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Microwave Ovens for the Home

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Learning Electronic Theory With Hand Calculators

TEST REPORTS:

Nikko 7075 AM/FM Stereo Receiver

MXP Stereo E...

SBE ... Sc...

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JULY 1976 VOLUME 10, NUMBER 1

Popular Electronics®

WORLD'S LARGEST SELLING ELECTRONICS MAGAZINE

FEATURE ARTICLES

CONSTRUCTION ARTICLES

COLUMNS

PRODUCT TEST REPORTS

DEPARTMENTS

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Editorial

WHO KILLED TV PICTURE QUALITY?

The April 3 issue of *TV Guide* observed that U.S. citizens returning from Europe or Japan often "rave about beautiful TV reception there, the vividness of colors and detail in the picture . . ." Obviously, *their* system of TV must be better than ours, they conclude. Not so! The capabilities are essentially the same.

Whereas the European TV system employs a 625-line picture linked with 50 Hz, Japan (and the U.S.) use a 525-line system in sync with 60 Hz. Then why is our TV video reception so poor compared to that in other countries? The inconclusive reasons include: Americans just don't care or won't bother to adjust receivers properly, antenna systems and TV receivers are allowed to deteriorate, broadcasters are shortchanging us by transmitting poor-quality video and color, and receiver manufacturers take design shortcuts that prevent reception of good, clean signals.

There's probably some truth in all the foregoing speculations. Certainly, there is no question that many TV broadcasts are poor. You can prove this by switching from channel to channel, observe differences between film source and tape source, etc. But things are getting better (slowly, very slowly):

- The "purple plague" rarely touches the faces of TV performers nowadays.
- Broadcasters at least have a transmitted reference of tint and color intensity with which to make adjustments or to acknowledge that their equipment is obsolete.
- Broadcasters are also experimenting with "circular polarized" transmitting antennas, which might eliminate "ghosts" (a different outdoor receiving antenna design would be needed to take advantage of this).
- Receiver manufacturers have introduced models with automatic color screen grid tracking (RCA) and automatic adjustment to the broadcaster's color/tint intensity reference (General Electric). The latter is VIR, for vertical interval reference, but you cannot see it without a decoder and it's not yet universally used.

Surely these advances are welcome. But how come the other countries managed to produce substantially better color and black-and-white TV pictures without them? Ignoring all the possible causes for our "picture-quality lag" except for the TV receiver itself, we know that U.S. video reception can be significantly improved at the consumer equipment end.

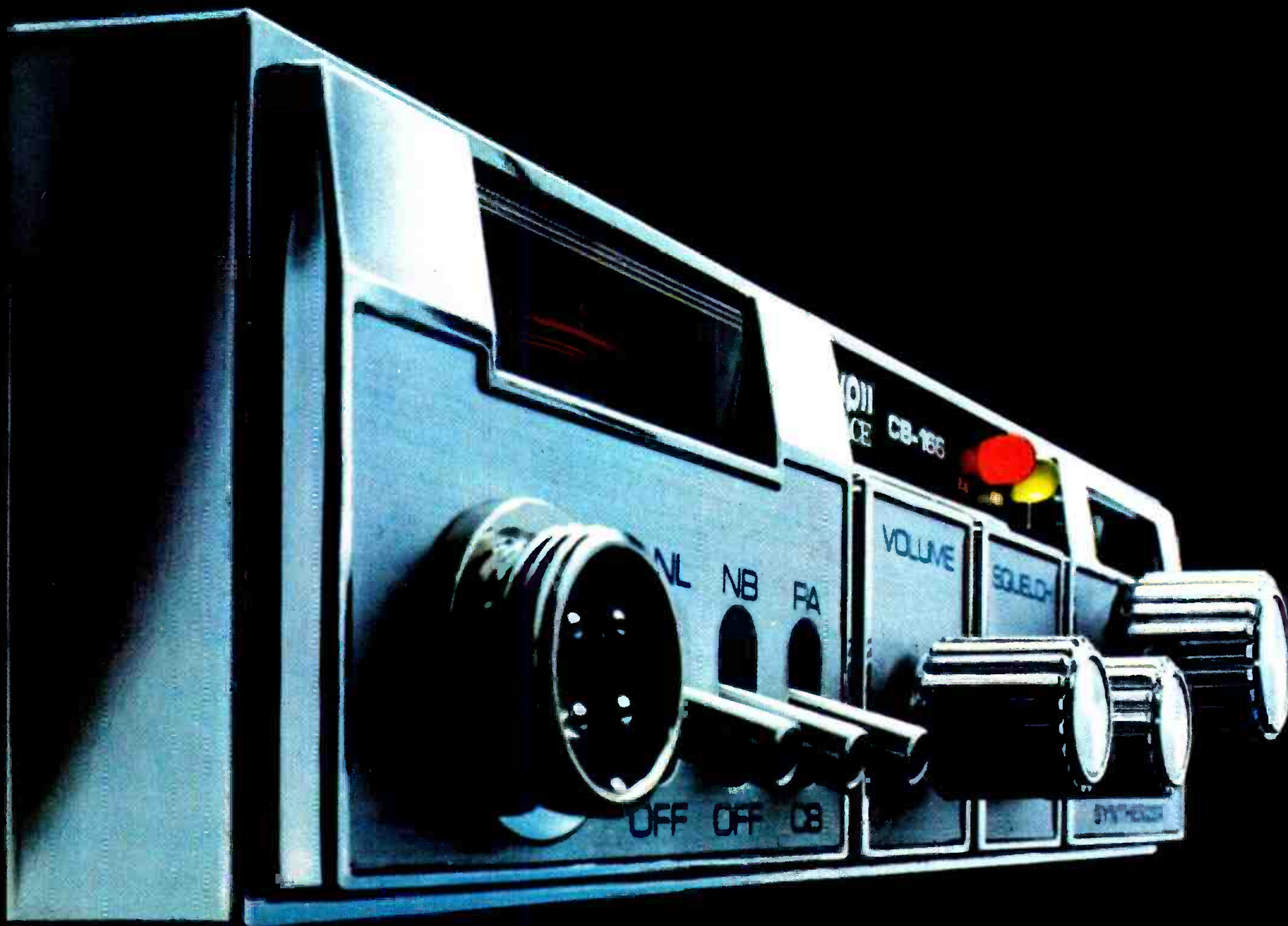
Our technical editor, Les Solomon, for example, observed in his August 1973 "Test Scene" that most TV receivers are incapable of even reproducing 262½ lines, let alone close to our 525-line "standard." What interlace there is in most receivers (trace on "odd" lines and retrace on "even" lines) is reproduced as "pairing." That is, scanning lines of one field are positioned directly behind the lines of the other field. The result is a TV picture lacking good detail.

Another video-quality degenerator is the absence of good, if any, dc restoration. Instead of being capable of shifting to deep black, the typical receiver can only go to "tattle-tale gray." The black level is simply lost because the dc signal level, destroyed by capacitive coupling, hasn't been restored. Sadly, all it takes is a diode and a resistor to do the job.

Another improvement that is long overdue is providing an inexpensive audio output jack from the detector on a TV receiver. FM TV sound can go to 15 kHz. For the future, a video jack would be in order to handle TV electronic games, computers and video tape decks.

So the question is: in our free-enterprise system, why hasn't some TV manufacturer scooped the competition and come out with a model that has full interlaced scanning, proper dc restoration, etc.? Believe me, the American public would recognize a vastly superior TV picture and "latch on" to the unit. The hi-fi component industry proved that we recognize and appreciate good quality!

Art Salsberg



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Letters

CBC RESPONDS TO QSL REPORTS

As many of us know, the CBC (Canada) has cut back on SW programming and requires QSL-seekers to fill in their own information. I can add that the CBC hasn't weakened its grip on QSL's for its MW stations. Such was the case when I reported receiving CMB Montreal last December 14 at 1600 EST. I sent in my report, including my log and reception figures, and two months later received not only my QSL but a program for the schedule for the Quebec Community Network (19 stations in the province anchored by CMB, which provides CBC coverage for Quebec).—*Charles E. Everett, Sag Harbor, NY.*

ARTWORK PACKAGE BLUES

With today's technology, some projects are so complex that they would occupy too much magazine space if they were described completely. Needless to say, I understand your problem in making available separately schematics and/or etching and drilling guides. However, I must take exception to the artwork package I received from M&R Enterprises for the "Pennywhistle Modem" (March 1976). The pc layouts were sloppily photocopied and of such low contrast that I would have to go over them with an inker before I could make work negatives from them. Also, the schematic that was claimed to be too large to fit on a POPULAR ELECTRONICS page (received from M&R on a single sheet) could easily have been included in the published article where space was wasted on a vague block diagram.—*David G. Potter, Sacramento, CA.*

These guides were not meant to be original artwork to be used in making pc boards. Rather, they were meant as guides for readers who wish to make exposure masks using the IC pattern, donut, and tape method of making exposure masks. Also, given a choice between a schematic and the block diagram, we chose the diagram as being more meaningful to most readers.

ACCESSING VIDEO INPUT

I'm planning to build the "Space-War Game" featured in the April 1976 issue of POPULAR ELECTRONICS. In reading over the article, I note that reference is made to connecting the game's output to the video input of a TV receiver. Just how is this accomplished? Also, how does one go about trimming fixed resistors *R13* through *R16*? —*Edward I. Williams, Peckville, PA*

The first thing to do is check the schematic diagram of your TV receiver to locate the connection between the video detector and video amplifier. Break this connection. Then connect the video game between the input of the video amp and ground. As for trimming the resistors, simply substitute resistor values as needed.

WHY PONGTRONICS IS BETTER

I was very intrigued by the "Pongtronics" tennis game featured in the April 1976 issue of PE. At the time I decided to build the project, I noticed that several other similar games became available completely assembled for about the same price. What advantages, if any does Pongtronics offer?—*E.L. Cassell, Allentown, PA*

Pongtronics is actually four games (tennis, gravity pong, handball, and basketball) with 10 game-player combinations in a single unit. Since it isn't designed around a single LSI chip (like department-store games), it is more flexible, offering player skill controls, variable rebound, variable court size, adjustable paddle size, etc. Pongtronics can also be modified to permit tennis doubles action.

DANGER—LIVE WIRES

Please remind readers that electric power lines are *not* insulated, except for the lead-in from the transformer to the house. Two of my neighbors were killed when the antenna they were putting up touched a power line. I fear that this type of accident will become rather common unless CB and TV antenna sales people warn the install-it-yourself hobbyist.—*Steve McKay, Athens, AL*

THEFT PREVENTION EXPANDED

Many thanks for "Theft Alarm for Handheld Calculators" (March 1976). I found the circuits presented useful for deterring thefts of transistor radios, tape recorders, etc., as well as keeping my calculator safe.—*David Hayes, Gander, Newfoundland*

Out of Tune

In "A Simple Logic Probe" (May, p 60), the Parts List should show *C1* as a 1000-pF disc capacitor; *C2* and *C3* as 1-μF, 25-V tantalum capacitors. The schematic is correct.

In "Solid State" (April, p 90), pins 7 and 8 of *IC10* and *IC11*, *in Fig. 3, should be grounded.*

One look inside proves it! The new Royce Wireless Module CB's are years ahead of competition.

Look, no wires!

Modular construction. With not one single wire on any module.

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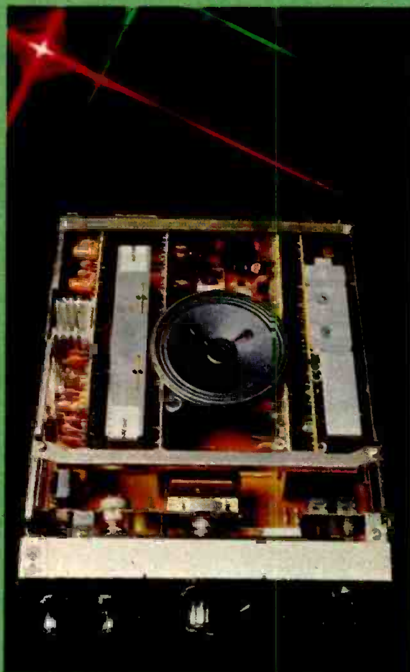
What does it all add up to? You know already. Greater reliability and performance in CB than you had ever dreamed possible!

See all 6 Royce Wireless Module Mobile CB Transceivers at your Royce dealer's soon! Write today for information on these models plus other innovative Royce CB's, antennas, and accessories.



Royce Wireless Model 1-650 — 23 channel mobile CB has Amplified Automatic Gain Control (AAGC) circuit to amplify weak signals, yet reduce nearby overload. Large, readable (1" X 1") S/RF meter. Exclusive IC audio stage for maximum clarity, power. 3 ceramic filters reduce channel interference. Dual conversion receiver + tuned RF stage pulls in even weakest signals. Rugged metal (not plastic) RF output transistor.

Royce Digital Wireless Model 1-660 — 23 channel mobile CB has digital readout dial system with bright L.E.D. numerals for fast channel selection. Phase Lock Loop Tuning adds greater reliability. ANL automatically minimizes noise, static. Pushbutton PA/CB activates powerful P.A., AAGC, 3 ceramic filters. Exclusive IC audio stage for maximum clarity.

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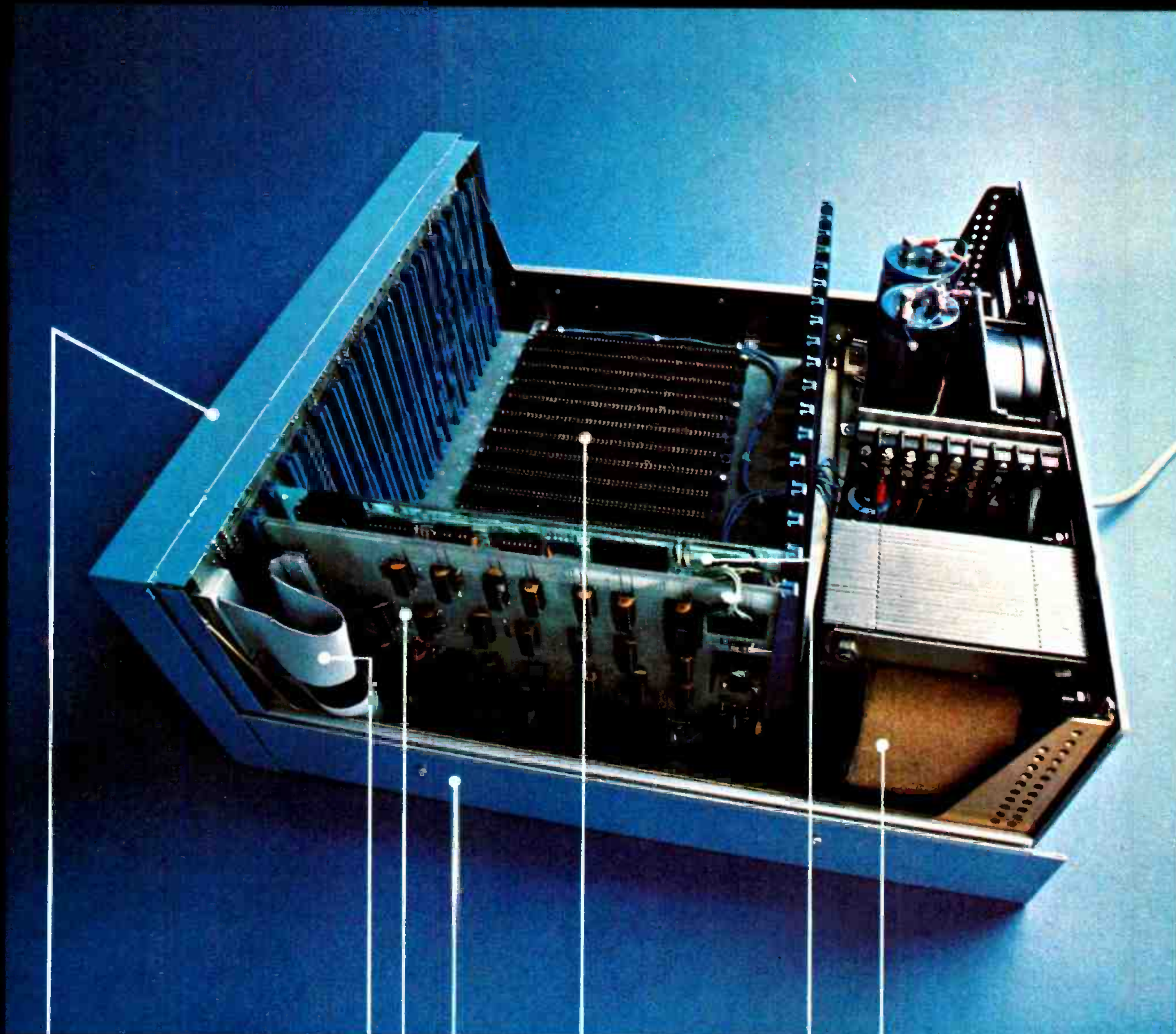

Redesigned front panel. Totally synchronous logic design. Same switch and LED arrangement as original Altair 8800. New back-lit Duralith (laminated plastic and mylar, bonded to aluminum) dress panel with multi-color graphics. New longer, flat toggle switches. Five new functions stored on front panel PROM including: DISPLAY ACCUMULATOR (displays contents of accumulator), LOAD ACCUMULATOR (loads contents of the 8 data switches (A7-A0) into accumulator), OUTPUT ACCUMULATOR (Outputs contents of accumulator to I/O device addressed by the upper 8 address switches), INPUT ACCUMULATOR (Inputs to the accumulator from the I/O device), and SLOW (causes program execution at a rate of about 5 cycles per second—for program debugging).

Full 18 slot motherboard.

Rugged, commercial grade Optima cabinet.

New front panel interface board buffers all lines to and from 8800b bus.

Two 34 conductor ribbon cable assemblies. Connects front panel board to front panel interface board. Eliminates need for complicated front panel/bus wiring.

New, heavy duty power supply: +8 volts at 18 amps, +18 volts at 2 amps, -18 volts at 2 amps. 110 volt or 220 volt operation (50/60 Hz). Primary tapped for either high or low line operation.

New CPU board with 8080A microprocessor and Intel 8224 clock generator and 8216 bus drivers. Clock pulse widths and phasing as well as frequency are crystal controlled. Compatible with all current Altair 8800 software and hardware.

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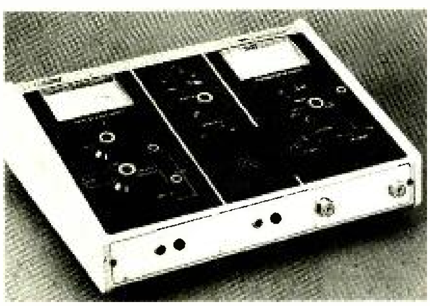
NOTE: Altair is a trademark of MITS, Inc.

New Products

Additional information on new products covered in this section is available from the manufacturers. Either circle the item's code number on the Reader Service Card inside the back cover or write to the manufacturer at the address given.

B&K-PRECISION CB TEST INSTRUMENT

The B&K-Precision Model 1040 is a new test instrument designed for fast, efficient servicing of CB equipment. It features a peak-indicating r-f wattmeter, dummy load, audio signal generator, and audio



wattmeter. When used with an oscilloscope, stable r-f signal generator, and frequency counter, it becomes a complete CB service center. It tests r-f output power, AM and SSB modulation, and antenna SWR in the transmitter section. In the receiver section, it checks sensitivity (S/N ratio), audio output power and distortion, frequency response, agc and squelch action, and adjacent-channel rejection. All tests can be performed without changes in the initial connections to the transceiver. $250.

CIRCLE NO. 85 ON FREE INFORMATION CARD

FINNEY MOBILE FM SIGNAL BOOSTER

The Finney Co. "Stereo One" mobile FM signal booster is designed to help eliminate signal fade and flutter associated with weak-signal FM reception. It can be used with any AM/FM car receiver without introducing adverse effects to normal reception. The device is said to more than triple the received signal level to provide clear FM reception in fringe signal areas. Even so, it is designed to avoid overloading the receiver in strong-signal areas. The two-piece Stereo One consists of an amplifier section that mounts close to the receiver and a small ON/OFF control box that self mounts where it is easily accessible.

