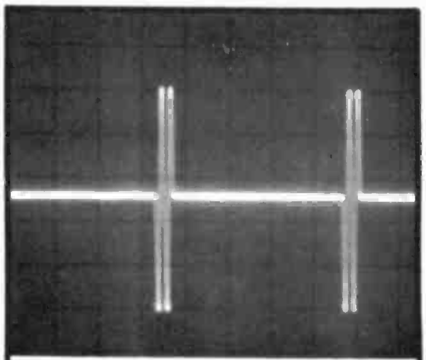
continued from page 77

Note, that the waveform is exactly four vertical divisions in height on the scope face.



5

We then applied a tone-burst signal to the amplifier and increased its amplitude until the 10-kHz sinewave bursts reached the clipping level (Fig. 6). This time, the overall amplitude was five vertical divisions. Calculating the voltage level for 102 watts (8-ohm resistive loads) we determined that the RMS voltage in Fig. 5 was 28.57. Five-fourths of that voltage (the amplitude in Fig. 6) equals 35.71 volts RMS which, translated to power across an 8-ohm load, equals 159.38 watts! Hitachi claims a "dynamic power" or music power output rating of a whopping 160 watts-per-channel and, according to the above calculations, they come close enough to meeting that amazing figure.



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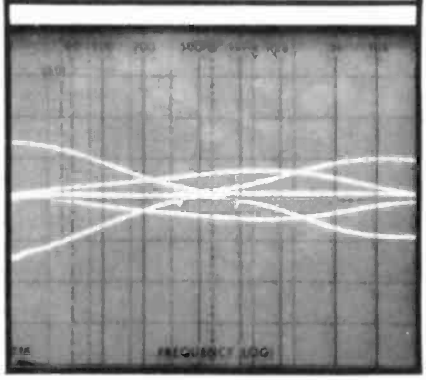


7

Phono preamplifier performance was quite good, with an input overload figure that should pose no problems with just about any cartridge and extremely accurate RIAA playback response. Bass, mid-range, and treble control range are shown in Fig. 7, while the

continued on page 84

LOOKING AHEAD
continued from page 4

for random-access tuning of up to seven channels, plus almost every function you'd normally find on the front of the set.

Pianocorder: The player piano is back, but now it uses digital electronics. Early next year, Superscope will market Pianocorder, which uses audio cassettes to do exactly what the old piano roll used to do, but better. Installed in a piano, it can bring concert and jazz pianists into the home in actual live performance, since it activates the piano's mechanism rather than using electronic reproduction. And it does one thing a player piano never could do—it can record an actual performance on the piano, and thus could be a boon for serious music students and performers.

Developing the Pianocorder was a labor of love for Superscope Chairman Joseph Tushinsky, who owns what is probably the world's largest and greatest collection of player pianos and piano rolls. Superscope will record some of the world's greatest piano-roll performances onto digital cassettes for the Pianocorder, and also will make available newly recorded works played by contemporary artists. The pianocorder will cost about $1,200 and must be professionally installed. The customer supplies the piano.

DAVID LACHENBRUCH
CONTRIBUTING EDITOR

RF SIGNAL GENERATORS

continued from page 51

When UHF signal generation is required, the L-C oscillator becomes hard to use. Stray inductance and capacitance must be reduced to an absolute minimum to reach the highest frequencies. An alternative to the L-C oscillator for these applications is either the cavity or shortened transmission line. In either type, the fundamental signal is no longer developed by independent inductance and capacitance, but uses the

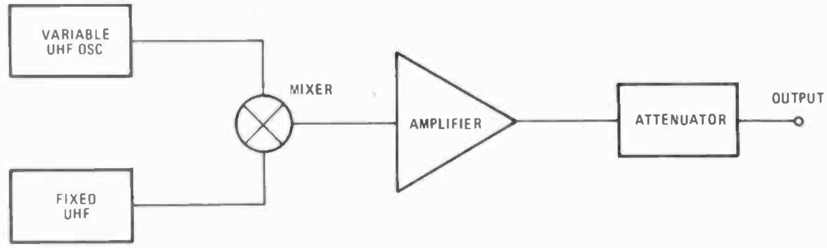


FIG. 6—UHF OSCILLATORS usually consist of a fixed cavity-type oscillator and a variable oscillator.

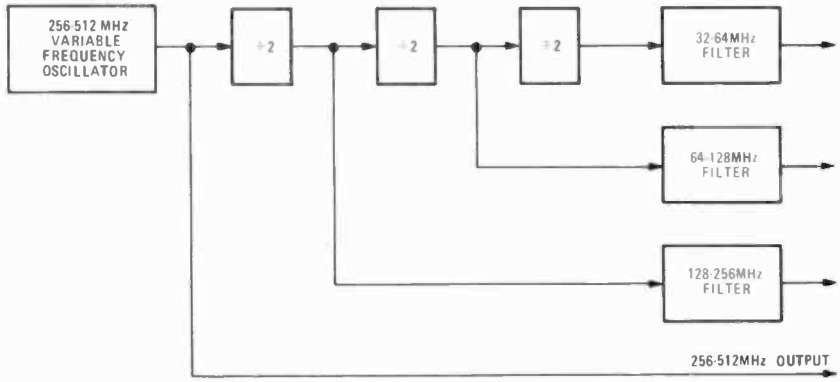


FIG. 7—ANOTHER UHF TECHNIQUE uses a tunable cavity oscillator and fixed dividers.

lump constant characteristics of transmission lines or coaxial cavities instead.

The cavity has considerably higher Q than an L–C circuit. The disadvantage of the cavity is normally one of size. Cavity dimensions may run from one-quarter of a wavelength to a full wavelength, thus making the cavity unsuitable for operation below 300 to 400 MHz. Cavities cannot be easily bandswitched, so other techniques must be used in generators that must cover a wide range of frequencies.

One technique is shown in Fig. 6. The output of the cavity and the output of a fixed oscillator are mixed to generate a lower frequency signal. Both the cavity and the fixed frequency oscillator operate at considerably higher frequencies than the desired generator output. Although only one oscillator is shown as a variable frequency cavity, both oscillators may be variable frequency cavities in certain generator designs. Modern cavity circuits are electronically tuned by an extremely high quality variable-capacitance diode. Such techniques require only simple feedback circuits to maintain frequency stability.

An alternate scheme presently used by Hewlett-Packard (see Fig. 7) is a tunable cavity oscillator with an upper limit of 512 MHz. The output of this oscillator is either used directly or applied to the input of high-speed flip-flops. The flip-flop output frequency is exactly one-half the oscillator frequency. All frequencies are covered, as the cavity oscillator has a tuning ratio of slightly more than 2:1. Although the output of a flip-flop is a squarewave, suitable filtering is inserted, on a bandswitch basis, to remove the odd harmonic components, thus producing a spectrally pure signal. As more high-speed logic becomes available, it seems reasonable this technique may become common.

Extended high-frequency operation can be obtained by using frequency doublers. They normally consist of diodes along with suitable filtering circuits to provide an output at twice the input frequency.

Two forms of additional frequency control are currently used on modern signal generator designs to get higher stability. In the first and simplest form, a variable-capacitance diode is placed in shunt with the tuning capacitor of the L–C oscillator. The electronic tuning range provided by the variable-capacitance diode is limited. Frequency comparison circuitry compares the generator frequency to an external standard frequency and supplies error correction to the electronic tuning circuits. These circuits lock the generator to the standard signal over a limited frequency range.

In the second, and more involved mode of electronic frequency control, the oscillator frequency is corrected by a variable-capacitance diode. An error signal is derived from digital circuitry that compares the measured generator frequency to the original frequency setting of the signal generator. Any difference between the frequency displayed at the front panel and the currently measured frequency generates an error signal that is fed to the variable-capacitance diode to bring the generator back on frequency. If the operator wants to change the generator frequency, the digital frequency meter is switched from this locking mode to a simple frequency measurement mode, and the measured frequency is displayed on the front panel. Although complete electronic tuning of oscillators is possible, it is not yet widely used on radio-frequency signal generators because of the difficulties that arise when attempting to provide very slight amounts of frequency modulation.

Next time we'll continue with a careful examination of modulators and attenuators.

(to be continued)

SOUND FOR HOME MOVIES

continued from page 48

on and the SCR conducts. A higher control current will discharge C3 faster and the SCR will turn on sooner. Waveforms at various points in this circuit are shown in Fig. 3. This control current is the analog signal that has to be provided by the rest of the synchronizer.

Let's take a closer look at how the control current affects circuit operation. With no control current, the collector of Q5 will stay near V++ and the SCR will not trigger, so that the projector would not run. If we look at what happens when the AC line passes through zero volts, we find that Q4 is conducting and the base of Q5 is grounded, which means that Q5 is cut off. At this moment, C3 charges towards V++ through R10. As soon as the AC line waveform gets away from zero, Q4 will cut off. If no control current is present, Q5 will also remain cut off and C3 will remain fully charged, cutting off Q6 and ensuring that the SCR will *not* trigger. When control current is present, Q5 will conduct and the voltage at the collector of Q5 will drop toward ground, as shown in Fig. 3-b.