CIRCLE NO. 86 ON FREE INFORMATION CARD

ADC REMOTE-CONTROL LOGIC TURNTABLE

The Audio Dynamic Corp. has introduced a unique single-play turntable called the Accutrac 4000. The direct-drive turntable

marries a digital-logic memory bank with an infrared generator and detector built into its special phono cartridge. The user can thus program which bands of an LP will be played in whatever desired sequence. Electronic controls include: automatic reject, cue and repeat, 13 track selection pushbuttons and separate all-tracks button, and 33 1/3- and 45-rpm speed-selector buttons. A handheld remote-control transmitter and remote receiver provide full track selection, reject, repeat, and cue control from a distance. Wow and flutter are reported to be less than 0.03% wrms, with DIN-weighted rumble down 70 dB. Tracking force range with the supplied cartridge is 3/4 to 1½ grams, and low-capacitance wiring is used. Price is $499.95, which includes base and dust cover.

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GBC HIGH-PERFORMANCE CCTV CAMERA

The "Mini-Max" Model CTC-3000 from GBC Closed Circuit TV Corp. features 600 lines of resolution; 10,000:1 automatic light compensation; adjustable white clip; and automatic voltage regulation. The camera employs a Vidicon tube and features plug-in circuit module construction. The case is heavy die cast aluminum. The camera can be operated from 24-, 117-, and 220-volt ac sources. When powered from a 24-volt source, it allows installation with a

single cable as far away as 2500′ (762 m) without 117 volts ac being required at the camera points. The camera includes a 16-mm f/1.6 "C" mount lens. $199.50.

CIRCLE NO. 88 ON FREE INFORMATION CARD

ROGERS ELECTRO-MATICS CB SWITCH

The new solid-state "Killer" switching system from Rogers Electro-Matics permits hands-free operation of both AM/FM radio and CB transceiver in a car. The device can be actuated by an incoming CB call, which immediately switches the speaker(s) from the AM/FM radio to the CB rig. The message is then heard through the radio's speakers. The Killer can also be activated when the CB mike button is pressed. A small time delay on drop-out prevents switching back and forth between words and transmissions, while virtually no time delay on pull-in cuts off the first part of a message. The Killer is designed to operate with almost all types of two-way radio systems, monitor receivers, scanners, etc. It is capable of controlling two speakers operating either monaurally or in stereo. Price is $49.95.

CIRCLE NO. 89 ON FREE INFORMATION CARD

SIMPSON PORTABLE DIGITAL VOM

The Model 360 Series 2 from Simpson is a 3½-decade DMM designed for both bench and field use. It can be operated on ac line power or its own internal batteries. The instrument has 29 ranges for measuring ac

rms and dc voltage, ac and dc current, and resistance. The 0.43″ (11-mm) LED display automatically indicates polarity on dc and flashes when an overrange condition exists. All ranges are overload protected. Two low-power-ohms ranges (200 mV maximum full-scale voltage) allow the user to make in-circuit tests without biasing on most semiconductor junctions. A zero-center analog meter movement is provided for peaking and nulling operations. Special analog output terminals are provided for connection to a graphic recorder. $257.

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VERO INSTRUMENT CASES

PVC-clad steel instrument cases are now available in five sizes from Vero Electronics, Inc. The three widths currently *state-of-the-art in sideband . . .*

Johnson sideband. again!

Nearly 10 years ago we introduced the world's first CB single sideband radio — a radio still sought after and prized today. *In that tradition of state-of-the-art performance,* Johnson offers you the *Viking* 352. With the most advanced SSB performance on-the-air ... including crystal lattice filtering, an efficient RF noise blanker, individual professional controls for every function, and color-keyed lights for instant indication of USB, LSB, or AM mode. Viking 352 brings famous Johnson quality, performance, warranty and service to CB sideband! **$359.95.**

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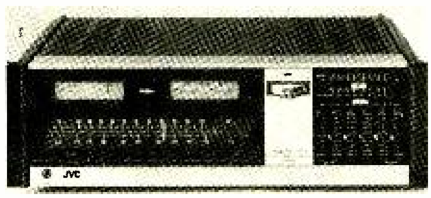
being offered are 15.9", 12.4", and 10.9" (40.4, 31.5, and 27.7 cm) with depth and height of 8.7" and 6.2" (22.1 and 15.7 cm). The widest version is also available in a 12.4" depth and 4.5" height (32 × 11.4 cm), while a second depth of 12.1" (30.7 cm) is offered for the 12.4" wide case. The base and rear panels of the cases are louvered for ventilation. An anodized front panel and all mounting screws are supplied with each case. Prices start at $17.43. Address: Vero Electronics Inc., 171 Bridge Rd., Hauppauge, NY 11787.

CIRCLE NO. 92 ON FREE INFORMATION CARD

JVC DELUXE AM/STEREO FM RECEIVER

Built into JVC's Model JR-S300 stereo receiver are direct-reading power output meters and an S.E.A. graphic equalizer.



The 50-watt/channel (into 8 ohms) receiver is rated at less than 0.3% THD at full power. The equalizer section divides the musical spectrum into five frequency bands with 12-dB boost or cut. The tuner section features linearly calibrated scales on both AM and FM and a dual flywheel mechanism. IC's are used in the FM i-f, stereo FM decoder, and AM sections. A dual-gate MOSFET and three-gang tuning capacitor are used in the front end. FM usable sensitivity is stated at 1.7 µV (10.97 dBf), 50-dB quieting sensitivity at 3.5 µV mono, S/N at 70 dB mono, selectivity at 60 dB, and capture ratio at 1.2 dB. $400.

CIRCLE NO. 93 ON FREE INFORMATION CARD

CONTINENTAL SPECIALTIES DIGITAL PROBE

The Continental Specialties Corp. Model LP-1 test probe tests TTL/DTL and MOS devices in circuit. The low-cost pocket-sized probe also employs a pulse detector, pulse stretcher, and memory circuit for maximum testing flexibility. Power for the probe is obtained from the circuit under test simply by clipping its test leads to the positive and negative buses. A slide switch is then set to TTL/DTL or CMOS, depending on the logic family used in the circuit. If more than one logic family is used, it is a simple matter to change switch positions as needed. A second switch allows selection of either the PULSE or MEM mode. Separate HI, LO, and PULSE LED's indicate the logic state at any given point in the circuit to which the probe point is touched. High input impedance virtually eliminates loading problems in any circuit under test. $44.95.

CIRCLE NO. 94 ON FREE INFORMATION CARD

MURA INTRODUCES THREE MIKES FOR CB

Mura Corp. has introduced three new CB microphones that feature a circuit designed to prevent voice-signal clipping and allow maximum modulated output power from limited-level amplifiers. The Peak-Redistribution Modulation (PRM) circuits used in the mikes are said to offer a fully modulated voltage gain of up to 16 dB for an average 4-dB increase in effective r-f transceiver output power. The mobile Model PRX-100 ($39.95) and base-station Model PRX-300 ($69.95) mikes provide an infinitely variable slide-type gain control, while the mobile Model PRX-200 offers a switch-selectable choice of 12, 14, or 16 dB of gain. All three mikes have push-to-talk switches (the Model PRX-300 also has a locking bar for hands-free operation) and are supplied with cords that can be wired for relay or electronic switching.

CIRCLE NO. 95 ON FREE INFORMATION CARD

CELESTION SPEAKER SYSTEMS

Three new speaker systems made by Celestion (England) and available in the U.S. from Rocelco Inc. offer a choice of performance and power-handling capacity. The tall, slim Model UL10 Data three-way system can handle 50 watts of continuous rms sine-wave power (100 watts peak music power) and has a frequency response of 70 to 20,000 Hz ± 3 dB. The Model UL8 Data two-way speaker system is rated at 25 watts continuous rms power (50 watts peak) and has a frequency response of 70 to 20,000 Hz ±3 dB. The Compact Model UL6 Data two-way system's power-handling capacity is 20 watts continuous rms (40 watts peak) and frequency response is 80 to 20,000 Hz ±3.5 dB.

CIRCLE NO. 96 ON FREE INFORMATION CARD

MOTOROLA CB TRANSCEIVERS

Motorola's new line of MOCAT CB transceivers includes four under-dash models. The basic Model 2000 rig offers a phase-locked loop synthesizer for maximum on-frequency operation reliability; FET front end; plug-in microphone with built-in

amplifier; top-facing speaker; large illuminated S/r-f meter; external PA and speaker capability; automatic noise limiter; and automatic gain control. The Model 2005 includes the foregoing plus a noise blanker. The Model 2010 adds an LED digital channel display with dimmer to Model 2000 features. The top-of-the-line Model 2020 has both Extender blanker and digital display. Prices range from $175 to $225.

CIRCLE NO. 97 ON FREE INFORMATION CARD

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Designed and engineered in the USA, Mocat is a 100% solid-state Motorola CB radio with the very latest in technological advances, and exciting features.

Motorola CB means reliability. A digital phase lock loop synthesizer assures on-frequency performance on all channels.

Motorola CB means quality reception. Automatic gain control, cross modulation rejection circuit and optional "Extender" noise blanker circuit give Mocat superior receiver performance.

Motorola CB means power. All models feature a rugged plug-in mike with built-in amplifier for maximum transmit signal strength.

Motorola CB means good looks. Contemporary styling across the line. Selected models offer easy channel identification with high-intensity L.E.D. digital channel read-out and dimmer.

Motorola CB also means high performance and attractively styled antennas and accessories.

Motorola CB is the biggest news and greatest value in personal communications today. Mocat from Motorola. Now is the time to own a Motorola CB. For complete details, write us at Motorola, Inc., Dept. CB-700, 1301 East Algonquin Road, Schaumburg, IL 60172.

MOTOROLA

CIRCLE NO. 37 ON FREE INFORMATION CARD

New Literature

PRINTED CIRCUIT ROTARY SWITCHES

An 8-page brochure from Oak Industries describes its family of rotary printed circuit switches. A chart illustrates the 17 categories of conventional rotary switches available with terminations. Diagrams and pictures of Oak's line of pc and pcb switches are also shown including 12- and 24-position models. Also covered is a technique for attaching conductor cable to rotary switches, and advantages such as compactness and elimination of harnessing are outlined. Address: Switch Division, Oak Industries, Inc. Crystal Lake, IL 60014.

ABOUT COMBINERS

"About Combiners," a new 20-page booklet from Decibel Products, describes, in detail, various types of transmitter and receiver combiners. The text, written for those engaged in two-way radio communications, but who are not engineers, includes a nontechnical presentation of different methods of combining a number of duplex or repeater and/or simplex systems on the same antenna. Address: Decibel Products, Inc. Box 47128, Dallas, TX 75247.

VHF EQUIPMENT CATALOG

Hamtronics' new catalog highlights vhf preamplifiers and FM communications subsystems for amateur and monitor applications. Included in the catalog are a vhf preamp, a uhf grounded-gate preamp for the 400-500-MHz region (both available in kit or wired form), a uhf converter, a vhf receiver and a uhf/vhf model (all in kit form). Address: Hamtronics, Inc., 182 Belmont Road, Rochester, NY 14612.

SEMICONDUCTOR REPLACEMENT SUPPLEMENT

GTE Sylvania announces its ECG Semiconductor Replacement Guide Supplement No. 1 (ECG 212F-1). Designed as a quick reference for technicians, engineers and hobbyists, the 18-page booklet includes substitute components for transistors, gate-controlled switches and integrated circuits for communications, audio, television and industrial applications. The booklet contains a product index, device specifications, package line drawings and dimensions, pin designations and a component cross-reference. A list of errata to Replacement Catalog ECG212F is included, as well as a list of additions and deletions which reflect changes in the Sylvania ECG semiconductor line. Available for 35 cents from the GTE Sylvania Advertising Services Center, 70 Empire Dr., West Seneca, NY 14224.

SCAN CONVERTER TRANSCEIVER

Robot Research, Inc. offers complete literature on its Model 300 Scan Converter Transceiver. Used in conjunction with any black-and-white monitor (or commercial TV receiver), this $995 converter can transmit pictures anywhere by telephone. Pictures have 256-line resolution. An entire image can be transmitted full-frame in 34 seconds or half-frame in 17 seconds. Address: Robot Research, Inc., 7591 Convoy Ct., San Diego, CA 92111.

CONTROL KNOBS CATALOG

Radial Controls offers a 16-page catalog illustrating its line of control knobs. Covered are low-profile knobs of uniform height, as well as calibrated, spinner, pointer and bar knobs. All are available in round, skirted, wing and concentric styles. Custom designs and optional indexing marks are also described. The catalog illustrates each knob and provides dimensional data. Address: Radial Controls, 2555 East 55th Pl., Indianapolis, IN 46220.

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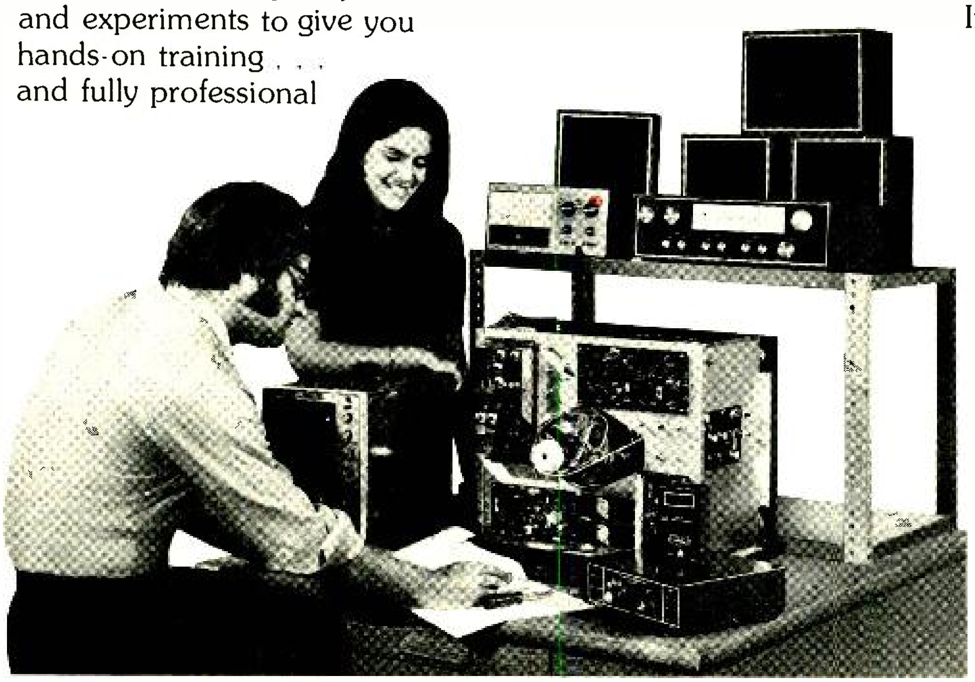

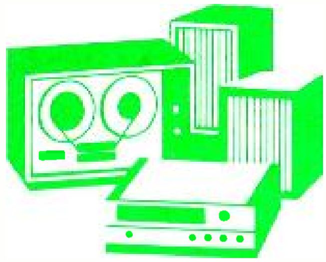

Stereo Scene

By Ralph Hodges

PERFECTING PHONO

FROM all indications, the principal program source for most hi-fi listeners is still the phonograph record. This is sensible, because phono discs continue to offer the (potentially) best signal-to-noise ratio of any consumer-available recording medium. But it is also nonsensical because the motional stability of *most* record-playing systems ranges from poor to abominable. By this, I don't mean to say that turntables suffer excessively from wow and flutter. On the contrary, most of them are excellent in this respect. I *do* mean that the typical cartridge/tonearm/turntable/record combination is troubled by what might be termed wow and flutter, and worse.

The Insidious Jiggle. In an ideal record-playing system, only two things move: the turntable platter, which spins the record at a uniform rate, and the phono stylus, which gets buffeted around by the record groove in a (hopefully) musical way. In a real record-playing system, everything moves. The turntable base shudders with the seismic impact of traffic passing outside and other stimuli. The motorboard, even if it is well isolated from the base by spring mounts and dampers, sings the tune of the motor's vibrational rate as well as the acoustic feedback from the loudspeakers. And the tone arm, under the influence of all these inputs, plus the warps and wriggles of the record, does a dance all its own. Usually you can observe this dance by watching the stylus closely as it plays a record. The bobbing around that it does has nothing to do with information in the record groove; it's a sign that the tone arm is moving grossly relative to the stylus tip, which it should not do.

This insidious jiggle has three effects. First, it generates within the cartridge infrasonic output signals of very high intensity. These are of course boosted by the RIAA equalization in the phono preamplifier, posing a serious threat of distortion or overdrive to subsequent stages and transducers. Second, the jiggle "modulates" the recorded information on the record. Third, it reduces the cartridge/record-groove alignment to complete ambiguity. Up to a few years ago this was probably a relatively minor side effect, but with modern stylus shapes there is mounting evidence that alignment is a cause for greater concern than heretofore.

The infrasonic signals are obvious enough on an oscilloscope. Often they even show up on the output-level meters of amplifiers equipped with them. The amount of trouble they cause depends heavily on the characteristics of the individual system, but in any case they are a persuasive argument for the use of sharp infrasonic cutoff filters in phono preamplifiers—features that are still all too rare in currently available equipment.

The "modulation" problem is, in my view, at least as serious if not more so. Figure 1 shows the right-channel frequency response of a high-quality record player, as measured with the sweep bands on the CBS STR 130 test record. The cyclical variations in the curve correspond to the 33⅓-rpm rotation rate of the record. The variations turned out to be symptoms of a slight amount of play in the tonearm's bearings — a condition that had developed of its own accord over a period of about eighteen months of completely normal use. It's difficult to describe what this condition sounded like without resorting to words like "nervous" or "subtly fuzzy and indistinct." But it had, in any case, reduced the performance of a highly refined phono cartridge and an acclaimed tonearm to bewildering mediocrity. A few minutes' work on the bearings improved matters dramatically. However, the point is that, although this problem was attributable to an actual fault in the tonearm, it illustrates what can happen even with properly functioning cartridges and arms when they are not well suited to one another.

In the view of most authorities, phono cartridges will gracefully tolerate rather large errors in alignment when they are installed in the tonearm. In fact, the measured amounts of distortion caused by serious lateral or vertical tracking-angle misalignments seem pretty moderate compared with some of the other distortion-producing mechanisms involved in record playing. Nevertheless, many people are finding that a careful job of cartridge alignment amply repays the effort. This seems to be particularly true with CD-4 styli that, instead of making a two-point contact with the record groove, attempt to achieve line contacts that extend from (almost) the bottoms to the tops of the groove walls. Obviously, if the groove is to be properly traced, the contact lines must be reasonably parallel to the contours of the groove. In other words, the *rake angle* of the stylus must be properly adjusted.

In working with various CD-4 cartridges, I have found that alterations in rake angle are frequently quite audible and also usually measurable in terms of their effect on high-frequency response. There seem to be other effects as well, which will be discussed in detail a little later. Unfortunately, if the tonearm is imposing excessive gyrations on the stylus in response to warps and other record

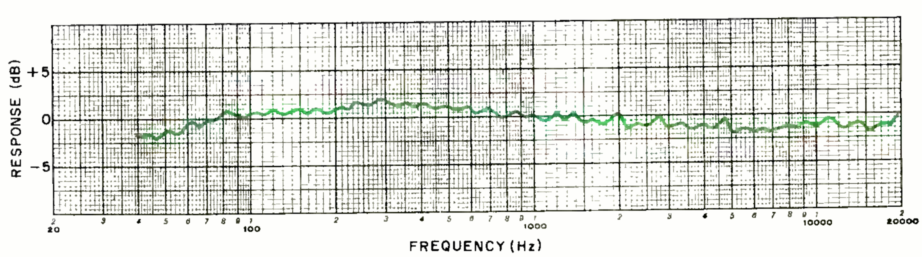

Fig. 1. Frequency response of good cartridge in misbehaving tonearm shows severe amplitude modulation by record-profile irregularities.

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Sansui is already the leading name in advanced high performance 4-channel sound reproduction and technology. And only with Sansui's exclusive QS vario matrix system can you enjoy the full potential of quadraphonic sound. But there is still always something new in the Sansui world of 4-channel.

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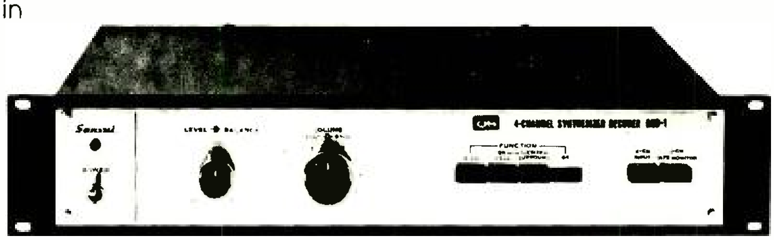
All 4-channel Sansui receivers command excellent cost-to-performance ratios. The QRX-7001[1], at less than $880.00,* delivers a full 35 watts per channel, min. RMS, all channels driven into 8 ohms, from 20Hz to 20kHz with no more than 0.4% total harmonic distortion. Every design element of this outstanding receiver lives up to Sansui's reputation for advanced high quality high fidelity performance. Available in the same series are the QRX-6001[1], at less than $760.00,* and the QRX-5001[2], at less than $600.00,* with many of the same outstanding features.

Sansui's new QSD-1 is the most exciting and effective decoder available today. Its QS vario matrix allows for very high inter-channel separation, as high as 20dB between adjacent channels and 30dB across the diagonally opposite channels, without any of the annoying side effects found in other decoders.



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undulations, the rake angle won't have any fixed value. Instead, it will change radically as the stylus cantilever squashes down and springs back up. The unappetizing prospect is that of a system in which record warps "modulate" the playback signal with tracing errors! Usually this is heard as an unsteadiness in the noise (tape hiss, for example) that exists on many records and which should have a very smooth and uniform character. Usually it is a bit too subtle to be identified readily in the musical information, although its presence tends to cause in the listener a vague feeling that all is not quite right.

Arm-Cartridge Resonance. The first step to take to avoid tonearm misbehavior is to adjust the arm's effective mass so that it interacts with the stylus compliance and produces a resonant frequency somewhat above 10 Hz but below 20 Hz. This range of frequencies is below that of the recorded information and above that of most warps and record-surface irregularities. Thus the arm-cartridge combination, with no stimulus to set it off, will theoretically behave in a very stable manner.

There are a few commercially available record players designed to meet this criterion, and hearing them at their best can be a genuine revelation. Unfortunately, however, this ideal condition is almost never achieved by accident. It must be designed into the arm and cartridge in anticipation of their being used together. Most top-quality cartridges are so compliant (and most tonearms so massy) that the resonance falls considerably below 10 Hz, where record warps can drive the system crazy.

Human nature being what it is, it's unlikely that many people will start selecting cartridges solely on the basis of how well they suit their tonearms' effective mass (although this may be a very logical way to assemble a high-performance system). Instead, audiophiles are resorting to such stratagems as arm modifications to reduce effective mass and, recently, to tonearm damping.

A few tonearms, mostly of English origin, are designed with damped pivots. Others can have damping added, the usual procedure being to attach a "paddle" to the arm that dips down into a reservoir of some suitably viscous fluid. There is every reason to believe that damping can help with problem record players, but the amount must be worked out empirically, too much being as bad in its way as too little. It is also of limited or doubtful effectiveness with certain specific tonearm problems, such as the sloppy bearings of Figure 1, or tonearm resonances that extend up into the audible range. Spectrum analyses made on some tonearms have shown significant resonant contributions extending well past 1000 Hz. The effects of these resonances (when audible) run the gamut from a muddying of the sound to an increase in the system noise level. Moreover, they are exceedingly difficult to pin down without the assistance of a good spectrum analyzer.

Flex Mounting. Before getting into the complications of arm damping (which indeed may be necessary to coax the system into performing at its peak), it's worthwhile to experiment with some simpler ways of nullifying the tonearm's troubles. To begin with, installing the cartridge with nylon mounting hardware will reduce the coupling between cartridge and arm and also usually bring about a reduction in overall mass. This approach can be carried a step further with the use of adhesive foam.

This foam, which comes in rolls about an inch wide by a little under 1/8 inch thick with a strong adhesive on both sides, can be used to mount the cartridge in the arm without screws. If the cartridge requires standoffs for proper alignment the foam can be built up layer by layer until the correct height is reached. What this type of "flex mounting" buys you is not the ideal method of installing a cartridge (in fact, it may introduce significant problems of its own), but it is the beginning of a test bed with which you can evaluate the effects of the tonearm on the reproduced sound.

For example, Fig. 2 shows the response of a cartridge so installed in the troubled tonearm of Figure 1. Note that the compliance of the foam introduced a serious resonant condition at about 200 Hz, which could readily be heard. However, in many other respects the performance of the system was audibly improved. The effects of the faulty bearings were reduced substantially, so that the treble re-acquired some of its former clarity and detail. Subjectively, the noise level also went down. On the basis of this, it seemed reasonable to diagnose tone-arm difficulties as the source of the record player's problems, and curative efforts could then be concentrated in that area.

Alignment. Aside from serving as a useful diagnostic tool, the adhesive foam can also assist in fine-tuning the alignment of a cartridge. The procedure is to re-install the cartridge mounting screws after the cartridge has been flex mounted, but to use the screws only to adjust the side-to-side and fore-to-aft tilt of the cartridge. The foam's resilience enables this to be done very precisely. With most cartridges, tightening both screws will tilt the front of the cartridge up (approaching a positive rake angle), while tightening the screws individually will alter the stylus azimuth.

So far, with alignment-sensitive cartridges, I haven't been able to work out any hard-and-fast rules for these adjustments. Generally, I set azimuth by eye, making sure that the front of the cartridge is vertical to the record surface, and set the rake angle by ear. The ear adjustment is really not as difficult as it might seem at first. As the screws are tightened in gradual increments, it's usually possible to hear changes in the character of the record noise. When the optimum setting is approached, the noise will begin to become quite clear and distinct, as will any high-frequency recorded material such as the overtones of cymbals. As a rule, when this sense of clarity is "locked in" I stop,

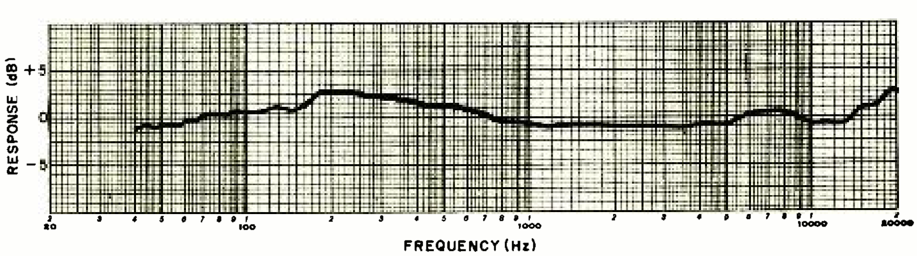
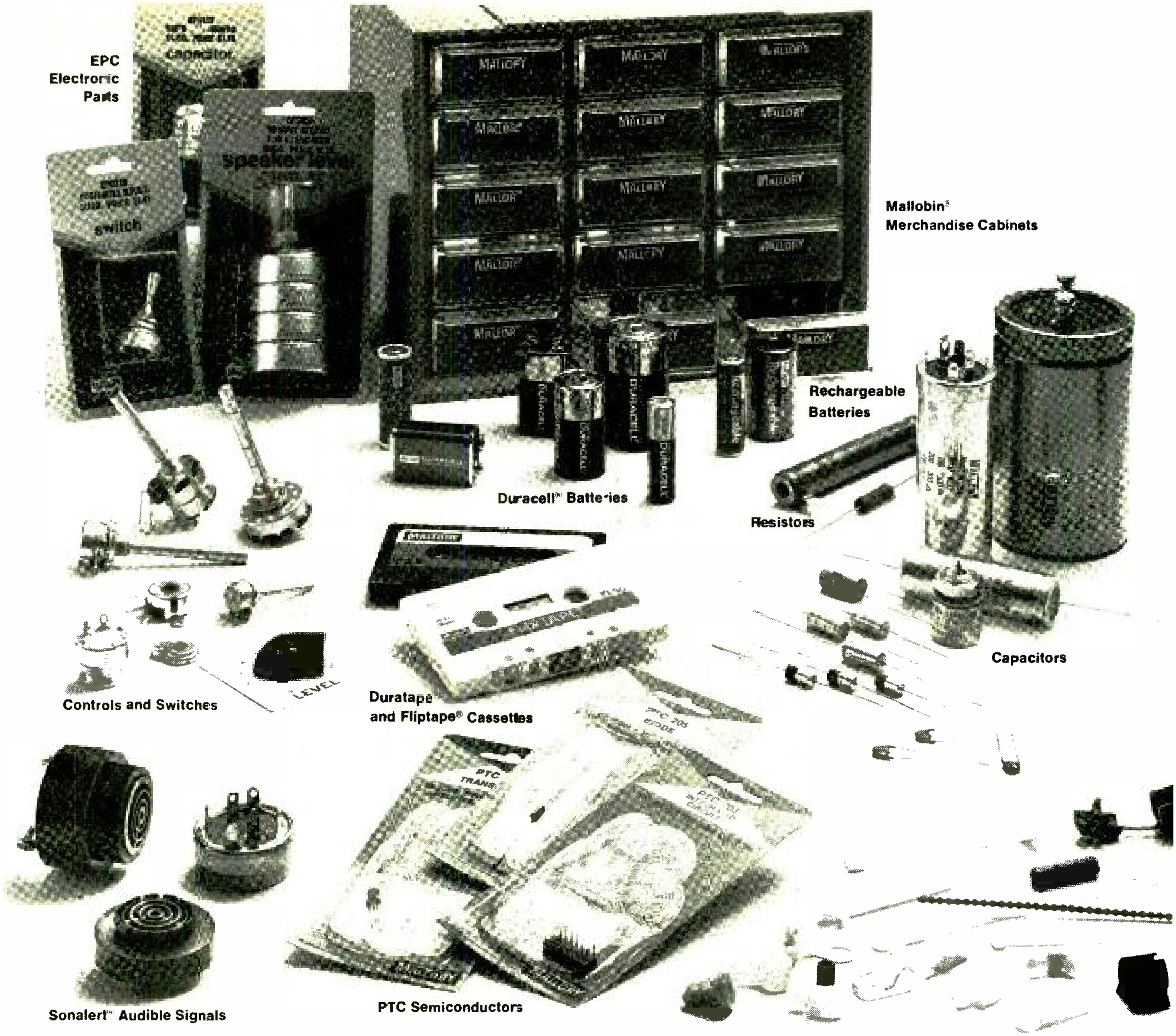


Fig. 2. Typical response irregularity introduced by flex mounting. Use of mounting screws with flex mount will improve the response.

(Continued on page 28)



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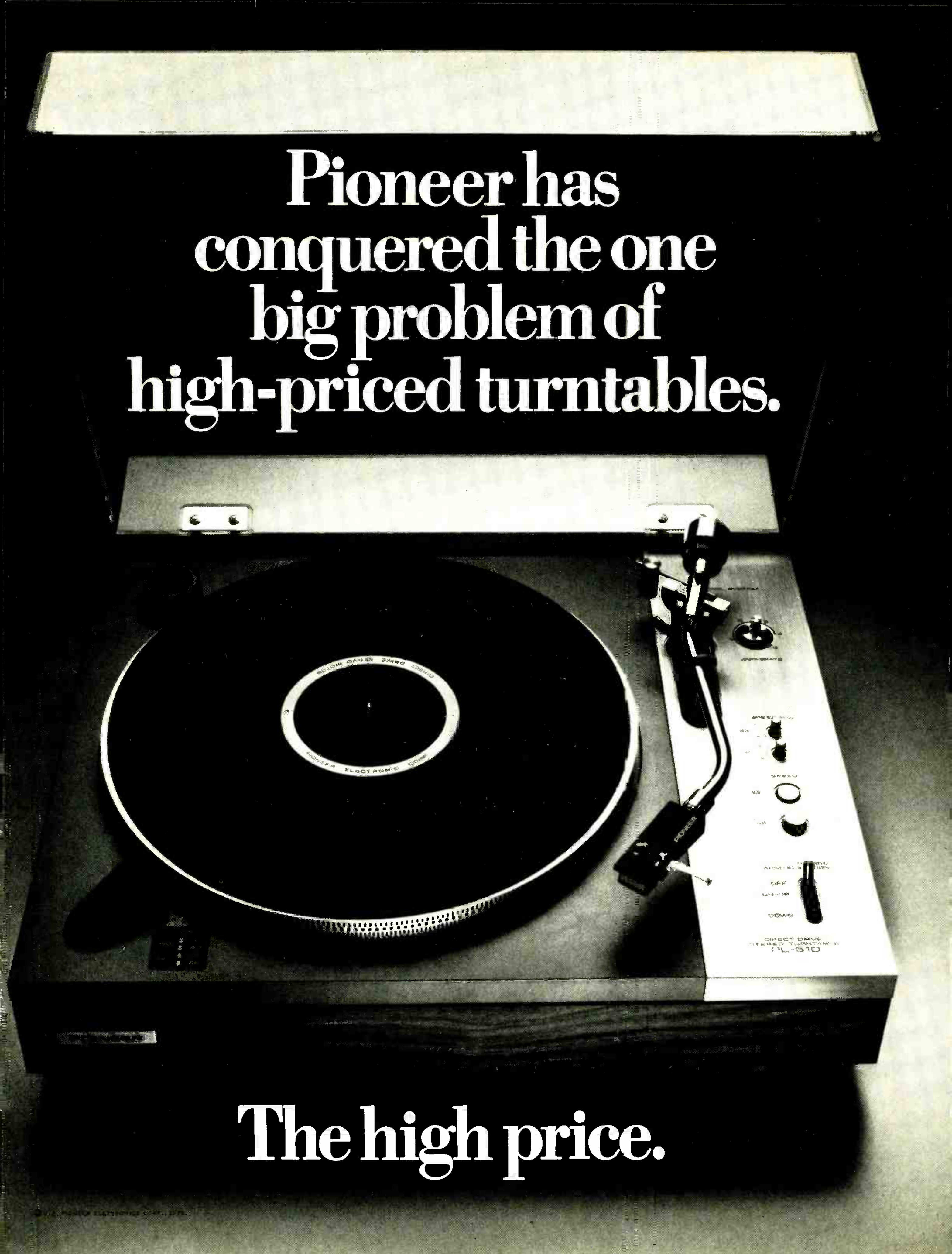
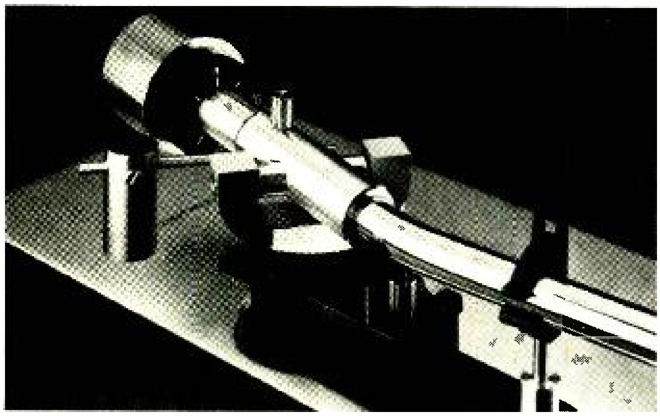

Pioneer has conquered the one big problem of high-priced turntables.
The high price.

For under $200,* you can now own the direct-drive PL-510.

The best way to judge the new Pioneer PL-510 turntable is to pretend it costs about $100 more. Then see for yourself if it's worth that kind of money.

First, note the precision-machined look and feel of the PL-510.

The massive, die-cast, aluminum-alloy platter gives an immediate impression of quality. The strobe marks on the rim tell you that you don't have to worry about perfect accuracy of speed at either 33⅓ or 45 RPM.



The S-shaped tone arm is made like a scientific instrument and seems to have practically no mass when you lift it off the arm rest. The controls are a sensuous delight to touch and are functionally grouped for one-handed operation.

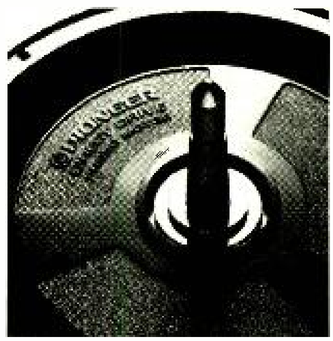
But the most expensive feature of the PL-510 is hidden under the platter. Direct drive. With a brushless DC servo-controlled motor. The same as in the costliest turntables.

That's why the rumble level is down to -60 dB by the super-stringent JIS standard. And that's why the wow and flutter remain below 0.03%. You can't get performance like that with idler drive or even belt drive. The PL-510 is truly the inaudible component a turntable should be.

Vibrations are damped out by the PL-510's double-floating suspension. The base floats on rubber insulators inside the four feet. And the turntable chassis floats on springs suspended from the top panel of the base. Stylus hopping and tone arm skittering become virtually impossible.

But if all this won't persuade you to buy a high-priced turntable, even without the high price, Pioneer has three other new models for even less.

The PL-117D for under $175.*



The PL-115D for under $125.* And the amazing PL-112D for under $100.*

None of these has a rumble level above -50 dB (JIS). None of them has more wow and flutter than 0.07%.

So it seems that Pioneer has also conquered the one big problem of low-priced turntables.

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although some of my correspondents go to much greater lengths, optimizing the rake angle for every record they play.

Ultimately, after going through this procedure (provided your cartridge is one of those that benefits from it), you will have a good idea of how the cartridge should be aligned when you remove the foam and re-install it in the conventional way. Or, as sometimes happens, you may find the flex mount has no deleterious effects on system performance, in which case you can retain it.

Maintenance. Even with a record player that has been carefully aligned and damped as necessary, there may be a tendency for performance to go downhill over a period of time. The usual reason for this is, again, that something is moving that shouldn't. Check the cartridge shell to see that it is securely fixed to the body of the arm. Then grasp the shell and tug on it a bit to see if any play is detectable throughout the arm mechanism. Any feeling of looseness is suspect, although there are some arms that are designed with loose bearings and seem to perform very well nonetheless. It is here that diagnosis gets tricky.

The great majority of tonearms have cone-type bearings that fit into ball races or finely machined sockets. Typically the cones are threaded, with a screwdriver slot at their rear; a locking nut holds the assembly in place. These are areas of potential wear, the effects of which can even differ with different cartridges. It's a good idea to ask the manufacturer how to adjust these bearings and to obtain from him whatever tools are used for the operation. One such tool is often a small spanner that engages the locking nut and has a hole through its center to accommodate a screwdriver for the cone. The spanner is an absolute necessity for working on this kind of bearing, since the cone and locking nut must be set simultaneously.

With proper adjustment and maintenance a good record player can attain a dazzling level of performance. Without it, there is little hope of its equaling the capabilities of a medium-priced cassette deck. As cartridges become more refined, it's likely that the demands on the tonearm and turntable will become more critical and complex. However, attention to the above considerations will take you a long way toward the best utilization of existing cartridges as we know them today. ◈

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A-170

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Hobby Scene Q&A

Have a problem or question on circuitry, components, parts availability, etc.? Send it to the Hobby Scene Editor, POPULAR ELECTRONICS, One Park Ave., New York, NY 10016. Though all letters can't be answered individually, those with wide interest will be published.

By John McVeigh

NEW MIICROCOMPUTER TERM

Q. ***I've recently come across the term "MPU" in mini- and microcomputer contexts. What does it mean?***

—Paul Mottola, Scranton, PA

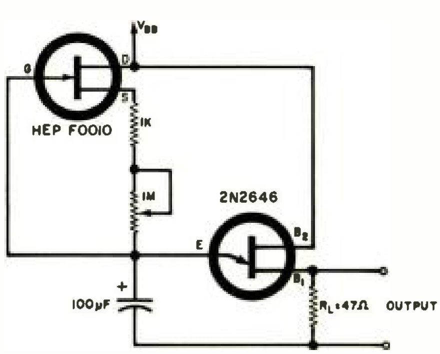
A. MPU stands for Micro-Processing Unit, and is synonymous with the older term, CPU (Central Processing Unit). They both contain key computer elements, such as accumulators, arithmetic logic units, I/O buffers, address drivers, multiplexers, timing and control, and instruction registers.