Control current from somewhere is absolutely necessary to run the circuit, and it can be from as simple a thing as a resistor or pot. A simple current-control that provides rather crude control of my machine consists of a 12,000-ohm resistor and 10,000-ohm pot in series from +12 volts to the collector of Q4.

The remainder of Fig. 2 is a simple power supply. A 12-volt, 1-watt Zener diode was tacked onto the logic board (not shown) for regulation. I connected the projector's original low-voltage winding in series with a small filament transformer to obtain a reasonable supply with a very small transformer that was on hand.

Construction

The circuit shown in Fig. 2 was assembled on one PC board and mounted in the projector on an aluminum bracket. The foil pattern is shown in Fig. 4 and component layout is shown in Fig. 5. Note that the components are mounted on the foil side of the board, and that the foil pattern is shown from this side. The aluminum bracket also served as a heatsink for SCR1. The whole assembly went quite neatly into the area formerly occupied by the rheostat, as shown in Fig. 6.

The bracket also held a miniature pot that I connected to the projector's speed control knob. I wanted to retain the function of the speed control knob when the machine was running without an external control signal. (The pot is hooked up in the synchronizer circuit, not shown in this article.) Figure 7

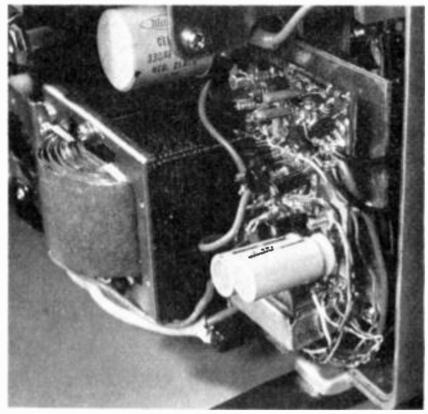


FIG. 6—PC BOARD mounted inside projector.

function of the speed control knob when the machine was running without an external control signal. (The pot is hooked up in the synchronizer circuit, not shown in this article.) Figure 7

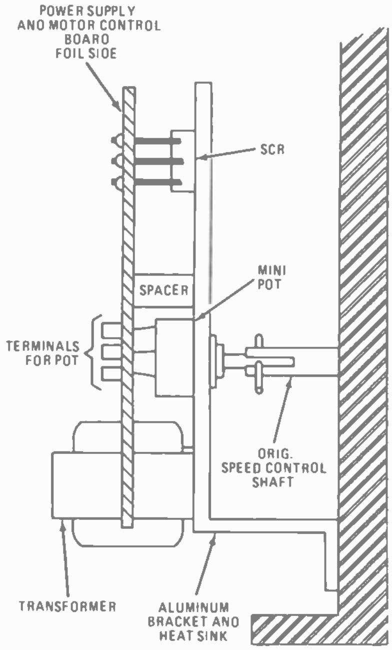


FIG. 7—MOUNTING DETAILS of the PC board.

shows a detailed side view of how the PC board was mounted.

The other thing the projector has to provide is some signal indicating when one frame has gone through. In every projector I have ever seen, the mechanism is built around a shaft that goes around once for every frame of film.

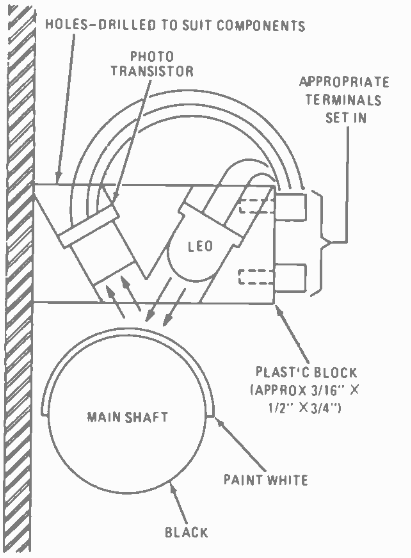


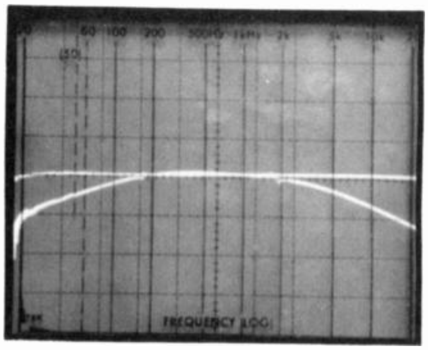
FIG. 8—COMPARISON SIGNAL is generated by an LED and photo-transistor mounted over the main shaft.

This provides a number of possibilities. The method I used is illustrated in Fig. 8. A white stripe is painted on a spot on the shaft and is illuminated by an LED. Every time the stripe goes by, the phototransistor produces an output that is amplified and used. The photo-pickoff is mounted near the projector's inching knob. This type of pickoff needs no alterations to the projector mechanism.

R-E TESTS HITACHI SR-903

continued from page 78

low- and high-cut filter action is shown in Fig. 8. We felt that the filter slope was too gentle, and cutoff points were set too far within the musical frequency spectrum.



Summary

Our overall product analysis for the Hitachi *model SR-903* is found in Table III, along with our summary comments. All our tests indicate that Hitachi's innovative output circuit is a significant achievement in audio design and offers clear consumer benefits. Until we see examples of proposed Class-D or "switching" amplifiers that promise even greater efficiency, the *model SR-903* stands alone among high-efficiency, excellent-performing all-in-one receivers. Clearly, more than "energy conservation" is involved in this design. The reduced heat-sink requirements and the significantly lower heat dissipation of this receiver should help give years of trouble-free service and reproduce music with greater dynamic range capability than its "continuous power" rating would suggest. **R-E**

RCA promoting service centers through Yellow Pages campaign

A nationwide campaign to encourage all authorized RCA service centers to list their names in the Yellow Pages under the heading "RCA Authorized Servicenters" is now under way, reports Arnold T. Valencia of RCA Sales Corp. This single listing, he believes, will benefit the servicenters by providing additional advertising exposure and will assist the public in finding service.

"We hope," said Mr. Valencia, "to increase the number of RCA Authorized Servicenters in the Yellow Pages from the present 1,200 to a level approaching the total 10,000 that exist in the country."

Double low-pass filters kill spurious emissions

Through the use of special networks in the transmitter/loading circuits, plus double low-pass filters in the output of both solid-state and tube RF amplifiers, Palomar Electronics has reduced harmonic content to a figure greater than 45-dB average. The filter system has been incorporated in all Palomar products made after April 15, 1977, in conformance with the FCC order related to Part 97.73 of FCC regulations.

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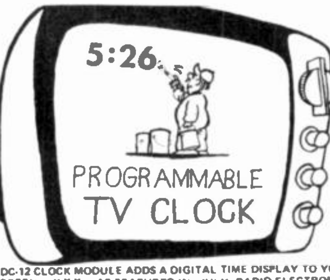

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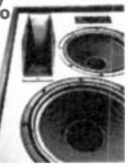

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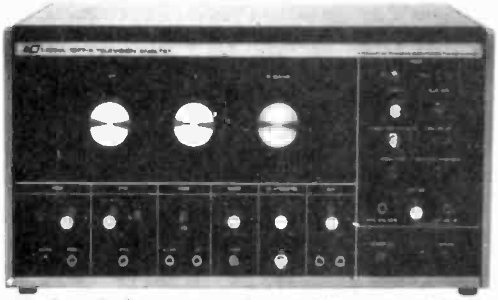

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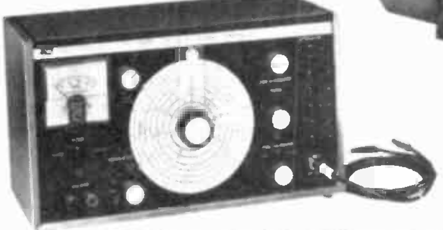

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74L10	.29	74L74	.56	74L164	2.25
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74LS04	.36	74LS42	1.40	74LS164	2.20
74LS08	.38	74LS74	.59	74LS193	2.20
74LS10	.36	74LS90	1.30	74LS197	2.20
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74H01	.25	74H30	.25	74H62	.25
74H04	.25	74H40	.25	74H74	.39
74H08	.25	74H50	.25	74H101	.58
74H10	.25	74H52	.25	74H102	.58
74H11	.25	74H53	.25	74H103	.60
74H20	.25	74H55	.25	74H106	.72
74H21	.25	74H60	.25	74H108	.72