SAWTOOTH GENERATOR

Q. ***Do you have a circuit for a low-frequency sawtooth generator that can be used as an external scope sweep generator?***

—John Blasing, Cincinnati, OH

A. The circuit shown will generate



sawteeth over a 0.1-to-100-Hz range. Use a 5-volt supply (V_{BB}) and a linear taper 1-meg pot.

AUDIO INITIALS

Q. ***The owner's manual of my stereo amplifier refers to the initials DIN, RIAA, NAB and IHF. What do they mean?***

—Hugh Banton, Windsor Locks, CT

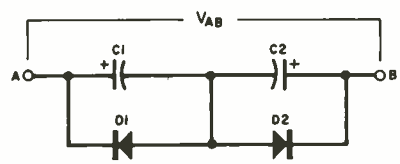
A. They all refer to organizations that have set up certain standards as a gauge of amplifier, preamplifier, and turntable performance. DIN stands for Deutscher Industrie Normenausschuss, a group of German manufacturers similar to our Electronics Industry Association or Institute of High Fidelity (or IHF). RIAA means the Record Industry Association of America, while NAB stands for the National Association of Broadcasters.

NONPOLAR ELECTROLYTICS

Q. ***I need large non-polarized coupling capacitors for dc and ac circuits. Can electrolytics and shunting diodes be used?***

—David R. Curott, Florence, AL

A. Yes, they can. Extremely large coupling capacitors can be fabricated in this manner, especially useful for instrumentation amplifiers. I've used this method in building an EKG



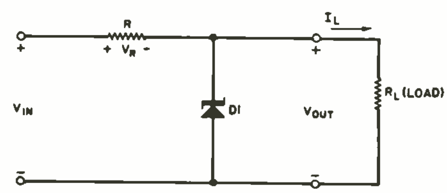
preamp and had no problems. When V_{AB} is negative, *D1* shorts out *C1*, *D2* is open and *C2* acts as the coupling capacitor. When V_{AB} goes positive, *D2* shorts and protects *C2*, *D1* is open and *C1* passes the signal. For best results, tantalum capacitors should be used. Note that the equivalent capacitance equals *C1* or *C2*, not their series combination.

CURRENT LIMITING RESISTOR

Q. ***I want to use my 6-volt cassette player in my car, which has a 12-volt system. If I use a zener diode to drop the supply to 6 volts, what size resistor do I need for current limiting?***

—Stewart Labus, Amarillo, TX

A. The accompanying sketch shows the common way of connecting a zener voltage regulator. Resistor *R* limits the current through the zener



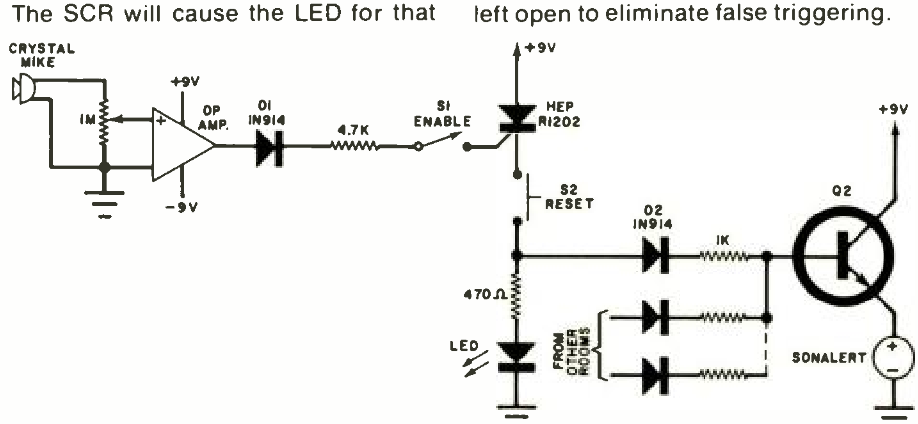
under all load conditions to a safe value. To determine the value of *R*, find the voltage across the resistor: $V_R = V_{in} - V_{out}$. Then determine the *maximum* current demand of the load (I_L) from specs or with an ammeter. The minimum rated power dissipation of the diode will be $P_Z = V_{out} \times I_L$. The value of the resistor will then be $R = V_R/I_L = (V_{in} - V_{out})/I_L$. Its power rating will be $P_R = I_L \times V_R$, or V_R^2/R.

INFANT ALERT

Q. ***Here at an orphanage we need a sound-activated alarm so that the night nurse can tell at her desk when one of the children wakes and starts crying. Do you have a circuit that will light an appropriate LED and enable a beeper when this happens?***

-Robert Wong, Aruba, N. Antilles

A. The circuit shown will work for you. When the infant starts to cry, the crystal mike (an inexpensive tape-recorder type) triggers the output of the op amp, which in turn activates the SCR. The SCR will cause the LED for that room to light, and enable the common beeper. When the nurse sees to the child's needs, she will push *S2* and cut off the SCR and transistor *Q2*. The leads from the rooms to the LED's and diodes can be any convenient length. Any medium-power (1 watt or so) npn transistor is suitable for *Q2*. Note that separate op amps (any general-purpose type), SCR's, etc., are needed for each location. Total cost can be reduced by using quad op amps. When the child is awake, *S1* should be left open to eliminate false triggering.



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CIRCLE NO. 12 ON FREE INFORMATION CARD

news HIGHLIGHTS

Teaching Computers To Speak English

The trouble with computers is that operators must learn to think like computers and communicate in *their* language. Professor David Waltz of the University of Illinois at Urbana-Champaign wants things the other way around, for the computer to think and listen to instructions like a human. The professor is formulating an intelligent program that will accept queries in conventional English to allow a nontechnical user to talk to, rather than program, computers. The completion of the natural-language program will be particularly helpful to individuals with limited computer skills. Most important, man and machine will be speaking the same language, English.

FCC Clobbers TV Game Makers

Nine violation notices have been issued by the Federal Communications Commission to companies marketing electronic TV devices that allegedly disregard Commission regulations. The home TV games did not have an approved Class 1 TV device, necessary when video games are connected directly to a TV receiver's antenna terminals. Such a TV game cannot be advertised, announced or sold before being tested and approved by the FCC. All nine companies cited replied to the FCC within the deadline of 15 days, stating that none of the TV games had been shipped and would not be shipped until official Commission approval is obtained. The Commission plans to issue more violation notices in the near future.

Pioneer Sets Guinness Record

In a nonstop marathon of playing records for almost 12 days (284.5 hours), Pioneer beat the previous record of 268 hours established in Norway, ranking it a feat that belongs in the "Guinness Book of Records," Royal Air Force Senior Aircraftsman Mike Buckley worked toward the new record with two PL-12D turntables. In all, more than 5690 single-disc changes were required between the two turntables during the record-breaking period.

Amateur Radio Changes

Code—The FCC is deleting part of Section 97.29(c) of the Commission rules concerning the standard an Amateur radio licensee must meet in reception and transmission of international Morse Code. The Rules currently require the licensee to transmit and receive one full minute of code, free of omissions and other errors, at the prescribed speed during a five-minute testing period. Believing this to be unduly restrictive, the FCC is planning to use one or more alternative test methods. One of them is a multiple choice examination covering a five-minute transmission of plain text. Such a test would relieve the applicant of copying one minute of mixed text without error, yet would provide an accurate gauge of competency in reception of code message content.

Study Guides—The FCC is releasing new study guides for amateur radio operator license examinations. They are in the form of a syllabus that outlines the various categories of questions from which the exams are devised and include sample questions representative of those appearing in the exams. The new guides have been reorganized to reduce the possibility of an individual acquiring a ham license simply by memorizing the answers to specific questions. Additionally, the guides have been designed to permit much greater flexibility in the selection of exam questions. This flexibility will allow more frequent revision of amateur examinations and, therefore, result in a more equitable exam program for all trainees.

Two Electronics Pioneers Die

On January 16, 1976, Dr. Hidetsugu Yagi died at the age of 89 in Tokyo, Japan. Dr. Yagi was the inventor of the Yagi array antenna commonly used in vhf and hf radio and TV communication.

On April 4, Swedish born and Yale educated Dr. Harry Nyquist died at the age of 87. Dr. Nyquist discovered a set of conditions to keep feedback circuits stable. The "Nyquist Criterion" is used to study electronic devices and to examine human reactions, such as driver responses to conditions while steering a car.

FCC Holds Off CB Expansion

The Federal Communications Commission has decided not to take immediate action on expanding the number of Class D CB radio channels on 27 MHz. Seems that there is a serious question of interference to CB operators on existing 23 channels. The FCC said that tighter specifications would be needed before there will be any approval of expansion.

Number of "E" Graduates Down For 1975

The engineering graduating class for the year ending June 1975 was the smallest in the last seven years, according to data compiled by the Engineering Manpower Commssion of the Engineers Joint Council. Among engineering specialties, electrical engineering had the largest number of graduates at all degree levels—14,537—followed by civil engineering with 11,237. A separate engineering category, computers, produced 1384 degrees. Women and minorities are showing rapid growth in engineering. Women earned more than 2% and minorities more than 7% of the 1975 bachelor's degrees. A survey of 2-year technology schools, though not including many smaller schools, revealed 4805 associate degrees in electronics and 1541 in computers for the year ending June 1975.

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CIRCLE NO. 5 ON FREE INFORMATION CARD

BUILD

SOL
An Intelligent Computer Terminal

BY ROBERT M. MARSH AND LEE FELSENSTEIN

Based on an 8080 MPU, this hobbyist's computer terminal can compete with most commercial units

THERE are essentially two types of video computer terminals in common use. The "dumb" terminal—little more than a "glass Teletype®"—is a simple data transmitter/receiver whose only stand-alone function is its use as a TV typewriter. The "intelligent" (also known as "smart") terminal, on the other hand, offers powerful stand-alone features. Built around a sophisticated microprocessor, intelligent terminals allow you to write, store, and edit programs for transmission to a computer or a hard-copy device. It also provides very powerful word processing at relatively low cost.

The SOL video terminal project presented here is one of the most advanced of intelligent terminals. It can interface with any mini- or microcomputer via its built-in RS-232 or 20-mA current-loop interfaces, in either serial or parallel format. It can also tie into a time-sharing computer via a telephone line and a modem (such as the Pennywhistle described in the March 1976 issue of POPULAR ELECTRONICS). In fact, it is even possible for two SOL terminals to communicate with each other without human supervision.

The key to SOL's versatility is its integral 8080 microprocessor (μP) chip. The μP operates on instructions stored in PROM's (programmable

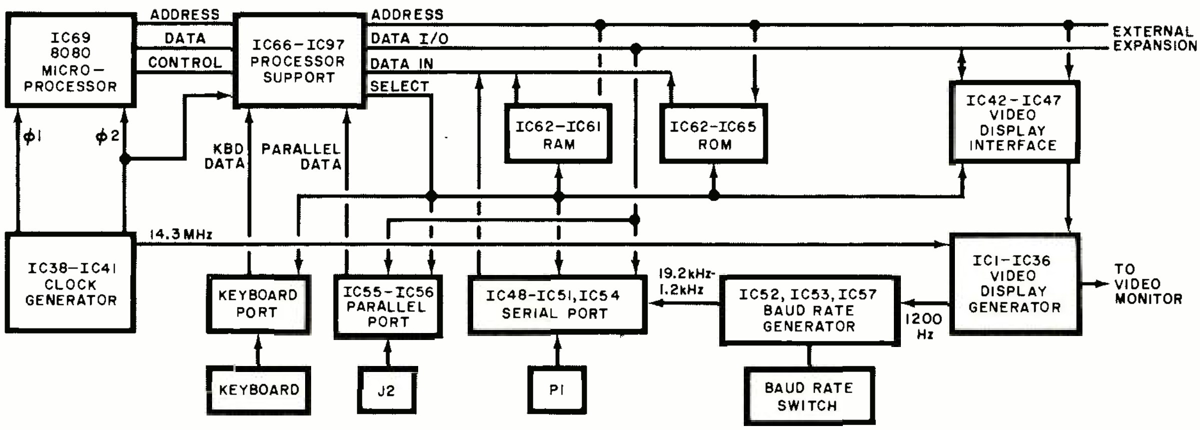


Fig. 1. Terminal accepts data from keyboard, parallel port, and RS-232 or 20-mA serial port. Output is 1 volt p-p for conventional TV requirements. Memory can be externally expanded to 65 k.

PARTS LIST

C1—10-pF disc capacitor
C2, C11, C21, C22—0.001-μF disc capacitor
C3, C7, C15, C16, C17, C18, C20, C27 through C63—0.1-μF disc capacitor
C4, C5—680-pF mica capacitor monolithic
C6—1.5-μF, 25-volt ceramic capacitor
C8, C13—1-μF, 35-volt dipped tantalum capacitor
C9, C10—15-μF, 20-volt dipped tantalum capacitor
C12—0.01-μF disc capacitor
C14, C23—680-pF disc capacitor
C19—100-μF, 16-volt upright aluminum electrolytic capacitor
C24—0.1-μF Mylar tubular capacitor
C25—0.001-μF Mylar tubular capacitor
C26—0.01-μF Mylar tubular capacitor
D1, D2, D4 through D9—1N4148 diode
D3—5.1-volt, 1-watt zener diode (1N5231B or similar)
IC1, IC8, IC11, IC12, IC23, IC39, IC73, IC74—74LS175N quad latch IC
IC2, IC79—74LS20N dual 4-input NAND gate IC
IC3—74LS86N quad exclusive-OR gate IC
IC4, IC42, IC45, IC47, IC71, IC72, IC94—74LS02N quad 2-input NOR gate IC
IC5, IC51—7406N open-collector hex inverter IC
IC6—DC4049AE CMOS hex inverter IC
IC7, IC14, IC25, IC26, IC53, IC57—74LS161 or 74LS163 4-bit synchronous counter IC
IC9—6575 MOS character generator IC
IC10—74166N 8-bit parallel-in shift register IC
IC13, IC24—CD4029AE 4-bit up/down counter IC
IC15—74L161, 74L163, or 93L16 4-bit synchronous counter IC (do not substitute)
IC16, IC93—74LS10N triple 3-input NAND gate IC
IC17—CD4001AE CMOS quad 2-input NOR gate IC
IC18 through IC21, IC29 through IC32—21L01-1 or 91L02APC MOS 1024-bit RAM IC
IC22, IC33, IC40, IC46, IC66, IC67, IC68, IC75, IC80, IC81, IC82—8T97 hex tristate buffer IC
IC27, IC48, IC78, IC95—74LS109N dual JK flip-flop IC
IC28, IC50, IC89, IC96—74LS04N hex inverter IC
IC34, IC35, IC36—74LS157N quad 2-input data selector IC
IC37—74HOON high-speed quad 2-input NAND gate IC (do not substitute)
IC38—74SO4N Schottky hex inverter IC (do not substitute)
IC41—MH0026P MOS clock driver IC
IC43, IC87, IC90—74LS74N dual D flip-flop IC
IC44, IC83, IC86—74LS00N quad 2-input NAND gate IC
IC49, IC88—74LS08N quad 2-input AND gate IC
IC52—CD4046AE CMOS phase-locked loop IC
IC54—TR1602B, AY-5-1013, or S1883 UART IC
IC55, IC56—74173N quad tristate latch IC
IC58 through IC61—21L01 or 91L01PC 256 × 4 MOS RAM IC
IC62, IC63, IC64, IC65—S5204A or MM5204Q 512 × 8 MOS erasable PROM IC (optional; write to address below for details)
IC69—8080, 8080A, or 9080A microprocessor IC
IC70, IC77, IC84, IC91—74LS253N dual 4-input tristate data selector IC
IC76—DM8836N quad 2-input NOR gate IC
IC85, IC92—74LS155 dual 2-to-4 line decoder IC
J1—Right-angle PC mount (AMP206584-1 or DB25S)
Q1, Q2, Q3—2N2907 transistor
The following resistors are ¼-watt, 10% tolerance:
R1, R2—330 ohms
R3, R9, R10, R21, R23 through R30, R80—10,000 ohms
R4, R5, R6, R14 through R20, R22, R31 through R35, R37, R39, R41, R43, R45, R46, R48, R52, R56, R57, R58, R65, R72, R73, R74, R76, R77, R78, R79, R82, R83, R84, R89 through R98, R100, R101—1500 ohms
R7, R8—47 ohms
R36, R67, R68, R99—4700 ohms
R38, R40, R42, R47, R49, R53, R55—2200 ohms
R44, R60, R81—3300 ohms
R50, R54, R64, R87—100 ohms
R51—200 ohms
R59, R63—33,000 ohms
R61, R62, R66—1000 ohms
R69—15,000 ohms
R70, R71, R113—100,000 ohms
R75, R88—3.3 megohms
R85—75 ohms
R103, R105, R107, R109, R110, R111, R112—8200 ohms
R106, R108—39,000 ohms
R11, R12, R13—100-ohm 1-watt, 10% tolerance resistor
R86—330-ohm, ½-watt, 10% tolerance resistor
R102, R104—50,000-ohm trimmer potentiometer (Bourns No. 3352-1-503 or similar)
S1 through S4—Four-position dual in-line switch
S5—Momentary-action spst switch
S6—Single-pole, seven-position rotary switch
S7, S8, S9—Spst switch
S10—Spdt switch
XTAL—14.318-MHz, 0.01% or better tolerance, series-resonant crystal in HC18U case
Misc.—Two 40-pin, five 24-pin, 54 16-pin, and 31 14-pin IC sockets (optional); 75-ohm coaxial cable; TV monitor; ASCII keyboard; power supply; suitable chassis; mounting hardware; hookup wire; solder; etc.

Note: The following items are available from Processor Technology Corp., 6200 Hollis St., Emeryville, CA 94608: Complete SOL-PC kit of parts (does not include case, power supply, or keyboard) for $297.00. Available separately are SOL-PCB etched and drilled printed circuit board for $40.00; SOL-SS set of IC sockets for $40.00; and SOL-FAN fan for $20.00. A complete kit that includes all parts, pc board, power supply, ASCII keyboard, all cables and plugs, and a case is available for $497.00; specify kit SOL-1. **Free copies of the complete schematic, etching and drilling guide, and component placement guide are available from the same source on request when accompanied by a self-addressed stamped (26¢) envelope (9″ × 12″).**

read-only memories). In its basic configuration, the SOL terminal consists of a printed circuit assembly that contains the μP, 512 eight-bit bytes of PROM, 2048 eight-bit words of RAM (random-access memory), 1024-character video display generator, keyboard interface, serial and parallel interfaces for connection to external devices, and an edge connector for memory expansion. All you add are a power supply, TV receiver or video monitor, ASCII keyboard, and a case.

Since the SOL terminal is 8080 based, its memory capability can be expanded to 65k bytes. Hence, one might ask, is the SOL an intelligent terminal or a powerful microcomputer? In essence, it is both.

How It Works. The complete schematic diagram for the SOL terminal is much too large to be reproduced in this article. Therefore, a complete schematic, an etching and drilling guide, and component layout diagram for the printed circuit board are available on request simply by sending a self-addressed stamped (26¢) envelope (9"×12") to the source given in the Parts List.

The block diagram shown in Fig. 1 will be used to explain circuit operation. Notice the similarity of this diagram to that of a conventional 8080 microcomputer. The 8080 (or 8080A or 9080A) microprocessor, *IC69*, is the "heart" of the terminal. It is supported by *IC66* through *IC97*, which include address and data line drivers and selectors; "wait state" timers; flag latches for data ports; and partial address decoding. Both address and data I/O (input/output) ports are available for expansion using currently available 8080-type memory cards.

As many as four PROMS (*IC62* through *IC65*) allow up to 2048 bytes of program to be installed in the terminal. Up to 512 bytes of RAM can also be installed and are designated *IC58* through *IC61*.

SOL TERMINAL SPECIFICATIONS

Display: 16 lines of 64 characters per line. Black characters on white background or reverse.
Character set: 96 printable ASCII upper-and lower-case characters. Plus 32 control characters (optional).
Display position: Continuously adjustable both horizontally and vertically.
Cursor: Solid video inversion (switch selectable blink), cursors are programmable.
Serial interface: RS-232 and 20-mA current loop, 75 to 9600 baud, synchronous.
Parallel Interface: Eight data bits for input and output; output bus is tri-state for bidirectional interfaces; levels are standard TTL.
Keyboard interface: Seven-level ASCII encoded, TTL levels; requires strobe pulse with data stable for approximately 100 μs following positive edge.
Microprocessor: 8080, 8080A, or 9080A.
On-card memory: 512 bytes PROM (expandable to 2048 bytes), 1280 bytes RAM (expandable to 1560 bytes).
External Memory: Expandable to 56k bytes total ROM, PROM, and RAM.
Signal output: 1.0 to 2.5 volts peak-to-peak with composite negative sync; nominal bandwidth is 7 MHz.
Power required: +5 volts at 2.5 amperes, +12 volts at 150 mA, and −12 volts at 200 mA; all buses must be well regulated.

The heart of the video display section is character generator ROM *IC9*. The generator provides both upper- and lower-case characters in a 7 × 9 dot matrix format. Descenders on lower-case characters g, j, p, q, and y go below the base line to provide true typewriter character formatting. The remainder of the IC's in the video section (*IC1* through *IC36*) produce the horizontal and vertical sync, cursor options, video inversion (black characters on white background), and all video "handshake" requirements.

The video output has a maximum bandwidth of 7.15 MHz. It contains a composite sync to allow operation with any conventional video monitor or monochrome TV receiver converted for video input (Fig. 2). Color TV receiver CRT's may not be capable of providing the resolution required for a clean video display, although the authors have obtained acceptable results using a type-approved r-f modulator to feed color receivers through the antenna input. (CAUTION: Do *not* use a transformerless video monitor or TV receiver unless a line-isolating transformer is installed.)

The *IC54* UART is used in the terminal for data transmission and reception. It is supported by *IC48* and *IC51*. Clock pulses for the UART are provided by the baud-rate generator made up of *IC52*, *IC53*, and *IC57*. Phase-locked loop *IC52* operates with dividers to produce the required clock signals. A switch is provided for setting the baud rate for 75, 110, 150, 300, 600, 1200, 2400, 4800, or 9600 baud (data bits per second). The serial port has both RS-232 and 20-mA current-loop provisions.

The parallel port consists of an eight-bit latch made up of *IC55* and *IC56*. These IC's have tristate outputs that enable their use with a bidirectional parallel data channel if desired. Signals are eight data bits wide at standard TTL levels at the input and output.

The ASCII keyboard connects to the main terminal board by a single connector that provides power to the keyboard and accepts signals from the keys. The interface requires seven-level ASCII at TTL levels and a strobe pulse with the data stable for approximately 100 μs following the positive edge.

Power for the main board must be 5 volts dc at 2.5 amperes, +12 volts at 150 mA, and −12 volts at 200 mA. The power bus lines must be well regulated.

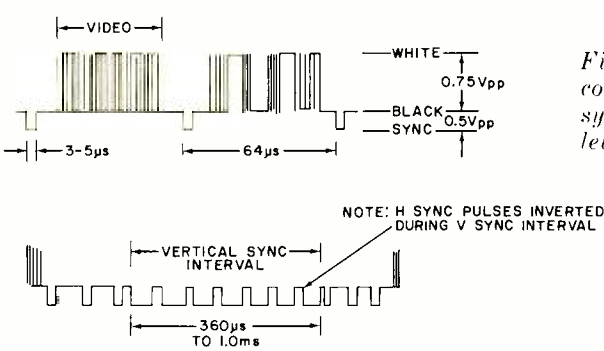
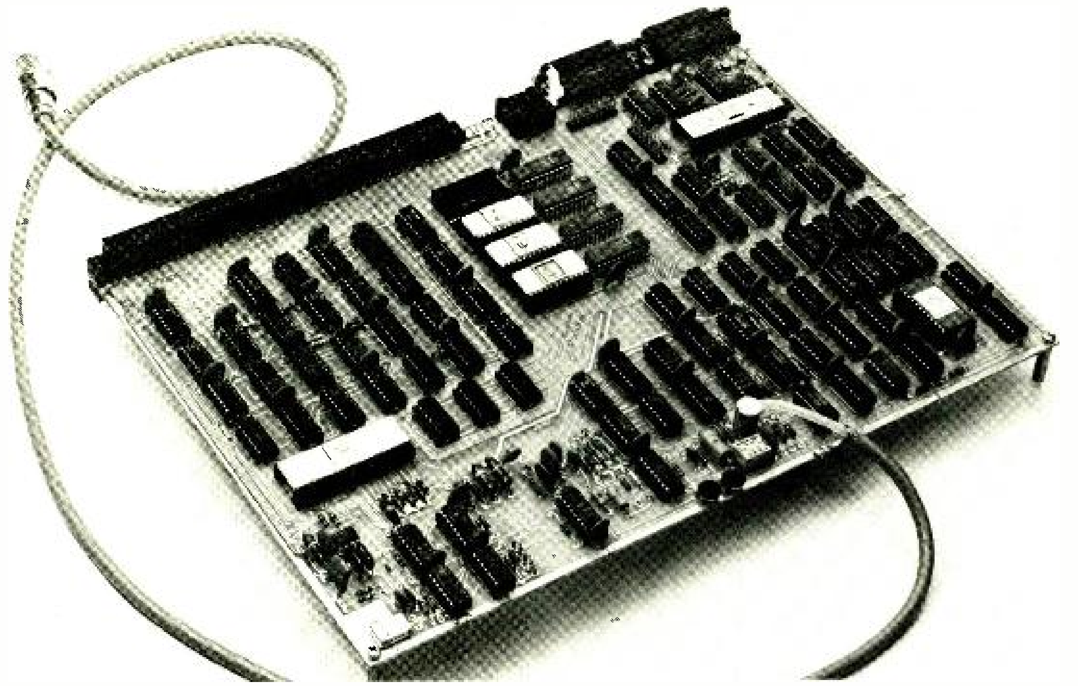


Fig. 2 Video output is conventional with negative sync and 1-volt p-p signal level.

Construction. Since the printed circuit board measures 13" × 11" (33 × 28 cm) and has numerous traces and pads that require careful registration, home fabrication of the board is not recommended unless you are highly experienced in making complex double-sided boards. Once you have the board and are ready to start mounting components, save IC installation for the last.

Start wiring the board by mounting



Large connector at left rear of assembled circuit board assembly is for external memory; coax cable is for composite video output. All input and output connectors are on rear edge.

IC sockets (recommended for all IC's to make removal and replacement easy) in place. Next, mount and solder into place the resistors, capacitors, diodes, and transistors. Then mount the baud rate switch and connectors flush to the surface of the board; make sure they do not sit askew after soldering them down.

Once the crystal is mounted and soldered into place, pass a length of bare hookup wire over its case and into the holes flanking the case. Solder the wire to the crystal's case and board pads. Install and solder into place the coaxial cable for the terminal's output.

Carefully check the board assembly for poor soldered connections, solder bridges between closely spaced pads and traces, and proper polarization of diodes and capacitors and basing of the transistors.

Checkout. Before installing any IC's, power up the circuit board assembly to verify that no short circuits exist. Measure the potential across zener diode *D3*; it should be −5 volts. Check the fine foil traces near *R85* (at the video output) for short circuits on the +12-volt line. If everything checks out, turn off the power.

Insert *IC37* through *IC41* in their sockets, making sure you properly orient them. Install jumpers from pad A to pad B and pad D to pad E (next to *IC37*). Turn on the power and use an oscilloscope to check the 47-ohm resistors next to *IC41* for the clock pulses. When you obtain the pulses, turn off the power.

Install *IC1* through *IC36*. Be particularly careful when handling *IC9* to avoid static discharges. After removing this IC from its protective foam carrier, be sure to touch the pc board with your other hand *before* bringing the IC into contact with its socket. Seat the IC carefully in its socket and gently press it home. (Note: If you encounter excessive resistance when trying to install *IC9,* replace the IC in its foam carrier. Then loosen the socket pin receptacles by repeatedly inserting and removing a non-MOS IC or piece of bare 24 gauge wire.) Install *IC9*.

Set horizontal and vertical sync controls *R104* and *R102* to midposition and the four-position dual in-line switch so that *S1* and *S4* are off and *S2* and *S3* are on. Connect SOL's video output cable to the video monitor and turn on the power to both monitor and terminal board. Displayed on the screen should be at least one line of random characters and white cursor blocks. Adjust the V and H controls on the terminal board for proper sync and the contrast and brightness controls on the monitor for the best display.

Set *S3* to off and *S4* to on; the cursor should flash at a slow rate. Set *S2* to off; the background should change from black to white. Set *S1* to on; the control characters (symbols or abbreviations, depending on the type of character generator being used) should disappear. Turn off the board's power supply.

Install *IC42* through *IC50* and *IC66* through *IC97*. Practice the same precautions for *IC69,* the microprocessor chip, that you took for *IC9* above. Connect the "wait state" jumper at *IC71* from pad W to pad 1.

With the video monitor still connected to the terminal and operational, turn on the board's power. The CRT screen should display one or more lines of alternating 9 and "null" characters and should flicker every few seconds. This indicates that the µP is working. If there is any doubt, briefly operate the RESET switch. If you observe no activity on the screen, turn off and remove power from the board and check that all IC's are in their proper sockets and properly oriented.

Install *IC52* through *IC61* and program PROM *IC62*. Use the same precautions detailed above for *IC9* and *IC69* when handling and installing *IC54, IC58* through *IC61,* and *IC62*. Make sure that the socket for UART *IC54* is not too tight. If you encounter difficulties during insertion, use a non-MOS IC or 24 gauge wire to loosen the socket pin receptacles.

Once everything seems to check out, power up the board. If the program is running properly, the monitor screen should display a blanked screen with the proper "message" at the bottom.

This completes construction of the SOL video terminal. You can now add an ASCII keyboard and hook up to the outside world via the serial and/or parallel ports. ◈

Microwave Ovens for the Home

How they work and what to look for in selecting one.

BY BILL EVA

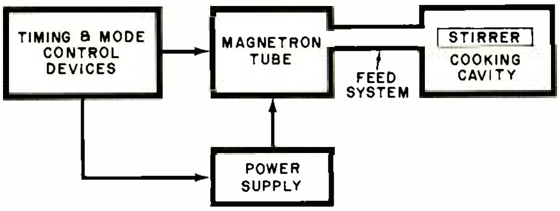
ONCE used almost exclusively for line-of-sight radio communication and in industrial heating applications, microwaves are now cooking food in homes. While the microwave oven existed as far back as 1945 and was first marketed by Tappan in 1955, its popularity as a consumer appliance didn't become established until the beginning of this decade. As a result of a reduction in prices, improvements in the ovens themselves, and availability of convenience features, microwave ovens are capturing a significant percentage of the total consumer dollar spent on major cooking appliances.

Microwaves cook foods faster than conventional gas and electric ovens; and because the microwave oven is considerably more efficient than a radiant-heat oven, it is a great deal more economical to operate. Convenience features and noncooking aesthetics have also helped to make the microwave oven an attractive consumer appliance.

Market Trends. As can be seen from the graphs, the microwave-oven market began a meteoric rise in 1970 when it captured about 1.5% of the large cooking appliance market. By the end of last year, an estimated 26% of the consumer dollar had gone into purchases of microwave ovens and combination conventional/microwave ranges. Extrapolating from this performance, estimates have been made that the microwave appliance will account for almost 50% of the worldwide market by the end of this decade.

It is interesting to note that the early microwave oven market was dominated by a few Japanese name brands but that the U.S. has since taken over the major portion of the market. Current figures give 75% of the market to U.S. manufacturers and the remainder to the Japanese manufacturers.

Ten manufacturers currently supply microwave-oven appliances to the



Magnetron tube, power supply, and cooking cavity make up basic elements of all microwave appliances.

consumer market. In the U.S., there are Amana, General Electric, Litton, Magic Chef, Tappan, and Thermador, while in Japan, there are Hayakawa (Sharp), Matsushita (Panasonic), Sanyo, and Toshiba. Together, these 10 companies offer a wide variety of appliances to meet any cooking need of virtually every budget.

Oven Operation. In its basic form (see block diagram), the microwave oven consists of a power supply, magnetron tube, and cooking cavity. The magnetron tube generates the r-f energy that cooks the food. It is designed to operate at a frequency in the 2400-to-2500-MHz (2.4-to-2.5-GHz) range. The magnetron tube is driven by a power supply that plugs directly into the normal ac line. The power supply is essentially a hefty transformer that delivers about 4000 volts to the magnetron.

The energy generated by the magnetron is coupled into the cooking (or microwave) cavity via a system of waveguides. Situated near the entrance to the cooking cavity is a "mode stirrer." This is a rotating device that has irregularly shaped reflective sections that scatter the microwave energy uniformly throughout the cavity to minimize hot and cold spots. (In some ovens, uniform energy distribution is obtained by having the food rotate on a turntable in the microwave energy field.)

Integral to every microwave cooking appliance are door seals and safety interlocks, both of which are required to make the appliance safe to operate. The seals block and absorb the potentially hazardous r-f energy to prevent it from escaping from the oven's cavity to the outside environment. The interlocks are designed to instantly remove the power from the magnetron tube in the event the door should be opened when the oven is turned on.

Another element basic to all consumer-type microwave ovens is a timer that precisely controls the cooking time. Since time is an important factor in microwave cooking, some oven models feature two timers—coarse and fine—to permit very accurate setting of the cooking cycle. With other oven models, a single timer is provided with two operating speeds. The time can be indicated in either mechanical scalar format or numerically with LED displays driven by an all-electronic system. Deluxe oven models even feature countdown and hold modes on their timers. And some digitally generated numeric timer displays double as clocks when the oven isn't being operated.

Large countertop microwave ovens generally deliver between 600 and 700 watts of r-f power to the food load. Smaller ovens are rated at 400 to 500 watts.

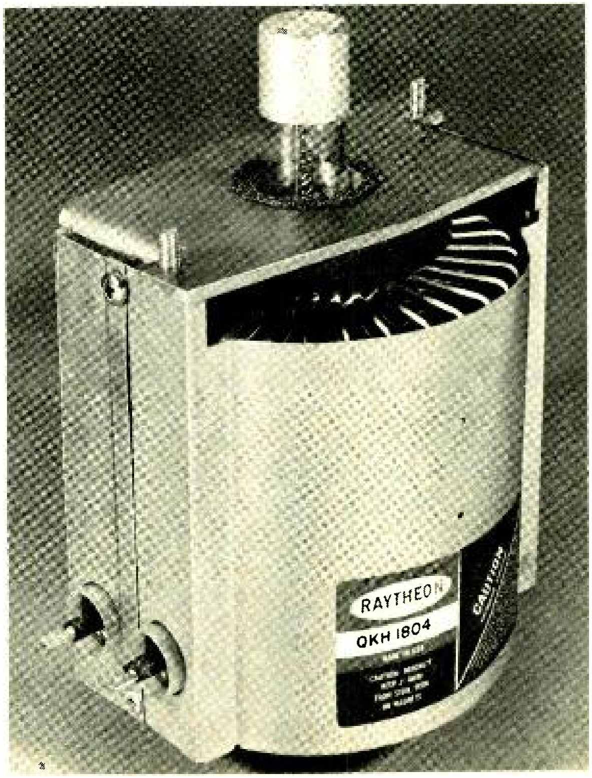
Most microwave-oven appliances give the user a choice of operating modes. Almost all models provide cook and warm modes. The latest modes to be introduced are defrost and slow cook. The cook and warm modes generally operate the oven at full power. Defrost usually pulses the microwave energy on and off without cooking the food. Slow cook, useful for making stews, casseroles, and other dishes that require gentle simmering, can be accomplished by operating the magnetron tube continuously at reduced power or by pulsing the full-power output on and off, with the on period determining the average cooking heat.

Bear in mind that no microwave oven can brown a roast or fowl, sear a steak, or form a crust on bread and pastry by microwave energy alone. For this, you need a source of radiant heat. Some microwave ovens feature internal browning elements to accomplish these tasks. Amana, however, does use microwave energy to brown, sear, and crust foods, but special Browning Skillets are required.

Microwave vs. Radiant. The modern microwave oven is more than just a new type of cooking appliance. It is a whole new approach to cooking. One must become accustomed to telescoped cooking times and take care to avoid using metallic cooking utensils (except in some Litton ovens).

The one great advantage the microwave oven has over conventional gas and electric ovens is its high efficiency. In conventional ovens, heat is radiated into the air before it gets to the food inside the oven. Hence, much of the energy goes into heating the air (a goodly portion of which escapes from the oven through a vent). The food being cooked heats from the outside toward the center. All told, only a

Typical magnetron tube is housed in rugged metal container along with necessary magnets.



fraction of the heat radiated into the oven goes into cooking the food.

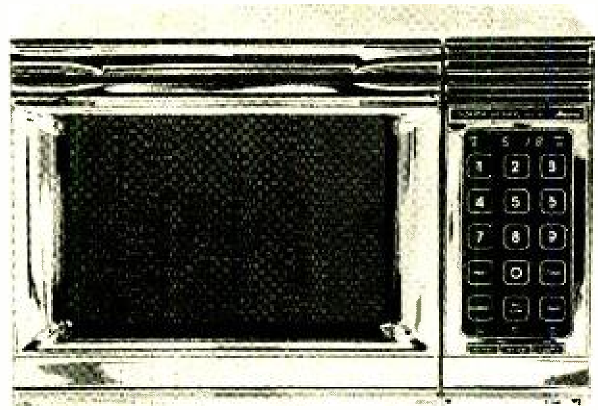
By contrast, all of the heat developed by the microwave energy is generated uniformly inside the foods. Foods, therefore, cook uniformly throughout and have less of a tendency to dry out near the surface. No heat is wasted in heating the air surrounding the food in the microwave oven. As a result, the air and walls of the cooking cavity remain relatively cool, which means that foods and splatters don't bake on. Cleaning up is as easy as wiping with a wet sponge or cloth.

Since little or no energy is wasted in a microwave oven, foods cook faster and the energy demand is greatly reduced. Energy savings range from 50% to 75% in a microwave oven, depending on the amount of food being cooked. Likewise, cooking times are reduced to only about 25% of those required in conventional ovens.

Virtually all of the microwave energy developed by the magnetron tube is absorbed by the food in the oven, regardless of size. Hence, it takes twice as long to cook two same-size potatoes, for example, than it does to cook one potato in a microwave oven. As a rule, cooking times in a microwave oven increase in direct proportion to the increase in the amount of food being cooked.

Microwave ovens use high-reliability magnetron tubes, most of which are rated at 3000 or more hours of useful life. Since a microwave oven in a typical home is operated on an average of 100 hours per year, the magnetron tube has an implied life of about 30 years. Compare this to the typical 15-year useful life of the average gas or electric oven. And the power supply, the other major expense item, is at least as reliable as the magnetron tube. Door seals and interlocks, too, should last for the life of the oven. In fact, manufacturers have such a high opinion of the reliability of their microwave appliances that they generally offer warrantees against defects and failures for periods ranging from three to five years.

Depending on size (and cooking power), basic microwave ovens draw between 8 and 15 amperes when operated from the 117-volt, 60-Hz ac line. The advantage here is that small countertop microwave ovens without built-in browning elements do not require an expensive overhaul of most electrical systems. Of course, if you decide on a deluxe countertop oven with built-in radiant-heat elements for browning or a combination radiant-heat/microwave appliance, the power demand will be greater.



Amana's Touchmatic Radarange is first to use microprocessor to control all cooking functions and timing.