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4006A	1.35	4022A	.94	4071A	.26
4007A	.26	4023A	.25	4072A	.35
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74C04	.44	74C107	1.13	74C164	2.66
74C08	.68	74C151	2.62	74C173	2.22
74C10	.35	74C154	3.15	74C195	2.26
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304	Neg V Reg TO-5	.80
305	Pos V Reg TO-5	.71
307	Op AMP (super 741) mDIP TO-5	.26
308	Micro Pwr Op Amp mDIP TO-5	.89
309K	5V 1A regulator TO-3	1.35
310	V Follower Op Amp mDIP	1.07
311	Hi perf V Comp mDIP TO-5	.95
319	Hi Speed Dual Comp DIP	1.13
320T	Neg Reg 5, 12, TO-220	1.39
320K	Neg Reg 5.2, 12 TO-3	1.39
322	Precision Timer DIP	1.70
324	Quad Op Amp DIP	1.52
339	Quad Comparator DIP	1.58
340K	Pos V reg (5V, 6V, 8V, 12V, 15V, 18V, 24V) TO-3	1.69
340T	Pos V reg (5V, 6V, 8V, 12V, 15V, 18V, 24V) TO-220	1.49
372	AF-IF Strip detector DIP	2.93
373	AM/FM/SSB Strip DIP	2.42
376	Pos V Reg mDIP	.68
380	2w Audio Amp DIP	1.30
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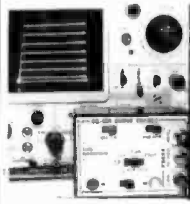

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1N914	.10	2N962	.40	2N2221	.25	2N2914	1.20	2N3771	1.75	2N4402	.20
		2N967	.50	2N2221A	.30	2N2916A	3.65	2N3772	1.90	2N4403	.20
2N173	1.75	2N1136	1.35	2N2222	.25	2N3019	.50	2N3773	3.00	2N4409	.20
2N178	.90	2N1142	2.25	2N2222A	.30	2N3053	.30	2N3819	.32	2N4410	.25
2N327A	1.15	2N1302	1.25	2N2270	.40	2N3054	.70	2N3823	.70	2N4416	.75
2N334	1.20	2N1305	.75	2N2322	1.00	2N3055	.75	2N3856	.20	2N4441	.85
2N336	.90	2N1377	.75	2N2323	1.00	2N3227	1.00	2N3866	.85	2N4442	.90
2N338A	1.05	2N1420	.20	2N2324	1.35	2N3247	3.40	2N3903	.20	2N4443	1.20
2N398B	.90	2N1483	.95	2N2325	2.00	2N3250	.50	2N3904	.20	2N4852	.55
2N404	.75	2N1540	.90	2N2326	2.85	2N3375	6.50	2N3905	.20	2N5061	.30
2N443	1.75	2N1543	2.70	2N2327	3.80	2N3393	.20	2N3906	.25	2N5064	.50
2N456	1.10	2N1544	.80	2N2328	4.20	2N3394	.17	2N3925	3.75	2N5130	.20
2N501A	3.00	2N1549	1.25	2N2329	4.75	2N3414	.17	2N3954	3.50	2N5133	.15
2N508A	.45	2N1551	2.50	2N2368	.25	2N3415	.18	2N3954A	3.75	2N5138	.15
2N555	.45	2N1552	3.25	2N2369	.25	2N3416	.19	2N3955	2.45	2N5198	3.75
2N652A	.85	2N1554	1.25	2N2484	.32	2N3417	.20	2N3957	1.25	2N5294	.50
2N677C	6.00	2N1557	1.15	2N2712	.18	2N3442	1.85	2N3958	1.20	2N5296	.50
2N706	.25	2N1560	2.80	2N2894	.40	2N3553	1.50	2N4037	.60	2N5306	.20
2N706B	.40	2N1605	.35	2N2903	3.30	2N3563	.20	2N4093	.85	2N5354	.20
2N711	.50	2N1613	.30	2N2904	.25	2N3565	.20	2N4124	.20	2N5369	.20
2N711B	.60	2N1711	.30	2N2904A	.30	2N3638	.20	2N4126	.20	2N5400	.40
2N718	.25	2N1907	4.10	2N2905	.25	2N3642	.20	2N4141	.20	2N5401	.50
2N718A	.30	2N2060	1.85	2N2905A	.30	2N3643	.15	2N4142	.20	2N5457	.35
2N720A	.50	2N2102	.40	2N2906	.25	2N3645	.15	2N4143	.20	2N5458	.30
2N918	.35	2N2218	.25	2N2906A	.30	2N3646	.14	2N4220A	.45	C103y	.25
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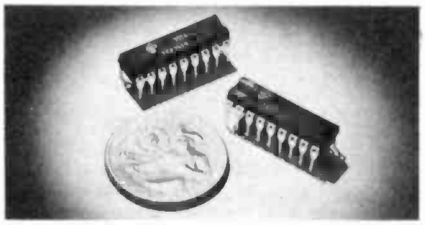

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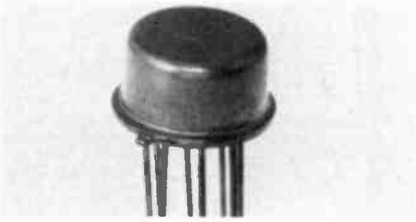

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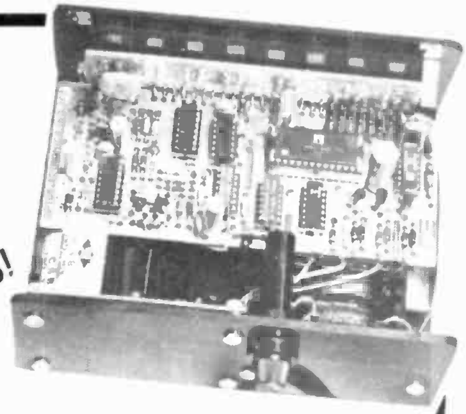
FREQUENCY COUNTER

TAKE ADVANTAGE OF THIS NEW STATE-OF-THE-ART COUNTER FEATURING THE MANY BENEFITS OF CUSTOM LSI CIRCUITRY. THIS NEW TECHNOLOGY APPROACH TO INSTRUMENTATION YIELDS ENHANCED PERFORMANCE, SMALLER PHYSICAL SIZE, DRASTICALLY REDUCED POWER CONSUMPTION [PORTABLE BATTERY OPERATION IS NOW PRACTICAL], DEPENDABILITY, EASY ASSEMBLY AND REVOLUTIONARY LOWER PRICING!



.4" DIGITS!

SIZE: 3" High, 6" Wide, 5½" Deep

1¾ LBS. COLOR: BLACK

FACTORY DIRECT PRICES

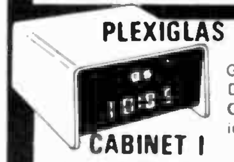
KIT #FC-50 C	60 MHZ	COUNTER WITH CABINET & P.S.	$99.85
KIT #PSL-350	350 MHZ	PRESCALER [NOT SHOWN]	23.95
KIT #PSL-650	650 MHZ	PRESCALER [NOT SHOWN]	29.95
MODEL #FC-50WT	60 MHZ	COUNTER WIRED, TESTED & CAL.	165.95
MODEL #FC-50/600 WT	600 MHZ	COUNTER WIRED, TESTED & CAL.	199.95

KIT #FC-50C IS COMPLETE WITH PREDRILLED CHASSIS ALL HARDWARE AND STEP-BY-STEP INSTRUCTIONS. WIRED & TESTED UNITS ARE CALIBRATED AND GUARANTEED. PRESCALERS WILL FIT INSIDE COUNTER CABINET.

FEATURES AND SPECIFICATIONS:

DISPLAY: 8 RED LED DIGITS .4" CHARACTER HEIGHT
GATE TIMES: 1 SECOND AND 1/10 SECOND [AUTO DEC. PT. PLACEMENT]
RESOLUTION: 1 HZ AT 1 SECOND, 10 HZ AT 1/10 SECOND
FREQUENCY RANGE: 10 HZ TO 60 MHZ. [65 MHZ TYPICAL]
SENSITIVITY: 10 MV RMS TO 50 MHZ, 20 MV RMS TO 60 MHZ TYP.
INPUT IMPEDANCE: 1 MEGOHM AND 20 PF [DIODE PROTECTED INPUT FOR OVER VOLTAGE PROTECTION]
ACCURACY: ± 1 PPM [± .0001%] AFTER CALIBRATION TYPICAL
STABILITY: WITHIN 1 PPM PER HOUR AFTER WARM UP [.001% XTAL]
IC PACKAGE COUNT: 8 [ALL SOCKETED]
INTERNAL POWER SUPPLY: 5.2 V DC AT 800 MA REGULATED
INPUT POWER REQUIRED: 8-12 VDC OR 115 VAC AT 50/60 HZ.
POWER CONSUMPTION: 4 WATTS
INPUT CONNECTOR: BNC TYPE

PLEXIGLAS CABINETS



Great for Clocks or any LED Digital project. Clear-Red Chassis serves as Bezel to increase contrast of digital displays.