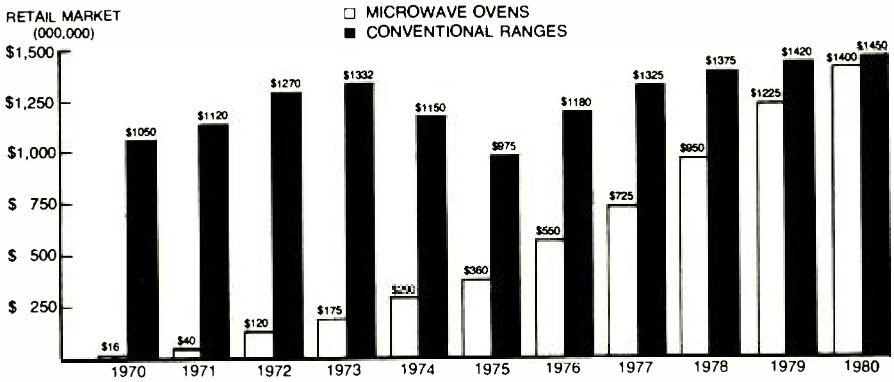
A Note On Safety. A few years ago, when the microwave oven was still relatively new to the consumer market, a question of safety arose with regard to the protection provided by the door seals against leakage of microwave energy.

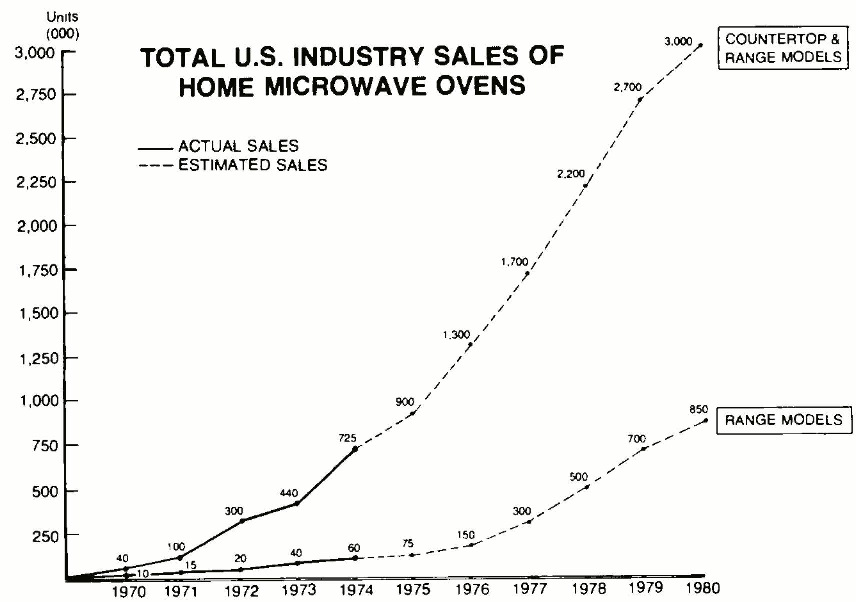
While some controversy still remains, much of the discussion has abated. In the meantime, a number of private and government agencies have conducted much radiation research; new standards have been written; and better and more lasting door seals have been developed by microwave-oven manufacturers. Almost all of the original objections have been put to rest as a result. Although microwave energy leakage has not been reduced to zero (an impossible task to say the least), leakage levels are now generally regarded to be well within the limits regarded as safe, even after an oven equipped with the new seals has been in service over a prolonged period of time.

The responsibility for producing microwave ovens that will maintain door-seal integrity rests with the manufacturers. To this end, all manufacturers perform exhaustive tests on every microwave oven for the consumer market. When a microwave oven has been put into its shipping carton and consigned for delivery to a retailer, you can be assured that it has been certified. (It is interesting to note that one manufacturer — Amana Refrigeration — has received a microwave oven warning label exemption from the government, which should provide some indication of

Litton's Micromatic combination range offers both radiant and microwave cooking and is the first microwave appliance to allow use of utensils.

MICROWAVE OVENS' GROWING SHARE OF MAJOR COOKING APPLIANCE MARKET





Source: Litton Microwave Cooking Products, July 1975

Graphs above left illustrate early market growth of microwave-oven appliances versus conventional ranges and predicted growth through 1980.

how much the safety of consumer microwave appliances have been upgraded in the past couple of years.)

Buying Tips. As with any other home appliance, the best advice is to shop around to determine which brand and model of microwave oven fills your needs. If you plan to do most of your cooking with a microwave oven and have a relatively large family (four or more individuals), look for a full-feature countertop oven or combination conventional/microwave range. On the other hand, if you have a small family and plan to use your conventional oven for most roasting, baking, and broiling, you can probably get along with a smaller, more economical model with fewer features.

Since a microwave oven represents a sizable investment, it pays to visit sources and make direct performance and cost comparisons. On occasion, large-appliance dealers—particularly discount centers—feature sales on microwave ovens. Pick up whatever manufacturer literature is available. And, if possible, have the salesperson demonstrate how the different models work.

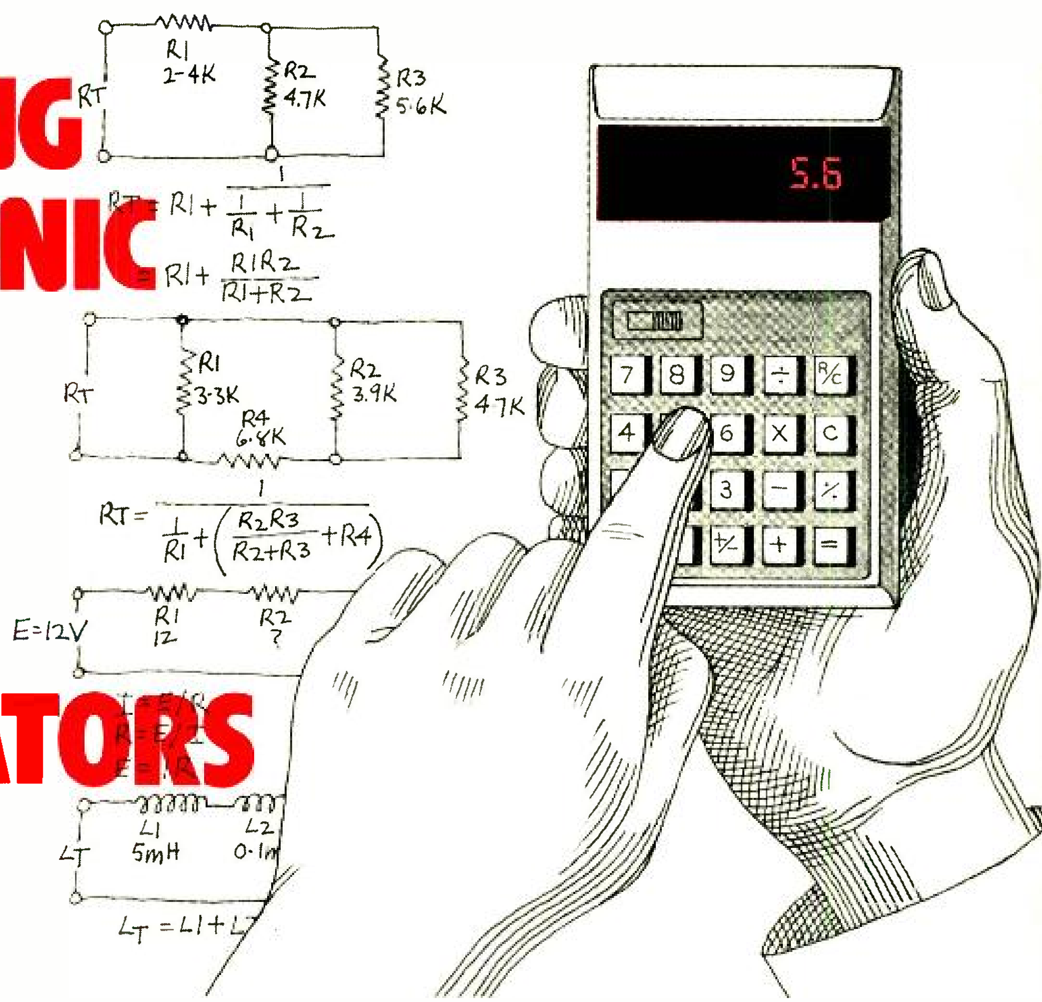
If you're on a tight budget, look at the "economy" models. Economy ovens, after all, contain roughly the same basic cooking elements common to even the most deluxe types. True, you won't have all the conveniences (high/low-power cooking, defrosting, slow-cook, and countdown and hold), but it is usually possible to compensate for the lack of these features by using your oven with a little imagination.

It is very important that, once you get your microwave oven home and before you plug it into an outlet, you check to make sure the door closes tightly. Don't just try one opening and closure to verify proper door operation. Check to make sure that there's no lateral play around the hinges when the door is open. Should you detect a loosely fitted door or less than solid closure, you should immediately contact the dealer from which you bought the oven and inform him of the problem. Do not, under any circumstances, operate the oven if a door problem exists. You will run the risk of radiation leakage. It is rare that a situation like this arises. But even with the extreme precautions taken by manufacturers to deliver a safe product, rough handling during shipping may result in improper sealing.

What to Buy. The decision to buy a microwave appliance will depend partly on need and partly on the confidence you have in the product. As detailed above, new microwave appliances can be given a high degree of confidence with respect to reliability. If you still have reservations about buying a microwave oven, they probably stem from the fact that you have to learn a new technique for cooking foods. Rest assured that the technique isn't difficult to master in a very short time. To this end, you might be wise to pick up one or more of the books devoted to microwave cookery on the market. We can recommend "The Amana Guide To Great Cooking With a Microwave Oven," available at many paperback book racks or from Amana dealers for $1.75. Litton Industries, P.O. Box 851, Maple Plain, MN 55359, has "Old-Fashioned Goodness With Variable Power Microwave Cooking" for $9.95 and "Discover Combination Microwave Range Cooking" for $12.95 (both hard-cover volumes).

While precooked and processed food packages are slow to list microwave cooking times (a situation that will doubtlessly be remedied as more and more microwave ovens come into use in consumer kitchens), several cooking magazines—at least one of which is devoted to gourmet cooking—recognize the merits of microwave cooking and are including a limited variety of recipes for the new cooking medium. ◈

LEARNING ELECTRONIC THEORY WITH HAND CALCULATORS



BY EDWARD M. NOLL

PART ONE: Basic Equations and Ohm's Law

THE deeper you get into electronics, the more you find how many mathematical manipulations are involved. The tedium involved in extracting roots, raising numbers to powers, calculating angles and vectors, and handling very large and very small numbers — sometimes in a single problem — often make students of electronics throw up their hands in despair.

Now, thanks to the availability of low-cost hand-held scientific calculators, you can put most of the drudgery of numer manipulation behind you. The calculator is an accurate, easy-to-use mathematical tool that eliminates the need for log and trig tables. It is also an extremely fast problem solver. Most people who become familiar with using a scientific calculator to solve problems actually *want* to learn the math that will take them deeper and deeper into electronics.

This article is the first of three installments on how to use a scientific calculator to solve basic electronics problems. We will discuss Ohm's Law and dc circuits; calculating the total resistance, capacitance, and inductance in series and parallel circuits; and resonance.

Throughout this series, the method of keyboard entry described is standard algebraic. If you are using a reverse-Polish notation (RPN) calculator, refer to its instruction manual for information on how to translate from algebraic to RPN format. In addition, it is pre-supposed that your calculator is equipped to handle two-digit power-of-ten superscript in the display and on command from the keyboard. It must also have parentheses (preferably "nested") and a memory register.

(Note: The answers to problems given in this series of artcles were obtained with a Melcor calculator. If you use a calculator from a different manufacturer, you may obtain slightly different answers as you work the problems. The differrences in answers will be negligible.)

Series and Parallel R. The simplest type of problem you are likely to encounter in electronics is finding the total resistance in a series circuit. The total resistance, R_T, is the sum of the individual resistances, as shown in the formula accompanying Fig. 1A. The value of R_T will always be greater than the highest value resistance in a series circuit.

In Fig. 1 are three series-resistor circuits, each containing four resistors of different values. Circuits A and B illustrate a very important rule to bear in mind: *Always make entries in identical units*. In Fig. 1A, you can simply add the resistances exactly as they are stated because they are all in kilohm units. However, if you look closely at the circuit of Fig. 1B, you will find that *R3*'s value is given in megohms, which means that you must first convert 1.2

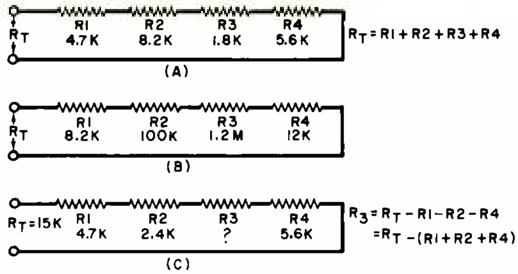


Fig. 1. In series-resistor circuit, total resistance is sum of individual resistances.

megohms to 1200 kilohms before attempting to sum the values.

What is the total resistance in kilohms for Fig. 1A? Using your calculator, solve the problem by making the following keyboard entries:

4.7 + 8.2 + 1.8 + 5.6 =

As soon as you make the last entry, the display should read 20.3, which is R_T in kilohms (20,300 ohms). To solve for R_T in kilohms for the Fig. 1B circuit, the keying sequence would be:

8.2 + 100 + 1200 + 12 =

yielding 1320.2 kilohms.

The object of the circuit shown in Fig. 1C is to find the value of *R3*, given R_T and the values of the remaining resistors. This is done simply by subtracting the given values from R_T as illustrated in the formula. The keying sequence is

15 − 4.7 − 2.4 − 5.6 =
or 15 − (4.7 + 2.4 + 5.6) =

Note that the second keying sequence introduces the use of parentheses. Here, the sum of the resistances inside the parentheses is subtracted from the first entry. Both sequences yield the same answer: 2.3 kilohms (2300 ohms).

When resistors are connected in parallel, as shown in Fig. 2, R_T is the reciprocal of the sum of the reciprocals of the individual resistor values (see formula in Fig. 2A). Total resistance R_T is always less than the lowest resistance value in a parallel circuit.

The use of the scientific calculator makes short work of the manipulations required for solving parallel circuits. In solving for R_T (in kilohms) for the values given in Fig. 2A, it is easiest to first find the sum of the reciprocals of *R1, R2,* and *R3* and then find the reciprocal of the result:

4.7 1/x + 8.2 1/x + 5.6 1/x
= 1/x Display: 1.948221701

The answer in kilohms can be rounded off and stated as 1.95 kilohms.

Total resistance and the values of two of the three resistors are given in Fig. 2B. The objective is to determine the value of the unknown resistor. To do this, the basic parallel-resistance formula must be rearranged as shown. Then solve for *R3* as follows:

1.2 1/x − 6.8 1/x − 8.2 1/x
= 1/x Display: 1.772033898

After rounding off, the value of *R3* becomes 1.8 kilohms.

The value of R_T for the circuit in Fig. 2C can be calculated using either of the two formulas shown:

6.8 1/x + 2.4 1/x = 1/x
or 6.8 × 2.4 ÷ (6.8 + 2.4) =
Display: 1.773913043

After rounding off the result, R_T becomes 1.8 kilohms.

Circuits containing both parallel and series grouping, like that shown in Fig. 3, must use a formula that includes all elements. The formula for R_T for the circuit shown is also given in Fig. 3. To solve for R_T here, make the following entries:

2.4 + (4.7 1/x + 5.6 1/x) 1/x =
or 2.4 + [4.7 × 5.6 ÷ (4.7 + 5.6)] = Display: 4.955339806

Round off the answer to 4.96 or 5 kilohms. Note that the second method introduces the use of nested parentheses. To be able to use the second method of entry, your calculator must have at least two levels of parentheses. Otherwise, you will have to use the calculator's memory register.

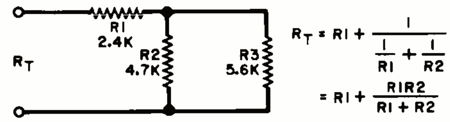


Fig. 3. In this series-parallel circuit, R_T is greater than R1.

The rather complex formula shown in Fig. 4 can be solved in several ways. We offer here two keyboard sequences you can use for solving for R_T. In the first, the calculator's memory register is used to store an intermediate result. In the second, the order of entry is slightly rearranged to avoid the use of the memory function and reduce by two the number of entries that must be performed. In both cases, however, the *R2/R3* network is first converted to a product-over-sum format: R2R3/(R2 + R3).

3.3 1/x STO 3.9 × 4.7 ÷ (
3.9 + 4.7) + 6.8 = 1/x +
RCL = 1/x Display: 2.409668219
or 3.9 × 4.7 ÷ (3.9 + 4.7)
+ 6.8 = 1/x + 3.3 1/x =
1/x Display: 2.409668219

After rounding off, R_T becomes 2410 ohms.

Ohm's Law. The voltage/current/resistance relationship known as Ohm's Law is one of the most important in electronics. Ohm's Law states that the current in a circuit varies directly with the voltage and inversely with the resistance in a circuit. In equation form, this becomes I = E/R, from which we derive E = IR and I = E/R. Now, referring back to Fig. 3 and using 4955 ohms as R_T, what is the current in the circuit if 200 volts is applied? Since I = E/R, your calculator entries would be:

200 ÷ 4955 =
Display: 4.036326942 −02

Note that the result in the display con-

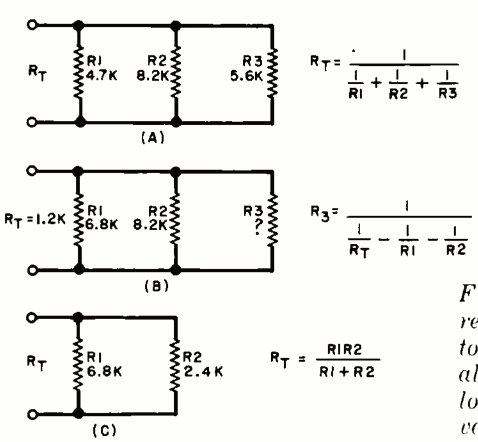


Fig. 2. In parallel-resistor circuit, total resistance is always less than lowest resistance value in circuit.

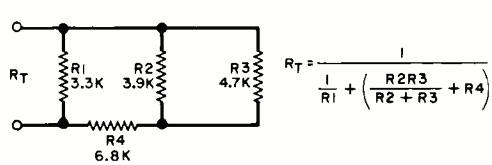


Fig. 4. Since R1 is in parallel with rest of circuit R_T must be less than value of R1.

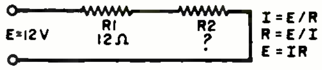


Fig. 5. Given any two I, E, R parameters, third can be derived.

tains an exponent of −02, which means that the decimal point must be moved two places to the left. This yields an answer of 0.04036 ampere (40.36 mA) after rounding off.

Once you know the current flowing through the circuit, you can easily calculate the voltage drop across any given resistor in that circuit. For example, let us calculate the voltage dropped across *R1* (E_{R1} = IR):

.04036 × 2400 = Display: 96.864

Next, what is the voltage drop across *R2* and *R3*? Bear in mind that while the full current flows through series resistor *R1* in this circuit, it splits in proportion to the resistances in the parallel legs consisting of *R2* and *R3* so that the voltage dropped across one resistor will be identical with that dropped across the other resistor. Hence, $E_{R2,R3}$ will be the difference between supply voltage E_S and E_{R1} ($E_{R2,R3} = E_S - E_{R1}$):

200 − 96.864 = Display: 103.136

You can now calculate the current through *R2* ($I_{R2} = E_{R2,R3}$/R2):

103.136 ÷ 4700 =

Display: 2.194383978 −02 (21.9 mA)

and through *R3* ($I_{R3} = E_{R2,R3}$/R3):

103.136 ÷ 5600 =

Display: 1.841714285 −02 (18.4 mA)

As an example in learning how to use your calculator with confidence, determine the total current drawn by the circuit in Fig. 4. Then calculate the current through and voltage dropped by each resistor in the circuit. Hint: The entire 100-volt E_S is applied across *R1* and also across the network made up of *R2, R3,* and *R4*. When you're through with your calculations your results should be: E_{R1} = 100 V; $E_{R2,R3}$ = 23.85 V; E_{R4} = 76.5 V; I_{R1} = 30.3 mA; I_{R2} = 6.1 mA; I_{R3} = 5.1 mA; and I_{R4} = 11.2 mA.

In the Fig. 5 circuit, what must be the value of *R2* if circuit current is to be limited to 200 mA. Since I = E/(R1 + R2), restating the formula yields R2 = (E/I) − R1. Therefore, the keyboard entry would be:

12 ÷ .2 − 12 =

or (12 ÷ .2) − 12 =

Display: 48

Hence, the value of *R2* must be 48 ohms.