CABINET I 3"H, 6¼"W, 5½"D

CABINET II 2½"H, 5"W, 4"D

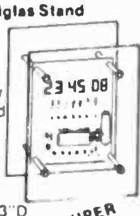
Black, White or Clear Cover $6.50 ea

RED OR GREY PLEXIGLAS FOR DIGITAL BEZELS 3"x6"x1/8" 95¢ ea. 4/$3

SEE THE WORKS Clock Kit Clear Plexiglas Stand

- 6 Big .4" digits
- 12 or 24 hr time
- 3 set switches
- Plug transformer
- all parts included

Plexiglas is Pre-cut & drilled



Kit #850-4 CP

Size: 6"H, 4½"W, 3"D

$23.50 ea 2/$45. A SUPER CLOCK!

60 HZ. XTAL TIME BASE

Will enable Digital Clock Kits or Clock-Calendar Kits to operate from 12V DC. 1"x2" PC Board. Power Req. 5-15V (2.5 MA TYP.) Easy 3 wire hookup. Accuracy ± 2PPM (Adjustable)

#TB-1 Complete Kit $4.95

Wir & Cal $9.95

SPECIAL PRICING!

PRIME - HIGH SPEED RAM

21L02-3 400 NS

LOW POWER - FACTORY FRESH

1-24	$1.95 ea	100-199	$1.60 ea
25-99	1.75 ea	200-499	1.45 ea

OVER 500 PCS. $1.39 ea.

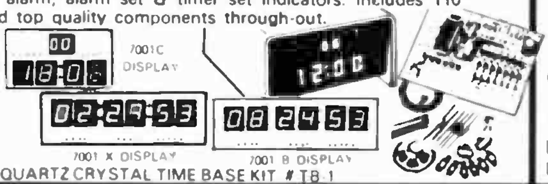
6-DIGIT LED CLOCK CALENDAR KIT

DATE-TIME-SNOOZE ALARM & MORE... KIT 7001

FOR THE BUILDER THAT WANTS THE BEST. FEATURING 12 OR 24 HOUR TIME — 29-30-31 DAY CALENDAR, ALARM, SNOOZE AND AUX. TIMER CIRCUITS

Will alternate time (8 seconds) and date (2 seconds) or may be wired for time or date display only, with other functions on demand. Has built-in oscillator for battery back-up. A loud 24 hour alarm with a repeatable 10 minute snooze alarm, alarm set & timer set indicators. Includes 110 VAC/60Hz power pack with cord and top quality components through-out.

KIT 7001B WITH 6 .5" DIGITS	$39.95
KIT 7001C WITH 4 .6" DIGITS & 2 .3" DIGITS FOR SECONDS	$42.95
KIT 7001X WITH 6 .6" DIGITS	$45.95



KITS ARE COMPLETE (LESS CABINET)

ALL 7001 KITS FIT CABINET I AND ACCEPT QUARTZ CRYSTAL TIME BASE KIT # TB-1

PRINTED CIRCUIT BOARDS for CT 7001 Kits sold separately with assembly info. PC Boards are drilled Fiberglass, solder plated and screened with component layout.

Specify for 7001 B, C or X - $7.95

JUMBO DIGIT CLOCK

A complete Kit (less Cabinet) featuring six .5" digits, MM5314 IC 12/24 Hr. time, PC Boards, Transformer, Line Cord, Switches and all Parts. Ideal Fit in Cabinet II

Kit #5314-5 $19.95 2/$38.

JUMBO DIGIT CONVERSTION KIT $9.95 ea

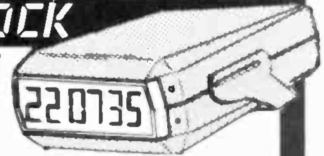
Convert small digit LED clock to large .5" displays. Kit includes 6 - LED's, Multiplex PC Board & Hook up info.

Kit #JD-1CC For Common Cathode
Kit #JD-1CA For Common Anode

MOBILE LED CLOCK

12/24 HR .4" DIGITS!

MODEL #2001 12 VOLT AC or DC POWERED



- 6 JUMBO .4" RED LED'S BEHIND RED FILTER LENS WITH CHROME RIM
- SET TIME FROM FRONT VIA HIDDEN SWITCHES • 12/24-Hr. TIME FORMAT
- STYLISH CHARCOAL GRAY CASE OF MOLDED HIGH TEMP. PLASTIC
- BRIDGE POWER INPUT CIRCUITRY — TWO WIRE NO POLARITY HOOK-UP
- OPTIONAL CONNECTION TO BLANK DISPLAY [Use When Key Off in Car, Etc.
- TOP QUALITY PC BOARDS & COMPONENTS - INSTRUCTIONS.
- MOUNTING BRACKET INCLUDED

KIT #2001 COMPLETE KIT [Less 9V. Battery] $29.95 EA · 3 OR MORE $27.95 EA · 115 VAC Power Pack #AC-1 $2.50 EA

ASSEMBLED UNITS WIRED & TESTED ORDER #2001 WT [LESS 9V. BATTERY] Wired for 12-Hr. Op. if not otherwise specified $39.95 EA · 3 OR MORE $37.95 EA

AUTO BURGLAR ALARM KIT

AN EASY TO ASSEMBLE AND EASY TO INSTALL ALARM PROVIDING MANY FEATURES NOT NORMALLY FOUND. KEYLESS ALARM HAS PROVISION FOR POS. & GROUNDING SWITCHES OR SENSORS. WILL PULSE HORN RELAY AT 1HZ RATE OR DRIVE SIREN. KIT PROVIDES PROGRAMMABLE TIME DELAYS FOR EXIT, ENTRY & ALARM PERIOD. UNIT MOUNTS UNDER DASH. REMOTE SWITCH CAN BE MOUNTED WHERE DESIRED. CMOS RELIABILITY RESISTS FALSE ALARMS & PROVIDES FOR ULTRA DEPENDABLE ALARM. DO NOT BE FOOLED BY LOW PRICES! THIS IS A TOP QUALITY COMPLETE KIT WITH ALL PARTS INCLUDING DETAILED DRAWINGS AND INSTRUCTIONS OR AVAILABLE WIRED AND TESTED

KIT #ALR-1 $9.95

#ALR-1WT WIRED & TESTED $19.95

VARIABLE REGULATED 1 AMP POWER SUPPLY KIT

- VARIABLE FROM 4 to 14V
- SHORT CIRCUIT PROOF
- 723 IC REGULATOR
- 2N3055 PASS TRANSISTOR
- CURRENT LIMITING AT 1 Amp

KIT IS COMPLETE INCLUDING DRILLED & SOLDER PLATED FIBERGLASS PC BOARD AND ALL PARTS (Less TRANSFORMER) KIT #PS-01 $8.95

TRANSFORMER 24V CT will provide 300MA at 12V and 1 Amp at 5V. $3.50

OPTOELECTRONICS, INC.

BOX 219 • HOLLYWOOD, FLA. 33022 • (305) 921-2056

STORE: 823 S. 21 AVE.

master charge · BANKAMERICARD

ORDER BY PHONE OR MAIL
COD ORDERS WELCOME
Orders Under $15 Add $1.00 Handling
Fla. Res. Please Add 4% Sales Tax.

WE PAY ALL SHIPPING IN CONTINENTAL USA — OTHERS ADD 5% (10% FOR AIRMAIL)

CIRCLE 37 ON FREE INFORMATION CARD

CRYSTALS

THESE FREQUENCIES ONLY

Part #	Frequency	Case/Style	Price
CY1A	1.000 MHz	HC33/U	$5.95
CY2A	2.000 MHz	HC33/U	$5.95
CY2.01	2.010 MHz	HC33/U	$1.95
CY3A	4.000 MHz	HC18/U	$4.95
CY7A	5.000 MHz	HC18/U	$4.95
CY12A	10.000 MHz	HC18/U	$4.95
CY14A	14.31818 MHz	HC18U	$4.95
CY19A	18.000 MHz	HC18/U	$4.95
CY22A	20.000 MHz	HC18/U	$4.95
CY30B	32.000 MHz	HC18/U	$4.95

MICROPROCESSOR COMPONENTS

8080A	CPU	$19.95	8228	System Controller - Bus Driver	$10.95
8212	8 Bit Input/Output	4.95	MC6800L	8 Bit MPU	35.00
8214	Priority Interrupt Control	15.95	MC6820L	Periph. Interface Adapter	15.00
8216	Bi-Directional Bus Driver	6.95	MC6810AP1	128 x 8 Static RAM	6.00
8224	Clock Generator/Driver	10.95	MC6830L8	1024 x 8 Bit ROM	18.00
CDP1802	with user manual	39.95	Z80	CPU	49.95

CPU'S

8080	Super 8008	24.95
8080A	Super 8008	19.95
2650	8 BIT MPU	26.50

SR'S

2504	1024 Dynamic	$3.95
2518	Hex 32 BIT	7.00
2519	Hex 40 BIT	4.00
2524	512 Dynamic	2.49
2525	1024 Dynamic	6.00
2527	Dual 256 BIT	3.95
2529	Dual 512 BIT	4.00
2532	Quad 80 BIT	3.95
2533	1024 Static	Special 5.95
3341	Fifo	6.95
74LS670	16 x 4 Reg	3.95