Now, what is the total power (P_T) consumed by the circuit in Fig. 5 and power dissipated by each resistor in the circuit? Power (in watts) is a simple voltage-current relationship (P = IE). For P_T:

.2 × 12 = Display: 2.4 (watts)

To determine the power dissipated by each resistor, use the formula P = I^2R. This introduces you to the use of the x^2 squaring key. For *R1:*

.2 x^2 × 12 = Display: 0.48 (watt)

and for *R2:*

.2 x^2 × 48 = Display: 1.92 (watts)

Add the two dissipation figures obtained for *R1* and *R2:*

.48 + 1.92 = Display: 2.4 (watts)

and you have P_T.

Series and Parallel L & C. When dealing with inductances in series and parallel circuits, the rules are the same as those for resistive circuits. For series inductances, simply add the various L values (don't forget to use a common number notation), while for

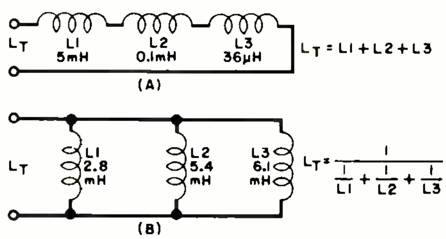


Fig. 6. L_T is calculated in a manner similar to finding R_T.

parallel circuits, calculate the reciprocal of the sum of the reciprocals of the various L values. Capacitances, on the other hand, are totalized in exactly the opposite manner: In a series ciruit, C_T is the reciprocal of the sum of the reciprocals of the various C values, while in a parallel circuit, C_T is the simple sum of the C values.

Given the above criteria, calculate the total inductance, L_T, for Fig. 6a:

5 + .1 + .036 =

Display: 5.136 (mH)

and for Fig. 6B:

2.8 1/x + 5.4 1/x + 6.1 1/x = 1/x Display: 1.41590426

which when rounded off becomes 1.416 mH.

Now, calculate C_T for Fig. 7A:

.1 1/x + .02 1/x + .005 1/x = 1/x Display: 3.846153846 −03

which rounds off to approximately 3850 pF. To calculate C_T for the Fig. 7B circuit, simply add the various C values:

1500 +820 + 680 =

Display: 3000 (pF)

The result can also be stated as 0.003 microfarads.

Resonance Formulas. Whenever a capacitor and an inductor are connected together in series or parallel, they will resonate at a frequency determined by the L and C values. The basic equation for determining resonance (f_r) is given in Fig. 8, as are the equations for determining the L and C values when f_r is given.

When working with the resonance formula, pay careful attention to the units in which the L and C values are stated. Values are generally stated in powers of 10, which may or may not be the same for L and C. However, you don't have to convert the numbers to a common exponent notation because you will be using the exponent key (EE or EEX, depending on the calculator you are using). On scientific calculators, the exponent key automatically states the number entry in "scientific notation" (power of 10).

Now, what is f_r for the Fig. 8 circuit? To solve this problem, make your keyboard entries as follows:

2 × π × (10 EE +/− 6 × 20 EE +/− 12) $\sqrt{x}$ = 1/x

Display: 11253953.95 (Hz)

In conventional notation, this would be 11.253954 Mhz, or 11.3 MHz. Note that in solving this problem we not only introduce the use of the EE key, but we also have occasion to use the π and square-root ($\sqrt{x}$) keys.

Since the same resonance equation applies to both series and parallel-resonant circuits, what is f_r for the circuit in Fig. 9? In solving this problem, bear in mind that capacitors connected in parallel with each other yield a C_T that is the sum of their values. Your keyboard entries would be:

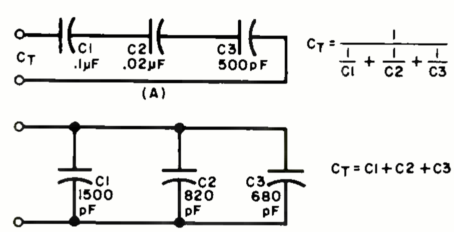


Fig. 7. Finding C_T for series and parallel circuits is similar to finding R_T for parallel and series circuits, respectively.

50 EE +/− 12 + 20 EE +/− 12 × 40 EE +/− 6 = $\sqrt{x}$ × 2 × π = 1/x or 2 × π × [(20 EE +/− 12 + 50 EE +/− 12 × 40 EE +/− 6) $\sqrt{x}$] = 1/x

The result displayed in both cases would be 3007745.709, which becomes approximately 3 MHz.

A capacitor of 140 pF is to be used in a parallel circuit that must resonate at 4 MHz. Using the equation given in Fig. 8 for determining the value of L, what must be the inductance used? The keyboard entry is as follows:

2 × π × 4 EE 6 = 1/x x^2 ÷ 140 EE +/− 12=

Display: 1.130816781 −05

Hence, the inductor would have a value of roughly 11.3 μH. You can double check your calculation by solving for f_r using 11.3 μH and 140 pF as the L and C values.

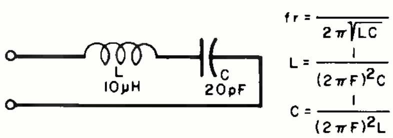


Fig. 8. Values of L and C determine resonant frequency.

Gain Formulas. Calculating power and voltage gain with a scientific calculator is a cinch because the calculator's built-in logarithm function eliminates the need for log tables. To see how simple the procedure is, let us assume that the output power of an amplifier is 4 watts and its input is 2 watts. What is the decibel (dB) gain of the amplifier, using the basic formula dB = 10 log (P_o/P_{in}), we get:

4 ÷ 2 = log × 10 =

Display: 3.010299954 (dB)

You can round this off to 3.01 dB. (When you work this problem on your calculator, use only the common-logarithm, or "log," key. Do NOT use the natural-logarithm, or "ln," key in power and voltage gain calculations or your answer will be incorrect.) Note that a doubling of power corresponds to a 3 dB gain.

If the output voltage of the circuit is 8 volts and the input is 4 volts, what is the voltage gain of the amplifier? Use the formula dB = 20 log (E_o/E_{in}):

8 ÷ 4 = log × 20 =

Display: 6.020599908

which rounds out to a 6-dB gain. Note here that doubling the voltage corresponds to a 6-dB voltage gain. Voltage and current gain and loss figures are appropriate only when the input and output impedances are identical. As a result, power gain and loss values are given most often because in most practical situations the input and output impedances are not the same.

In passing through a network, the output power drops from 6 watts at the input to 3 watts at the output. What is the power loss in decibels, using the formula dB = 10 log (P_o/P_{in}):

3 ÷ 6 = log × 10 =

Display: −3.0103 (or about − 3 dB)

In a network that has the same input and output impedance, the voltage drops from 16 to 8 volts. What is the loss in decibels. Using the formula dB = 20 log (E_o/E_{in}):

8 ÷ 16 = log × 20 =

Display: −6.020599918 (or −6 dB)

Finally, the input power to an amplifier

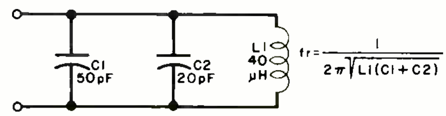


Fig. 9. C_T is sum of C1 + C2.

is 5 mW and the output power is 10 watts. What is the gain of the amplifier? First, convert 5 mW to 0.005 watt:

10 ÷ .005 = log × 10 =

Display: 33.01029995 (or 33 dB)

Summing Up. You have probably noted that it is a rather slow process making entries if mistakes are to be avoided. In the beginning, while you are becoming familiar with your calculator and the electronics math involved in problem solving, it is best to work each problem two or three times to avoid errors. As your confidence builds, however, you will find the process considerably speeded up.

In our second installment, we discuss impedance and ac formulas. ◈

A FLASHER/BATTERY INDICATOR

BY DALE HILEMAN

SINCE readers have considerable interest in flasher circuits, perhaps this flasher and battery indicator circuit will be helpful for use in a battery-operated test instrument.

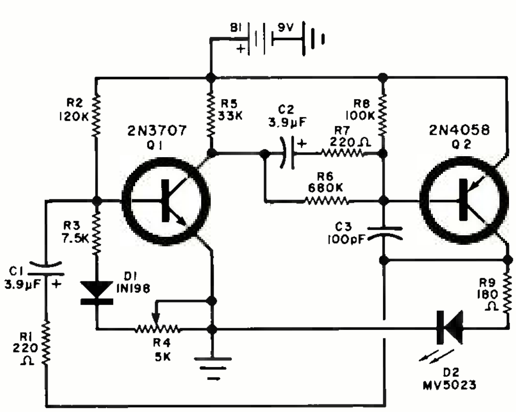
The flashing is intended to call the operator's attention to the fact that power is on so that he won't go away and leave the instrument operating. It flashes brightly about twice a second, but average current consumption is only about 200 μA because the duty cycle is only about one percent.

Helping keep power consumption to a minimum, transistors *Q1* and *Q2*, in an unusual complementary multivibrator circuit, are both cff 99 percent of the time, conducting only when the LED is on.

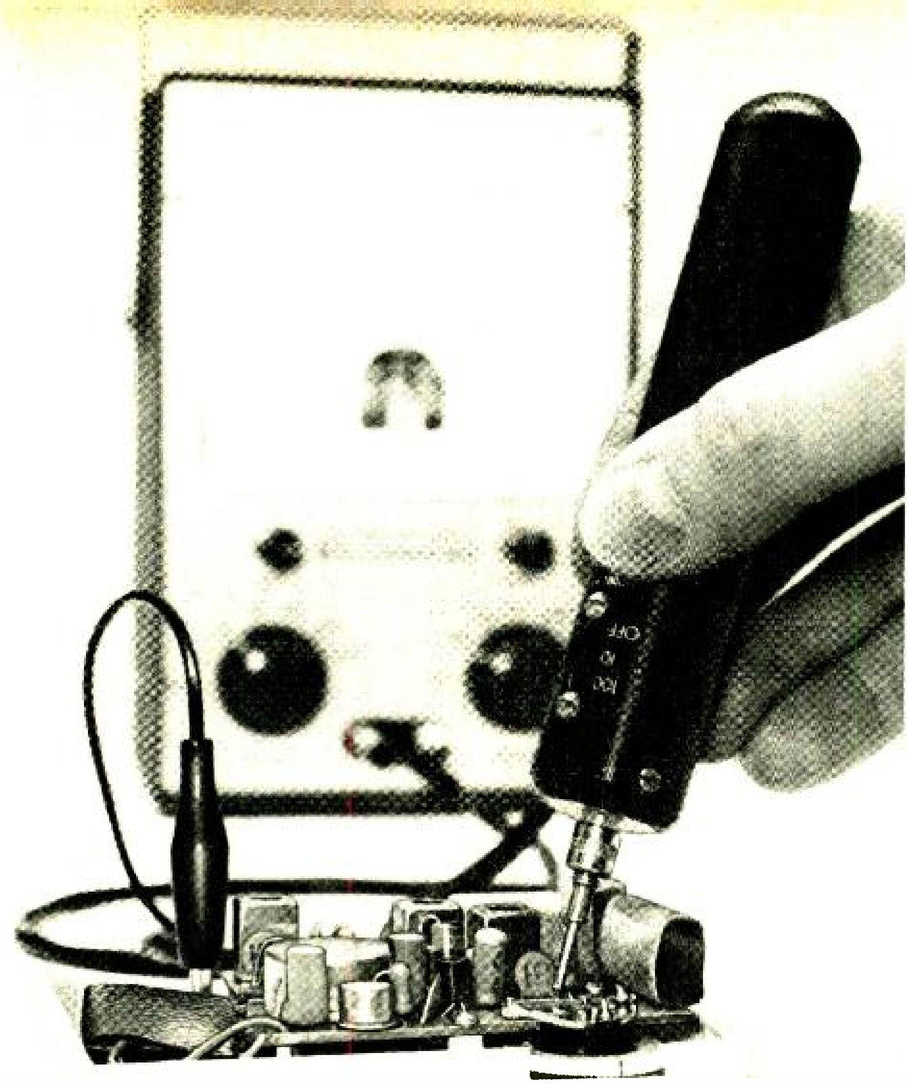
The circuit is intended for use with a 9-volt battery, and values are chosen so that *R4* can be adjusted to stop the flashing when the voltage drops to six volts. This point may be changed by altering the ratio of *R2* to *R3*.

As the battery voltage approaches the turnoff point, the flashing rate suddenly drops, to warn the operator of impending failure. Of course, when the battery voltage has dropped below this point, there is no flashing to remind the operator to turn the power off. Presumably, however, the battery is nearly dead anyway; so it doesn't matter much if left on. A germanium diode, *D1*, temperature-compensates the base-emitter junction of *Q1* to keep the turnoff voltage stable. This diode must be a 1N198; you *cannot* substitute.

Average current can be further reduced by increasing the values of *R1*, *R7*, and *R9*. The former two limit surge and the latter determines the current in the LED. ◈



While the 9-volt battery powers other equipment, this circuit indicates power on, and changes flash rate or turns off when battery gets low.



Update Your Multimeter with a CMOS Millivolter

Converts any voltmeter into a high-sensitivity input meter for low millivolts measurements.

BY DAVID H. DAGE

YOU CAN inexpensively update any dc voltmeter to measure in the low-millivolt range at an input sensitivity of 1000 megohms/volt with the Millivolter. The self-contained, battery-powered Millivolter is basically a high-sensitivity amplifier housed in a 5″ (12.7-cm) long probe that plugs into the standard input of any voltmeter rated at 1000 ohms (or greater) per volt.

When the Millivolter is used with an ordinary dc voltmeter, it can supply gains of ×10 or ×100 through its built-in CMOS operational amplifier circuit. This means that a 3-volt range in the meter effectively becomes a 30-mV range and a 1-volt range becomes a 10-mV range full scale. Additionally, the probe can be used to measure current, with 1 nA indicating full scale on a 1-volt range.

You can build the Millivolter for about $12, which is a great deal less than you would have to pay for a new instrument capable of providing its measurement features.

How It Works. The Millivolter is built around a new CA3130 linear CMOS op amp (*IC1* in Fig. 1) that has extremely low bias current requirements. This permits large values of input resistance to be effectively used. In this case, 10 megohms is used without seriously affecting the output voltage when the probe inputs are shorted.

When using a CA3130 op amp with a 10-megohm input resistor (*R1*), the output changes only 5 mV, or 0.5% of the full-scale indication. This is a sharp contrast to the unusual behavior of most other op amps on the market.

The output of the new op amp consists of CMOS transistors that operate as a class-A amplifier whose gain is dependent on the load impedance that it drives. With a gain of 100 and a reasonably high-input-impedance voltmeter (5000 ohms/volt), negligible error is introduced even when driving the output to within a few millivolts of the supply potential. When driving low-impedance voltmeters (1000 ohms/volt), the output is reliable to within ±3 volts with less than 2% load error. Shorting the output to ground will not damage the IC.

The circuit shown in Fig. 1 employs 1% tolerance resistors in the gain-setting feedback loop, which means that no gain-adjusting trimmer potentiometers are required. The offset voltage can be adequately trimmed to null by adjusting potentiometer *R6*.

With *S1* in the OFF position, the probe is completely bypassed, the voltmeter operates in the normal manner, and power is removed from the probe's circuit. In either of the other two positions (×10 and ×100), *S3* applies power to the probe's circuit and simultaneously performs all switching functions for the gain selected.

A single 9.8-volt battery, *B1*, powers the op amp amplifier circuit through *Q1* and the resistor network consisting of *R7*, *R8*, and *R9*. This network provides a common (ground) refer-

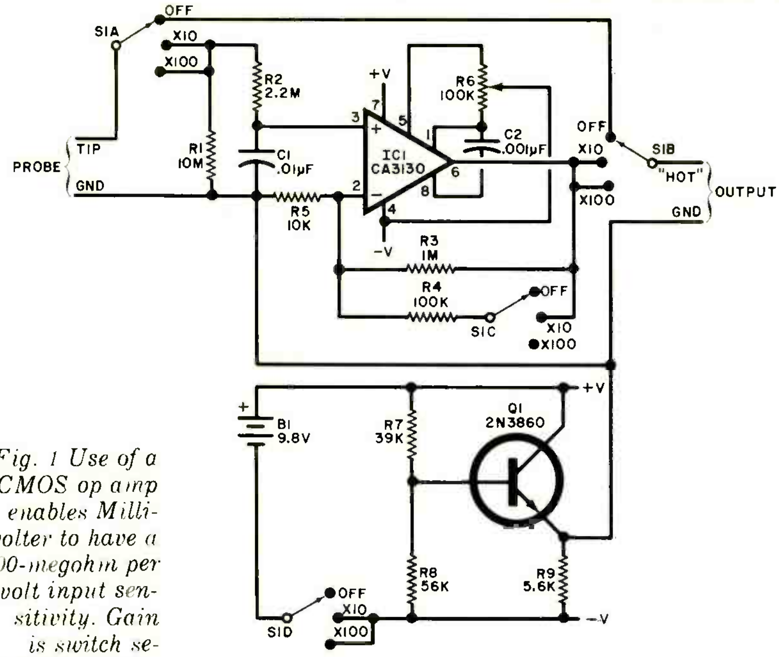


Fig. 1 Use of a new CMOS op amp enables Millivolter to have a 1000-megohm per volt input sensitivity. Gain is switch selectable between 10 and 100 times.

PARTS LIST

B1—9.8-volt mercury battery (RCA No. VS177 or similar)
C1—0.01-μF disc capacitor
C2—0.001-μF disc capacitor
IC1—CA3130 CMOS linear op amp IC (RCA)
Q1—2N3860 or similar transistor
R1—10-megohm, 5% resistor
R2—2.2-megohm, 5% resistor
R3—1-megohm, 1% resistor
R4—100,000-ohm, 1% resistor
R5—10,000-ohm, 1% resistor
R6—100,000-ohm miniature trimmer potentiometer
R7—39,000-ohm, 5% resistor
R8—56,000-ohm, 5% resistor
R9—5600-ohm, 5% resistor
S1—Four-pole, three-position miniature slide switch
Misc.—Suitable probe assembly (see text); printed circuit or perforated board; battery connector clips; probe tip; shielded cable (audio or coaxial) for output; miniature alligator clip; brass angle bracket; rubber grommet and silicone adhesive (optional—see text); hookup and test-lead wire; machine hardware; dry-transfer lettering kit; solder; etc.
Note: The following items are available from Dage Scientific Instruments, P.O. Box 1054, Livermore, CA 94550: Complete kit of parts (less battery and output cable connectors) for $11.95 plus $1.00 shipping and handling; RCA No. VS177 9.8-volt mercury battery for $2.50. California residents, please add sales tax.

ence at approximately half the battery potential, or 4.9 volts.

Construction. The Millivolter circuit can be assembled on either a printed circuit board or perforated board using point-to-point wiring techniques. It can also be housed in a small box instead of in a probe housing, although the latter is more convenient for testing purposes.

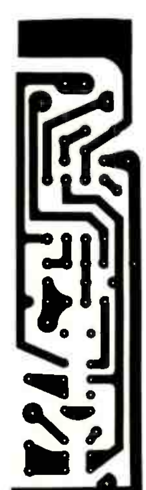
If you use pc wiring and plan to house the circuit in a probe body, use the actual-size etching and drilling guide in Fig. 2. Mount a small brass (not aluminum) angle bracket at the battery end of the board, sweat-soldering it into place. Then either solder or rivet a female battery connector clip to the bracket. This clip will accommodate the positive (+) terminal of the battery. Mount and solder into place trimmer potentiometer *R6*, about 1/16" (1.6mm) away from the surface of the board. This pot mounts on the *foil* side of the board. Mount and solder into place all remaining components on the blank side of the board as shown in Fig. 2.

Although the input of *IC1* is protected, it is still a MOS device and should be handled with care. Therefore, it is best not to handle the IC by its leads. Once *IC1* is soldered to the board pads, all pins will be properly terminated and no further safety precautions need be practiced.

You can use just about any plastic tube that has a 7/8" (22.2-mm) inner diameter and measures 5" (12.7 cm) in length to house the pc board assembly. If you want to reduce the amount of ac pickup, you can use a metal tube, but make absolutely certain that none of the components on the board touch the metal probe body. (Only the common ground circuit should make good electrical contact with the metal tube.)