UART'S

AY-5-1013	30K Baud	$5.95

ROM'S

2513(2140)	Char. Gen. (upper case)	$9.95
2513(3021)	Char. Gen. (lower case)	9.95
2516	Char. Gen.	10.95

RAM'S

1101	256 x 1	Static	$1.49
2101	256 x 4	Static	5.95
2102	1024 x 1	Static	1.75
2107/5280	4096 x 1	Dynamic	4.95
2111	256 x 4	Static	6.95
7489	16 x 4	Static	2.49
8101	256 x 4	Static	6.95
5111	256 x 4	Static	6.95
8599	16 x 4	Static	3.49
91L02	1024 x 1	Static	2.25
74200	256 x 1	Static	6.95
93421	256 x 1	Static	2.95
MM5262	2K x 1	Dynamic	2 for 1.00

PROMS

1702A	2048	Famos	$9.95
5203	2048	Famos	14.95
82S23	32 x 8	Open C	5.00
82S123	32 x 8	Tristate	5.00
74S287	1024	Static	7.95
3601	256 x 4	Fast	3.95
2708	8K	Eprom	29.95
6301-1	1024	Tri-State Bipolar	3.49
6330-1	256	Open Collector Bipolar	2.98
6331-1	256	Tri-State Bipolar	2.95

Timeband

A Trademark of Fairchild Camera and Instrument Corporation

Digital Alarm Clocks

- 24-hour alarm
- Doze Button
- 100% Solid State
- Large Red Led Display (.8" high)
- AM/PM Indicator
- Seconds display at touch of button
- Power failure indicator
- One year factory warranty

C-500 - Ivory Case
C-500B - Ebony Case
$16.95

C-8211
Woodgrain Case
$19.95

EXAR

XR-2206K8 Kit $29.95 **Special** XR-2206KA Kit $19.95

WAVEFORM GENERATORS		MISCELLANEOUS		TIMERS	
XR-205	$8.40	XR-2211CP	$6.70	XR-555CP	$.39
XR-2206CP	4.49	XR-4136	.99	XR-320P	1.55
XR-2207CP	3.85			XR-556CP	1.85
				XR-2556CP	3.20
				XR-2240CP	3.25

STEREO DECODERS				PHASE LOCKED LOOPS	
XR-1310CP	$3.20	XR-1468	3.85	XR-210	5.20
XR-1310EP	3.20	XR-1488	5.80	XR-215	6.60
XR-1800P	3.20	XR-1489	4.80	XR-567CP	1.95
XR-2567	2.99	XR-2208	5.20	XR-567CT	1.70

SPECIAL REQUESTED ITEMS

FCM3817	$5.00					8T97	2.00
AY-3-8500-1	$16.95						
MC3061P	3.50	CD4508	6.75	82S115	25.00	3341	6.95
MC4016P (74416)	7.50	CD4515	6.50	5841	9.95	9368	3.95
MC14583	3.50	CD4520	2.70	MK50240	17.50	MC1408L7	9.95
MC14562	14.50	MCM6571	17.50	11C90	19.95	LD110/LD111	25.00 set
CD4059	9.95	MCM6574	17.50	DS0026CH	3.75	AY-5-9100	17.50 ea
CD4070	.95	MCM6575	17.50	TIL308	10.50	95H90	13.95
MC14409	14.95	MC14419	14.95	ICM7208	22.00	ICM7209	7.50
MC14410	14.95	ICM7045	24.95	ICM7207	7.50	HD0165	7.95

DIGITAL AUTO INSTRUMENT

SEVEN DIFFERENT INSTRUMENTS!

MEETS OR EXCEEDS ORIGINAL AUTOMOTIVE SPECS

Please specify which **one** *of the seven models you want when ordering – these* **do not** *all come in one unit. Each model must be bought separately.*

1. TACHOMETER 0-9900 RPM 4, 6 or 8 Cylinders
2. WATER TEMP 100-250° F
3. FUEL LEVEL Percentage Low Fuel Indicator
4. SPEEDOMETER* 0-99 MPH
5. OIL PRESSURE 0-80 PSI
6. OIL TEMP 200-350° F
7. BATTERY MONITOR ±.1 Volts From 11-15 VDC

BRIGHT YELLOW ORANGE 3" LED DISPLAY!

Kit includes case, bracket and all components — complete. Nothing else to buy! 12 Volt NEG GRD.

DIMENSIONS 4½ x 4 x 2

KIT: $49.95

* Add $10.00 for required speed transducer **ASSEMBLED: $59.95**

CONNECTORS

PRINTED CIRCUIT EDGE-CARD

156 Spacing-Tin-Double Read-Out
Bifurcated Contacts — Fits .054 to .070 P.C. Cards

15/30	PINS (Solder Eyelet)	$1.95
18/36	PINS (Solder Eyelet)	$2.49
22/44	PINS (Solder Eyelet)	$2.95
50/100 (.100 Spacing)	PINS (Solder Eyelet)	$6.95

25 PIN-D SUBMINIATURE

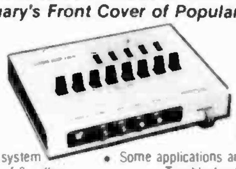
DB25P	PLUG	$3.25
DB25S	SOCKET	$4.95

PARATRONICS

ALLOW 1 TO 3 WEEKS DELIVERY

Featured on February's Front Cover of Popular Electronics

Logic Analyzer Kit



MODEL 100A
$189.00/Kit

- Analyzes any type of digital system
- Checks data rates in excess of 8 million words per second
- Trouble shoot TTL, CMOS, DTL, RTL, Schottky and MOS families
- Displays 16 logic states up to 8 digits wide
- See ones and zeros displayed on your CRT, octal or hexadecimal format
- Tests circuits under actual operating conditions
- Easy to assemble — comes with step-by-step construction manual which includes 80 pages on logic analyzer operation.
- Some applications are:
  — Troubleshooting microprocessor address, instruction, and data flow
  — Examine contents of ROMS
  — Tracing operation of control logic
  — Checking counter and shift register operation
  — Monitoring I/O sequences
  — Verifying proper system operations during testing

DIGITAL STOPWATCH

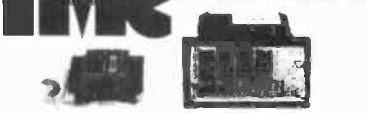
- Bright 6 Digit LED Display
- Times to 59 minutes 59.59 seconds
- Crystal Controlled Time Base
- Three Stopwatches in One
  Times Single Event — Split & Taylor
- Size 4.5 x 2.15 x .90 (4½ ounces)
- Uses 3 Penlite Cells

Kit — $39.95
Assembled — $49.95
Heavy Duty Carry Case $5.95

Stop Watch Chip Only (7205) $19.95

IMC

3½ DIGIT DVM KIT



This 0-2 VDC .05 per cent digital voltmeter features the Motorola 3½ digit DVM chip set. It has a .4" LED display and operates from a single +5V power supply. The unit is provided complete with an injection molded black plastic case complete with Bezel. An optional power supply is available which fits into the same case as the 0-2V DVM allowing 117 VAC operation.

A. 0-2V DVM with Case	$49.95
B. 5V Power Supply	$14.95

AUTOTEL

AUTOTEL — an audible alarm kit indicating potential engine damage. An audible signal (70 db pulsing) immediately forewarns a malfunction or failure. There is no sound during normal operation. Features CMOS circuitry. 2½" x 2½" x ⅝" case. Complete kit with all components, hardware and case.

SPECIAL $6.95/Kit

Vector

Etching Kits

32 X A-1	P.C. Etch Materials Kit enough for 5 circuit boards	$29.95 ea.
27 X A-1	Etched Circuit Kit Complete kit — only add water	$ 9.95 ea.

Plugboards

3662	6.5 X 4.5 X 1/16 Epoxy glass P-Pattern-44 P.C. Tabs spaced .156"	$ 6.95 ea.
8800V	Universal Microcomputer/Processor plugboard — Epoxy Glass — complete with heatsink and mounting hardware 5.313 x 10 X 1/16 copper clad	$19.95 ea.

BUGBOOK®

Continuing Education Series

BUGBOOK I & II - Basic concepts of TTL Logic — over 90 experiments **$17.00/set**

BUGBOOK IIa - Introduces UART — recommended for RTTY enthusiast **$5.00/book**

BUGBOOK III - Explores 8080 chip — introduces Mark 80 Microcomputer **$15.00/book**

555 TIMER APPLICATIONS SOURCEBOOK WITH EXPERIMENTS — over 100 design techniques **$6.95/book**

CMOS-M-DESIGNERS PRIMER AND HANDBOOK a complete CMOS instruction manual **$6.00**

Introductory Offer — all 6 books (worth $49.95)
SPECIAL - $42.95

QUARTZ DIGITAL AUTO CLOCK OR ELAPSED TIMER!

Elapsed Timer: Hrs, Mins and Secs
12 or 24 Hr Capacity
Simple Reset - Start Pushbutton Control

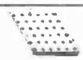
Complete kit includes mounting bracket, case and all components, nothing else to buy. Features MM5314 chip; Large .4" LED's. Accuracy better than ± min. per mo. internal battery backup. 12 volt non-polar operation.

DIMENSIONS 4½ x 4 x 2
12 or 24 HOUR MODE

Kit: $29.95
Assembled: $39.95

CASE ONLY (includes hardware, mounting bracket and bezel) **$6.50**

1/16 VECTOR BOARD



0.1" Hole Spacing, P-Pattern

	Part No.	L	W	Price 1	2-Up
PHENOLIC	64P44 062XXXP	4.50	6.50	1.72	1.54
	169P44 062XXXP	4.50	17.00	3.69	3.32
EPOXY GLASS	64P44 062	4.50	6.50	2.07	1.86
	84P44 062	4.50	8.50	2.56	2.31
	169P44 062	4.50	17.00	5.04	4.53
	169P84 062	8.50	17.00	9.23	8.26
EPOXY GLASS COPPER CLAD	169P44 062C1	4.50	17.00	6.80	6.12

HEAT SINKS

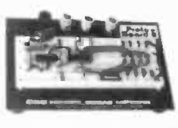
205CB 680-75A

205-CB	Beryllium Copper Heat Sink with Black Finish for TO-5	$.25
291-36H	Aluminum Heat Sink for TO-220 Transistors & Regulators	$.25
680-75A	Black Anodized Aluminum For TO-3	$1.60

CONTINENTAL SPECIALTIES

PROTO BOARD 6

$15.95
(6" long X 4" wide)



Other CS Proto Boards

PB100 - 4.5" x 6"	$ 19.95
PB101 - 5.8" x 4.5"	29.95
PB102 - 7" x 4.5"	39.95
PB103 - 9" x 6"	59.95
PB104 - 9.5" x 8"	79.95
PB203 - 9.75 x 6½ x 2¾	75.00
PB203A - 9.75 x 6½ x 2¾ (includes power supply)	120.00

Logic Monitor $84.95
for DTL, HTL, TTL or CMOS Devices

PROTO CLIPS

14 PIN	$4.50
16 PIN	4.75
24 PIN	8.50

DESIGN MATES

DM1 - Circuit Designer 54.95
DM2 - Function Generator 69.95
DM3 - RC Bridge 59.95

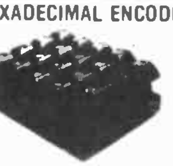
JE700 CLOCK

12 or 24 Hour
115 VAC

The JE700 is a low cost digital clock, but is a very high quality unit. The unit features a simulated walnut case with dimensions of 6" x 2½" x 1". It utilizes a MAN72 high brightness readout, and the MM5314 clock chip.

$17.95

HEXADECIMAL ENCODER 19-KEY PAD



- 1 - 0
- ABCDEF
- Return Key
- Optional Key (Period)
- — Key

$10.95 each

DIGITAL CLOCK KIT — 3½ INCH DIGITS

4 DIGIT KIT $49.95	4 DIGIT ASSEMBLED $59.95
6 DIGIT KIT $69.95	6 DIGIT ASSEMBLED $79.95

This clock features big 3½" high digits for viewing in offices, auditoriums, etc. Each digit is formed by 31 bright 0.2" LED's. The clock operates from 117 VAC, has either 12 or 24 hr. operation. The 6 digit version is 27" x 3½" x 1½" and the 4 digit is 18" x 3½" x 1½". Kits come complete with all components, case and transformer.

Specify 12 or 24 Hour When Ordering

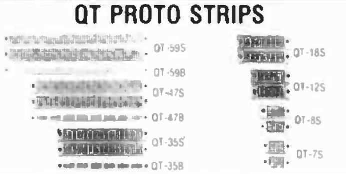
60 KEY KEYBOARD

This keyboard features 60 unencoded SPST keys, unattached to any kind of P.C.B. A very solid molded plastic 13" x 4" base suits most applications.

$19.95

HD0165 16 LINE TO FOUR BIT PARALLEL KEYBOARD ENCODER $7.95

QT PROTO STRIPS

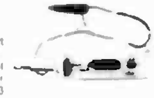


QT type	# holes	price
QT-59S	590	12.50
QT-59B	bus strip	2.50
QT-47S	470	10.00
QT-47B	bus strip	2.25
QT-35S	350	8.50
QT-35B	bus strip	2.00
QT-18S	180	4.75
QT-12S	120	3.75
QT-8S	80	3.25
QT-7S	70	3.00

Experimentor 300	$ 9.95
Experimentor 600	$10.95

JE803 PROBE

The Logic Probe is a unit which is for the most part indespensible in trouble shooting logic families TTL, DTL, RTL, CMOS. It derives the power it needs to operate directly off of the circuit under test, drawing a scant 10 mA max. It uses a MAN3 readout to indicate any of the following states by these symbols (HI) 1 (LOW) 0 (PULSE) P. The Probe can detect high frequency pulses to 45 MHz. It can't be used at MOS levels or circuit damage will result.



$9.95 Per Kit

printed circuit board

TOOLS

A97MS	— Diagonal Cutter - 4" semi-flush cut	$8.50 ea.
A11DMS	— Chain Nose Pliers - 4¾" long	7.50 ea.
T-6	— Wire Stripper - #16 to #26 gauge	3.75 ea.
55B	— Wire Stripper - #10 to #20 gauge	2.50 ea.
CS-8	— Cutter-Crimper Tool - 8¼" long	8.50 ea.
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Nibbling Tool Replacement Punch		3.75 ea.

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SN7403N	.16	SN7472N	.39	SN74157N	.99
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SN7440N	.15	SN74126N	.60	SN74194N	1.25
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CD4022	1.25	CD4071	.45	74C161	3.25
CD4023	.25	CD4081	.45	74C163	3.00
CD4024	1.50	CD4511	2.50	74C164	3.25
CD4025	.25	CD4518	2.50	74C173	2.60
CD4026	$3.95	MC14566	3.00	74C193	2.75
CD4027	.69	74C00N	.39	74C195	2.75
CD4028	1.65	74C02N	.55	MC4044	4.50
CD4029	2.90			MC14016	.56

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LM320K-12	1.35	NE565H	1.25	75452CN	.39
LM320K-15	1.35	NE565N	1.25	75453CN	.39
LM320T-5	1.75	NE566CN	1.25	75454CN	.39
LM320T-5.2	1.75	NE567H	1.95	75491CN	.79
LM320T-8	1.75	NE567V	1.50	75492CN	.89
LM320T-12	1.75	LM703CN	.45	75494CN	.89
LM320T-15	1.75	LM709H	.29	RCA LINEAR	
LM320T-18	1.75	LM709N	.29	CA3013	2.15
LM320T-24	1.75	LM710N	.79	CA3023	2.56
LM323K-5	9.95	LM711N	.39	CA3035	2.48
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LM340T-15	1.75	LM1305N	1.40	CA3130	1.39
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74LS00	.29	74LS74	.49	74LS139	1.95
74LS02	.29	74LS75	.69	74LS151	1.55
74LS03	.29	74LS76	.49	74LS153	1.89
74LS04	.35	74LS83	1.25	74LS157	1.55
74LS05	.35	74LS85	2.49	74LS162	2.25
74LS08	.29	74LS86	.49	74LS163	2.25
74LS10	.29	74LS90	1.25	74LS164	1.95
74LS13	.69	74LS92	1.25	74LS175	1.95
74LS14	1.75	74LS93	1.25	74LS181	3.69
74LS20	.29	74LS95	1.95	74LS190	2.85
74LS26	.39	74LS96	1.89	74LS191	2.85
74LS27	.39	74LS107	.59	74LS192	2.85
74LS28	.39	74LS109	.59	74LS193	2.85
74LS30	.29	74LS112	.59	74LS194	1.89
74LS32	.39	74LS132	1.25	74LS195	1.89
74LS40	.39	74LS136	.59	74LS257	1.75
74LS51	.29	74LS138	1.89	74LS260	.55
74LS55	.29			74LS279	.79
74LS73	.49			74LS670	3.95

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MM5314	6 Digit, 12 or 24 Hour, 50 or 60 Hz	4.95
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CT7001	6 Digit, Calendar, Alarm, 12 or 24 Hour	5.95

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LED

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XC209	Red	10/$1
XC209	Green	4/$1
XC209	Orange	4/$1
XC209	Yellow	4/$1

.190" dia.

XC111	Red	10/$1
XC111	Green	4/$1
XC111	Yellow	4/$1
XC111	Orange	4/$1

.200" dia			.185" dia.			.200" dia.		
XC22	Red	10/$1	XC526	Red	5/$1	XC556	Red	10/$1
XC22	Green	4/$1	XC526	Green	4/$1	XC556	Green	4/$1
XC22	Yellow	4/$1	XC526	Yellow	4/$1	XC556	Yellow	4/$1
XC22	Orange	4/$1	XC526	Orange	4/$1	XC556	Orange	4/$1
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DL 707 DL 338

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MAN 1	Common Anode	.270	2.95	MAN 3640	Common Cathode-orange	.300	1.75
MAN 2	5 x 7 Dot Matrix	.300	4.95	MAN 4710	Common Anode-Red	.400	1.95
MAN 3	Common Cathode	.125	3/1.00	DL701	Common Anode-red	.300	.99
MAN 4	Common Cathode	.187	1.95	DL704	Common Cathode	.300	.99
MAN 7	Common Anode	.300	1.25	DL707	Common Anode	.300	.99
MAN 7G	Common Anode-green	.300	1.95	MAN 4740	Common Anode-Red	.400	.99
MAN 7Y	Common Anode-yellow	.300	1.95	DL741	Common Anode	.600	1.50
MAN 52	Common Anode-green	.300	.99	DL 747	Common Anode	.600	2.25
MAN 64	Common Anode-red	.400	.99	DL 750	Common Cathode	.600	2.49
MAN 74	Common Cathode	.300	1.50	DL 338	Common Cathode	.110	.50
MAN 82	Common Anode-yellow	.300	.99	FND70	Common Cathode	.250	.75
MAN 84	Common Cathode-yellow	.300	.99	FND503	Common Cathode	.500	1.00
MAN 3620	Common Anode-orange	.300	1.75	FND507	Common Anode	.500	1.00

FCS 8000A — 3½ Digit — .8" Display

NEW! 25 Pin version with colon & am/pm indicator

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SPECIAL $4.95 EA.

- Connects almost one for one with 3817, 3817A or D. (3817 available at $5.00 each).
- Typical segment current 8mA except colon, 10 hrs b & c and 10 min. a & d which are 16 mA
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- MAXIMUM FORWARD CURRENT — 25 mA

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- ⅛" Ht. • Common Cathode • Dip Package
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2 Digit	$ .79
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8 pin	$.17	.16	.15	24 pin	$.38	.37	.36
14 pin	.20	.19	.18	28 pin	.45	.44	.42
16 pin	.22	.21	.20	36 pin	.60	.59	.58
18 pin	.29	.28	.27	40 pin	.63	.62	.61
22 pin	.37	.36	.35				

SOLDERTAIL STANDARD (TIN)

14 pin	$.27	.25	.24	28 pin	$.99	.90	.81
16 pin	.30	.27	.25	36 pin	1.39	1.26	1.15
18 pin	.35	.32	.30	40 pin	1.59	1.45	1.30
24 pin	.49	.45	.42				

SOLDERTAIL STANDARD (GOLD)

8 pin	$.30	.27	.24	24 pin	$.70	.63	.57
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16 pin	.38	.35	.32	36 pin	1.75	1.40	1.26
18 pin	.52	.47	.43	40 pin	1.75	1.59	1.45

WIRE WRAP SOCKETS (GOLD) LEVEL #3

10 pin	$.45	.41	.37	24 pin	$1.05	.95	.85
14 pin	.39	.38	.37	28 pin	1.40	1.25	1.10
16 pin	.43	.42	.41	36 pin	1.59	1.45	1.30
18 pin	.75	.68	.62	40 pin	1.75	1.55	1.40

50 PCS. RESISTOR ASSORTMENTS $1.25 PER ASST.

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ASST. 1	8 ea	10 OHM / 27 OHM	12 OHM / 33 OHM	15 OHM / 39 OHM	18 OHM / 47 OHM	22 OHM / 56 OHM	1/4 WATT 5% = 50 PCS
ASST. 2	5 ea	68 OHM / 180 OHM	82 OHM / 220 OHM	100 OHM / 270 OHM	120 OHM / 330 OHM	150 OHM / 390 OHM	1/4 WATT 5% = 50 PCS
ASST. 3	5 ea.	470 OHM / 1.2K	560 OHM / 1.5K	680 OHM / 1.8K	820 OHM / 2.2K	1K / 2.7K	1/4 WATT 5% = 50 PCS.
ASST. 4	5 ea	3.3K / 8.2K	3.9K / 10K	4.7K / 12K	5.6K / 15K	6.8K / 18K	1/4 WATT 5% = 50 PCS.
ASST. 5	5 ea.	22K / 56K	27K / 68K	33K / 82K	39K / 100K	47K / 120K	1/4 WATT 5% = 50 PCS.
ASST. 6	5 ea	150K / 390K	180K / 470K	220K / 560K	270K / 680K	330K / 820K	1/4 WATT 5% = 50 PCS.
ASST. 7	5 ea.	1M / 2.7M	1.2M / 3.3M	1.5M / 3.9M	1.8M / 4.7M	2.2M / 5.6M	1/4 WATT 5% = 50 PCS.

ASST. 8R Includes Resistor Assortments 1-7 (350 PCS.) **$7.49 ea.**

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Complete with built-in bit and sleeve

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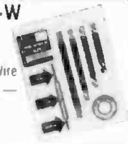
WIRE-WRAP KIT — WK-2-W

WRAP • STRIP • UNWRAP



- Tool for 30 AWG Wire
- Roll of 50 Ft. White or Blue 30 AWG Wire
- 50 pcs. each 1", 2", 3" & 4" lengths — pre-stripped wire.

$11.95

WIRE WRAP TOOL WSU-30

WRAP • STRIP • UNWRAP - $5.95

WIRE WRAP WIRE — 30 AWG

25 ft. min. $1.25 50 ft. $1.95 100 ft. $2.95 1000 ft. $15.00
SPECIFY COLOR — White - Yellow - Red - Green - Blue - Black

Plastic Push Button Switch

- 18 AWG Solid Wire - 5" Long
- .50 (wide) X .60 (high) ⅜-27 Thread
- 8 AMP @ 14 Volt - 1 AMP @ .10 Volt

		1-9	10-Up
J-188-1	Push On-Push Off	.59	.49
J-188-2	Normally Open	.59	.49
J-188-3	Normally Closed	.59	.49

DIP SWITCHES

SPST Slide Action

#206-4	(8 pin dip)	4 switch unit	$1.75 ea.
#206-7	(14 pin dip)	7 switch unit	$1.95 ea.
#206-8	(16 pin dip)	8 switch unit	$2.25 ea.

TV GAME CHIP SET — $14.95

Includes AY-3-8500-1 chip and 2.010 mhz crystal — if purchased separately would cost $18.95.

ZENERS — DIODES — RECTIFIERS

TYPE	VOLTS	W	PRICE	TYPE	VOLTS	W	PRICE
1N746	3.3	400mm	4/1.00	1N4005	600 PIV	1 AMP	10/1.00
1N751A	5.1	400m	4/1.00	1N4006	800 PIV	1 AMP	10/1.00
1N752	5.6	400m	4/1.00	1N4007	1000 PIV	1 AMP	10/1.00
1N753	6.2	400m	4/1.00	1N3600	50	200m	6/1.00
1N754	6.8	400m	4/1.00	1N4148	75	10m	15/1.00
1N959	8.2	400m	6/1.00	1N4154	35	10m	12/1.00
1N965B	15	400m	4/1.00	1N4305	75	25m	20/1.00
1N5232	5.6	500m	.28	1N4734	5.6	1w	.28
1N5234	6.2	500m	.28	1N4735	6.2	1w	.28
1N5235	6.8	500m	.28	1N4736	6.8	1w	.28
1N5236	7.5	500m	.28	1N4738	8.2	1w	.28
1N456	25	40m	6/1.00	1N4742	12	1w	.28
1N458	150	7m	6/1.00	1N4744	15	1w	.28
1N485A	180	10m	6/1.00	1N1183	50 PIV	35 AMP	1.60
1N4001	50 PIV	1 AMP	12/1.00	1N1184	100 PIV	35 AMP	1.70
1N4002	100 PIV	1 AMP	12/1.00	1N1185	150 PIV	35 AMP	1.50
1N4003	200 PIV	1 AMP	12/1.00	1N1186	200 PIV	35 AMP	1.80
1N4004	400 PIV	1 AMP	12/1.00	1N1188	400 PIV	35 AMP	3.00

SCR AND FW BRIDGE RECTIFIERS

C36D	15A @ 400V	SCR	$1.95
C38M	35A @ 200V	SCR	1.95
2N2328	1.6A @ 200V	SCR	.50
MDA 980-1	12A @ 50V	FW BRIDGE REC	1.95
MDA 980-3	12A @ 200V	FW BRIDGE REC	1.95

TRANSISTORS

MPS A05	5/$1.00	PN3567	3/$1.00	PN4249	4/$1.00
MPS A06	5/$1.00	PN3568	4/$1.00	PN4250	4/$1.00
2N2219A	3/$1.00	PN3569	4/$1.00	2N4400	4/$1.00
2N2221	4/$1.00	2N3704	5/$1.00	2N4401	4/$1.00
2N2227A	5/$1.00	2N3705	5/$1.00	2N4402	4/$1.00
2N2369	5/$1.00	2N3706	5/$1.00	2N4403	4/$1.00
2N2369A	4/$1.00	2N3707	5/$1.00	2N4409	5/$1.00
2N2484	4/$1.00	2N3711	5/$1.00	2N5086	4/$1.00
2N2906A	4/$1.00	2N3724	$.65	2N5087	4/$1.00
2N2907A	5/$1.00	2N3725	$1.00	2N5088	4/$1.00
2N2925	5/$1.00	2N3903	5/$1.00	2N5089	4/$1.00
2N3053	2/$1.00	2N3904	4/$1.00	2N5129	5/$1.00
2N3055	$.89	2N3905	4/$1.00	2N5138	5/$1.00
MJE3055	$1.00	2N3906	4/$1.00	2N5139	5/$1.00
MJE2955	$1.25	2N4013	3/$1.00	2N5209	5/$1.00
2N3392	5/$1.00	2N4014	3/$1.00	2N5951	5/$1.00
2N3398	5/$1.00	2N4123	10/$1.00	C106B1SCR	2/$1.00
				2N5432	$2.00

CAPACITOR CORNER

50 VOLT CERAMIC DISC CAPACITORS

	1-9	10-49	50-100		1-9	10-49	50-100
10 pf	.05	.04	.03	.001µF	.05	.04	.035
22 pf	.05	.04	.03	.0047µF	.05	.04	.035
47 pf	.05	.04	.03	.01µF	.05	.04	.035
100 pf	.05	.04	.03	.022µF	.06	.05	.04
220 pf	.05	.04	.03	.047µF	.06	.05	.04
470 pf	.05	.04	.035	.1µF	.12	.09	.075

100 VOLT MYLAR FILM CAPACITORS

.001mf	.12	.10	.07	.022mf	.13	.11	.08
.0022	.12	.10	.07	.047mf	.21	.17	.13
.0047mf	.12	.10	.07	.1mf	.27	.23	.17
.01mf	.12	.10	.07	.22mf	.33	.27	.22

+20% DIPPED TANTALUMS (SOLID) CAPACITORS

.1/35V	.28	.23	.17	1.5/35V	.30	.26	.21
.15/35V	.28	.23	.17	2.2/25V	.31	.27	.22
.22/35V	.28	.23	.17	3.3/25V	.31	.27	.22
.33/35V	.28	.23	.17	4.7/25V	.32	.28	.23
.47/35V	.28	.23	.17	6.8/25V	.36	.31	.25
.68/35V	.28	.23	.17	10/25V	.40	.35	.29
1.0/35V	.28	.23	.17	15/25V	.63	.50	.40

MINIATURE ALUMINUM ELECTROLYTIC CAPACITORS

Axial Lead				Radial Lead			
.47/50V	.15	.13	.10	.47/25V	.15	.13	.10
1.0/50V	.16	.14	.11	.47/50V	.16	.14	.11
3.3/50V	.15	.13	.10	1.0/16V	.15	.13	.10
4.7/25V	.16	.14	.12	1.0/25V	.16	.14	.11
10/25V	.15	.13	.10	1.0/50V	.16	.14	.11
10/50V	.16	.14	.12	4.7/16V	.15	.13	.10
22/25V	.17	.15	.12	4.7/25V	.15	.13	.10
22/50V	.24	.20	.18	4.7/50V	.16	.14	.11
47/25V	.19	.17	.15	10/16V	.14	.12	.09
47/50V	.25	.21	.19	10/25V	.15	.13	.10
100/25V	.24	.20	.18	10/50V	.16	.14	.12
100/50V	.35	.30	.28	47/50V	.24	.21	.19
220/25V	.32	.28	.25	100/16V	.19	.15	.14
220/50V	.45	.41	.38	100/25V	.24	.20	.18
470/25V	.33	.29	.27	100/50V	.35	.30	.28
1000/16V	.55	.50	.45	220/16V	.23	.17	.16
2200/16V	.70	.62	.55	470/25V	.31	.28	.26

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**680 ohm	33K ohm
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2 2K ohm	47K ohm
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20K ohm	

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300KC xtal	1.50

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7806	7824
7808	7905
7812	7912
7815	7915

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*Case Included

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2N2369	6/1.00
2N2905	4/1.00
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1N4148 (1N914)	20/1.00
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*House numbered and P.C. Lead

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4 digit PCB for FND800 or 807	2 50
6 digit PCB for FND800 or 807	3 50
4 digit PCB for DL707	1 50
6 digit PCB for DL707	2 00
4 digit PCB for FND503 or 510	2 00
6 digit PCB for FND503 or 510	3 00
4 digit PCB for DL747	2 50
6 digit PCB for DL747	3.00
4 digit PCB for DL727 or 728	2 00
6 digit PCB for DL727 or 728	3.00
4 digit PCB for FND359 or 70	1 75

NOTE: All PC Boards are multiplexed for adding additional digits.

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14 pin	.22
16 pin	.25
18 pin	.25
24 pin (ww only)	.95
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40 pin	.50

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CD4000	.16
CD4001	.16
CD4002	.16
CD4007	.16
CD4009	.45
CD4010	.45
CD4011	.16
CD4012	.16
CD4013	.29
CD4014	.75
CD4015	.75
CD4016	.29
CD4017	.80
CD4018	.80
CD4019	.39
CD4020	.85
CD4021	.90
CD4022	.90
CD4024	.70
CD4025	.19
CD4027	.39
CD4028	.75
CD4029	.99
CD4030	.16
CD4034	2.30
CD4035	.99
CD4040	1.00
CD4041	.69
CD4042	.59
CD4043	.60
CD4044	.59
CD4046	.90
CD4047	.59
CD4049	.35
CD4050	.35
CD4051	.90
CD4053	.90
CD4056	1.00
CD4058	.90
CD4060	1.00
CD4066	.69
CD4069	.30
CD4071	.16
CD4076	.99
74C04	.29
74C107	.29
CD4116	.39
CD4507	.40
CD4512	.50
CD4516	.85
CD4518	.85
CD4520	.85

TTL

7400	.17	7473	.21
7401	.17	74H74	.45
7402	.17	7474	.35
7403	.17	7475	.55
74H04	.25	7476	.35
74S04	.30	7480	.45
7404	.17	7483	.76
7406	.25	7485	.89
7408	.17	7486	.35
7409	.17	7490	.71
7410	.17	7491	.71
7411	.25	7492	.71
7413	.45	7493	.67
7420	.17	7494	.90
7421	.17	7495	.71
7423	.35	7496	.85
7425	.27	74100	.96
7426	.25	74121	.31
7427	.17	74123	.61
7430	.25	74125	.44
7432	.30	74141	.71
7437	.35	74145	.97
7438	.35	74151	.71
7440	.17	74153	.81
7442	.60	74154	.97
7443	.60	74161	.91
7444	.65	74163	1.05
7446	.85	74164	1.05
74L47	1.75	74174	.91
7447	.81	74175	1.40
7448	.81	74180	.76
7450	.20	74181	2.25
7451	.17	74191	1.20
7453	.17	74192	1.20
7454	.17	74193	.95
7470	.35	74S195	1.05
7472	.21	74195	.65

L S

74LS00	.26	74LS145	1.00
74LS02	.26	74LS151	.70
74LS03	.26	74LS153	.70
74LS04	.30	74LS155	.69
74LS05	.32	74LS156	.76
74LS08	.26	74LS157	.95
74LS09	.26	74LS158	.85
74LS10	.26	74LS160	.85
74LS11	.35	74LS161	.85
74LS13	.58	74LS162	.85
74LS14	1.05	74LS163	.85
74LS15	.26	74LS168	.85
74LS20	.24	74LS169	.85
74LS21	.35	74LS170	2.00
74LS22	.35	74LS173	1.10
74LS26	.35	74LS174	1.00
74LS27	.35	74LS175	1.00
74LS30	.34	74LS190	.95
74LS32	.35	74LS191	.95
74LS37	.33	74LS192	.95
74LS38	.38	74LS193	.95
74LS40	.34	74LS194	.95
74LS42	.80	74LS195	.95
74LS51	.26	74LS196	.85
74LS54	.26	74LS197	.85
74LS55	.26	74LS251	.85
74LS73	.75	74LS253	.85
74LS74	.49	74LS257	.85
74LS76	.49	74LS258	.85
74LS86	.45	74LS260	.26
74LS90	.85	74LS266	.26
74LS92	1.00	74LS279	.55
74LS93	1.00	74LS290	.75
74LS109	.49	74LS293	.75
74LS112	.49	74LS295	.95
74LS113	.40	74LS298	.95
74LS114	.40	74LS365	.55
74LS125	.55	74LS366	.55
74LS126	.65	74LS367	.55
74LS132	1.00	74LS368	.55
74LS133	.35	74LS390	1.75
74LS136	.39	74LS393	1.45
74LS138	.85	74LS670	3.25
74LS139	.85		

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LM301	30
LM307	30
LM309K	95
LM311	85
LM377	1 85
LM380 (8 pin)	75
LM3900	30
LM710	25
LM711	25
LM723	40
LM741	25
LM748	25
NE553	1 95
NE555	.40
NE556	95
NE565	95
NE566	95
NE567	1 10
1458	49
RCA3043	75
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75492	.30

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