Before sliding the circuit assembly into the probe body, accurately locate and cut a slot in the body for *S1*. Prepare a length of stranded (preferably test-lead) wire; fasten one end to the circuit's common ground point and to the other end attach a small alligator clip.

If your voltmeter normally uses an isolation resistor (usually 1 megohm) in its "hot" probe, connect the same value resistor in series with the Millivolter's output pad and output cable. You can conveniently mount this re-



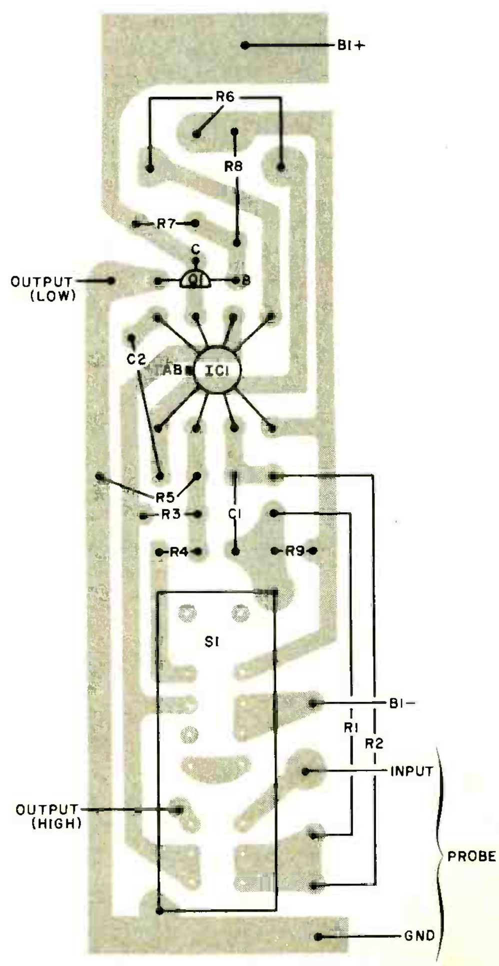


Fig. 2 Actual-size foil pattern and component installation on a board that can fit a 7/8" ID tube. The positive battery clip is soldered to one end of the board, with wire connection to the negative terminal.

FULL-SCALE CURRENT RANGES

Shunt Resistor	1-volt FS probe $\times 100$	3-volt FS probe $\times 100$	1-volt FS probe $\times 10$	3-volt FS probe $\times 10$
none	1 nA	3 nA	10 nA	30 nA
100,000 ohms	100 nA	300 nA	1 μA	3 μA
1000 ohms	10 μA	30 μA	100 μA	300 μA
10 ohms	1 mA	3 mA	10 mA	30 mA

sistor on the bottom (foil) side of the board.

Fashion a wood or plastic plug to fit the front of the probe body and mount a conventional test probe tip in it. Drill a hole through the rear of the probe body to allow the coaxial output cable to pass through. (If you're using a tube that's open at both ends for the probe body, you'll need another plug; drill the cable exit hole through the plug in this case.) The exit hole should be just large enough for a snug fit around the cable.

Solder the output cable to the appropriate points in the Millivolter's circuit. You can fashion a strain relief for the cable by sliding onto it a snug-fitting rubber grommet and fixing the grommet into place with silicone adhesive. (Trial fit the circuit assembly into the probe body to locate where along the cable the grommet is to be positioned before cementing it into place.)

With *S1* set to the OFF position, connect the battery to the clip mounted on the brass bracket. To the free end of a length of hookup wire connected to the wiper contact of *S1D*, solder a male battery connector. Snap this connector onto the negative (−) terminal of *B1*. Then slide the entire circuit assembly into the probe body, positioning the slider of *S1* in the cutout, and fasten the front plug into place with small machine screws. Finally, fit to the conductors at the free end of the output cable the appropriate connector(s) to mate with the input of your voltmeter.

Operation. Connect the assembled probe to your voltmeter, first setting the meter to the 1- or 3-volt dc range. The probe's output swing will be typically 4.5 volts in both the positive and negative directions. However, the maximum reliable output range should be limited to ± 3 volts. What this means is that if you were measuring voltages with the meter set to a range higher than 3 volts, an indication of 4 volts might represent a saturated output and not a true voltage measurement.

Make sure that the pointer of your voltmeter is set at mechanical zero and to a low dc voltage range. Then short the ground lead to the probe tip. Zero the probe by adjusting *R6* (you'll have to partially disassemble the probe to do this) in first the $\times 10$ and then the $\times 100$ positions of *S1*. Remove the ground clip from the probe tip and reassemble the probe. A very slight negative voltage variation can be expected when you remove the ground clip from the probe tip. Don't attempt to zero this offset. If you find this slight offset objectionable you can reduce the value of *R1* until it disappears.

The Millivolter probe is highly sensitive. Just touching the probe tip with your finger is enough to cause the meter pointer to peg against its upscale mechanical stop. Keep this in mind when measuring voltages in high-impedance circuits.

Switch *S1* should be kept in the OFF position when you're not using the probe's amplification function and when your meter is stored away. If you turn off the probe (*S1* set to OFF) when not in use and when you're measuring voltages in the bypass mode, you can expect the battery to last in excess of 70 hours when power is actually applied to the probe's circuit. (Current drain of the Millivolter's circuit is less than 5 mA.)

You can check the condition of the probe's battery by applying a positive and then a negative potential great enough to drive the probe's amplifier into saturation. The saturation voltage at the output of the Millivolter should be greater than 3.5 V in both directions and greater than 8 V between the two readings. When the voltage drops below these levels, it's time to replace the battery.

Accidental application of up to 200 volts dc to the input of the probe will not damage the Millivolter's circuit. Under no circumstances should you apply a voltage to the probe's output lead.

Other Applications. From Ohm's Law, we know that when 1 μA is flowing through a 1-ohm resistor, the voltage dropped across the resistor is 1 μV. If you connect the Millivolter probe in series with a circuit (assuming the value of *R1* is 10 megohms), you have a 0-to-1-nA current probe. Since there isn't much demand for such a sensitive current scale, you can add appropriate shunt resistors across *R1* to produce the ranges detailed in the Table. Keep a supply of 1% resistors of the values indicated to use as current shunts.

The probe also makes an ideal nulling device for use with a precision bridge. If your voltmeter can be set up for center-scale zero, the probe will turn it into 500-0-500-pA nulling meter.

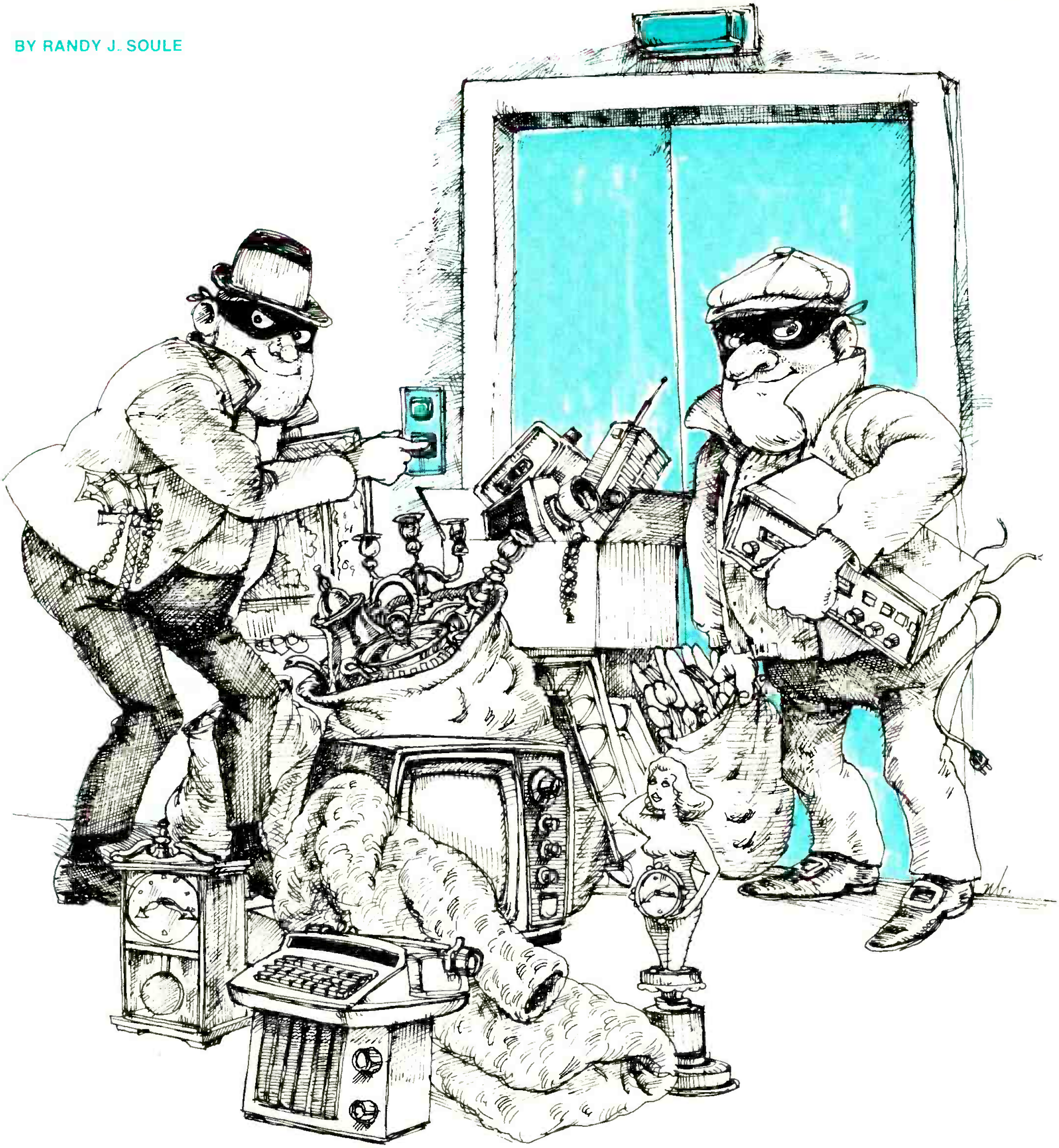
Photo shows component mounting details and location of battery bracket/connector at left end of pc board.

You can use current shunts if this range is too sensitive. Resistance in the milli-ohm range can be measured with the aid of a constant-current source pegged at 10 or 100 mA. Full-scale range will be 100 milliohms on a 1-volt meter scale with 100 mA test current.

You can also make a megohmmeter insulation tester by placing a 10-volt constant-voltage source in series with the unknown high resistance, while measuring the current flow with the probe. Resolution of up to 10^{12} ohms is possible with a full-scale reading of 100,000 megohms.

All in all, for a very small investment and a few hours of assembly time, you can build a really versatile Millivolter probe that can make an inexpensive VOM perform like a laboratory instrument that ordinarily costs several hundred dollars. ◈

BY RANDY J. SOULE



A Low-Cost APARTMENT BURGLAR ALARM

Self-powered system features adjustable time delay.

MOST home intruder/burglar alarms employ sensors of some sort scattered throughout the premises which, when tripped, sound a loud gong or siren. Although such elaborate alarm systems may be a necessity for private homes, the apartment dweller living above the ground floor can get by with a simpler system. With access usually limited to a single door and perhaps one or two windows that feed onto a fire escape, only a few sensors are needed. In addition the piercing tone of a Sonalert®

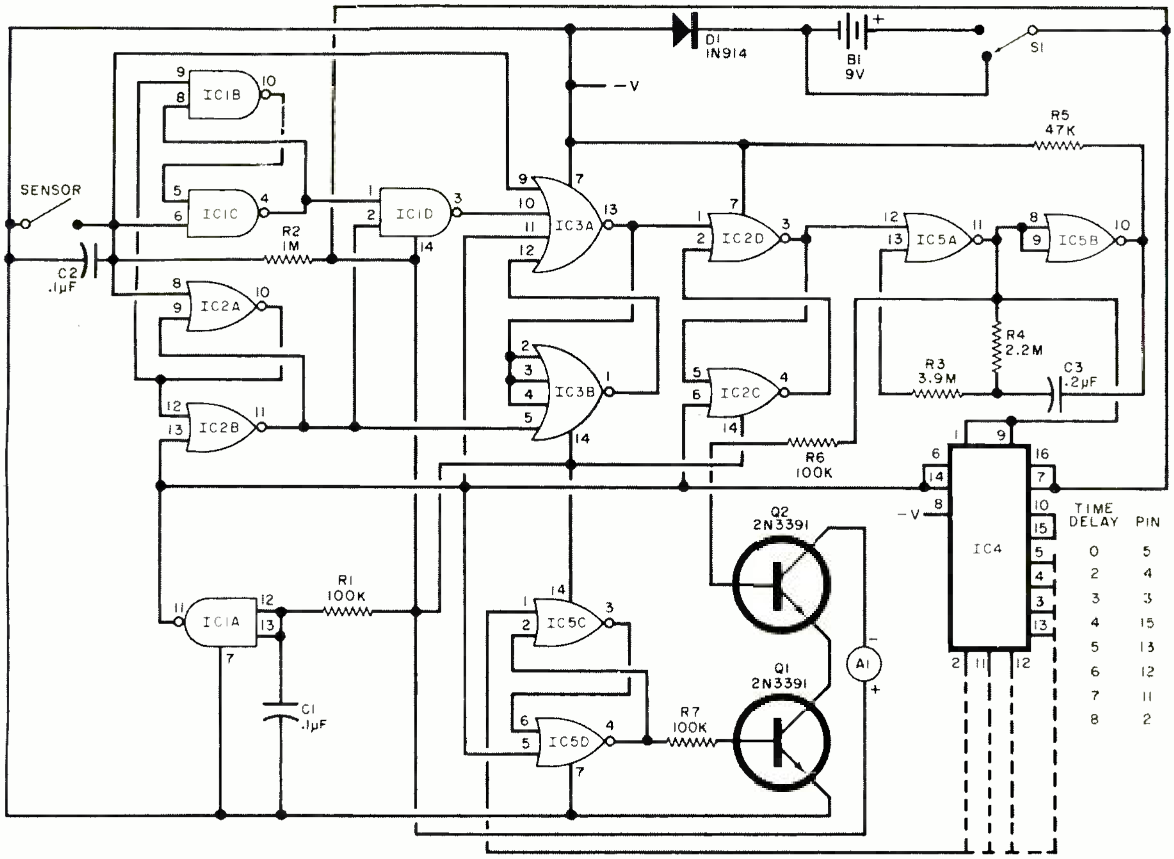


Fig. 1. When sensor contacts are shorted, the clock oscillator starts up. When timer counts desired delay, it causes the alarm to sound.

PARTS LIST

A1—Alarm (Mallory No. SC-628 Sonalert)
B1—9-volt battery
C1,C2—0.1-µF, 50-volt tantalum capacitor
C3—0.2-µF, 50-volt tantalum capacitor
D1—1N914 diode
IC1—4011 CMOS quad 2-input NAND gate IC
IC2,IC5—4001 CMOS quad 2-input NOR gate IC
IC3—4002 CMOS dual 4-input NOR gate IC
IC4—4015 CMOS dual 4-stage static shift register IC
Q1, Q2—2N3391 transistor
R1,R6,R7—100,000-ohm, ¼-watt, 5% tolerance resistor
R2—1-megohm, ¼-watt, 5% tolerance resistor
R3—3.9-megohm, ¼-watt, 5% tolerance resistor
R4—2.2-megohm, ¼-watt, 5% tolerance resistor
R5—47,000-ohm, ¼-watt, 5% tolerance resistor
S1—Spst switch
Misc.—Perforated board and solder clips; IC sockets (optional); battery connector; suitable enclosure (LMB-136 or similar); flexible aluminum strips (or reed switch and magnet) for sensor; machine hardware; hookup wire; solder; etc.

will usually be sufficient to alert an intruder that he has entered "protected" premises or warn occupants and neighbors of an illegal entry.

The low-cost apartment burglar alarm described here employs simple sliding metal contacts as sensors. It features a built-in selectable time delay of up to eight seconds so that you can enter your apartment and disarm the system before the alarm sounds. The alarm is battery powered so that, even if the power line is cut, full security will be maintained.

The alarm is armed by operating a simple switch. When you leave your apartment, you simply open the door and arm the alarm. The alarm then waits for the door to close, after which anyone gaining entry through the door will trigger the delay circuit. At the end of the delay, assuming the alarm hasn't been turned off, the alarm sounds.

How It Works. The circuit for the apartment alarm is shown in Fig. 1. When power is turned on, gate *IC1A* initializes the logic as *C1* charges up. The *IC1B* and *IC1C* gates form one RS flip-flop and *IC2A* and *IC2B* gates form another RS flip-flop. These flip-flops "remember" if the door was opened or closed, respectively. The combination of the RS flip-flop states is presented to *IC1D* to latch the *IC3A*/*IC3B* circuit. The *IC3A*/*IC3B* latch provides all the proper conditions for triggering the alarm control flip-flop made up of *IC2C* and *IC2D*. The output of this circuit turns on the oscillator circuit made up of *IC5A* and *IC5B*.

The oscillator supplies clock pulses to the *IC4* timer and also drives *Q2* to control the current flowing through the alarm. Transistors *Q1* and *Q2* form an AND circuit in which both transistors must be triggered on for the alarm to draw current and sound off. The output of the timer IC must be latched by *IC5C* and *IC5D* before *Q1* is energized.

The frequency of the oscillator is about 1 Hz. (It can be changed by manipulating the values of the time-constant components.) Hence, *Q2* allows current to flow through the alarm for about a half second. It then turns off the alarm for the other half second. The actual time delay of *IC4*'s circuit is

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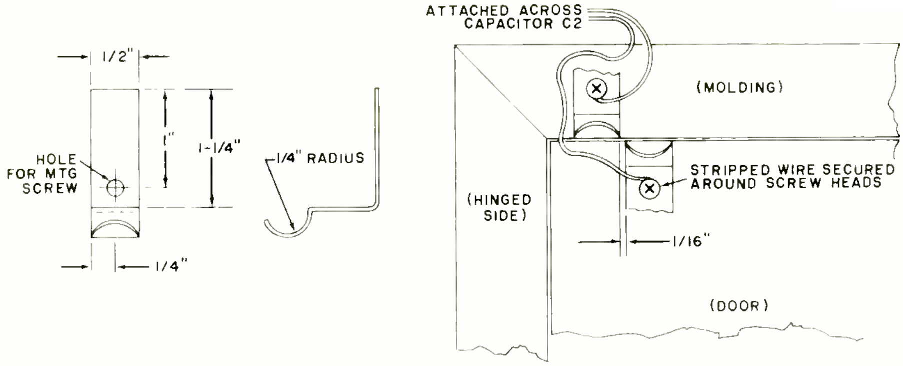


Fig. 2 The sensors can be made from small aluminum strips, or any other method where contacts are closed when the door is opened.

determined by which output pin is connected to the input of the *IC5C/IC5D* flip-flop.

The combination of *C2* and *R2* provides debouncing for the sensor contacts to prevent false triggering. Resistor *R5* insures an easy discharge path for capacitor *C3* to prevent the oscillator from locking up. The value of *C3* can be changed if you wish to change the clock frequency.

Transistors *Q1* and *Q2* can sink about 50 mA of current, which is more than sufficient to drive alarm *A1*. If you wish to drive a higher current alarm, such as a gong or siren, you can install a load resistor in the collector circuit of *Q2* and pick off the output of the circuit at the resistor/collector junction to drive a high-power transistor. The high-power transistor will, in turn, drive the high-current alarm.

Diode *D1* protects the logic in the alarm circuit from accidental application of reverse battery voltage. The alarm draws about 100 μA of current when armed and 5 mA when sounding the Sonalert. With the Sonalert operating, the battery will deliver several hours of power before becoming depleted.

Construction. A simple approach to assembling the alarm circuit is to use perforated board, IC sockets, and solder clips. There is nothing critical about circuit arrangement or parts location. Once you have assembled the circuit, mount it in any type of enclosure that will accommodate it and the battery.

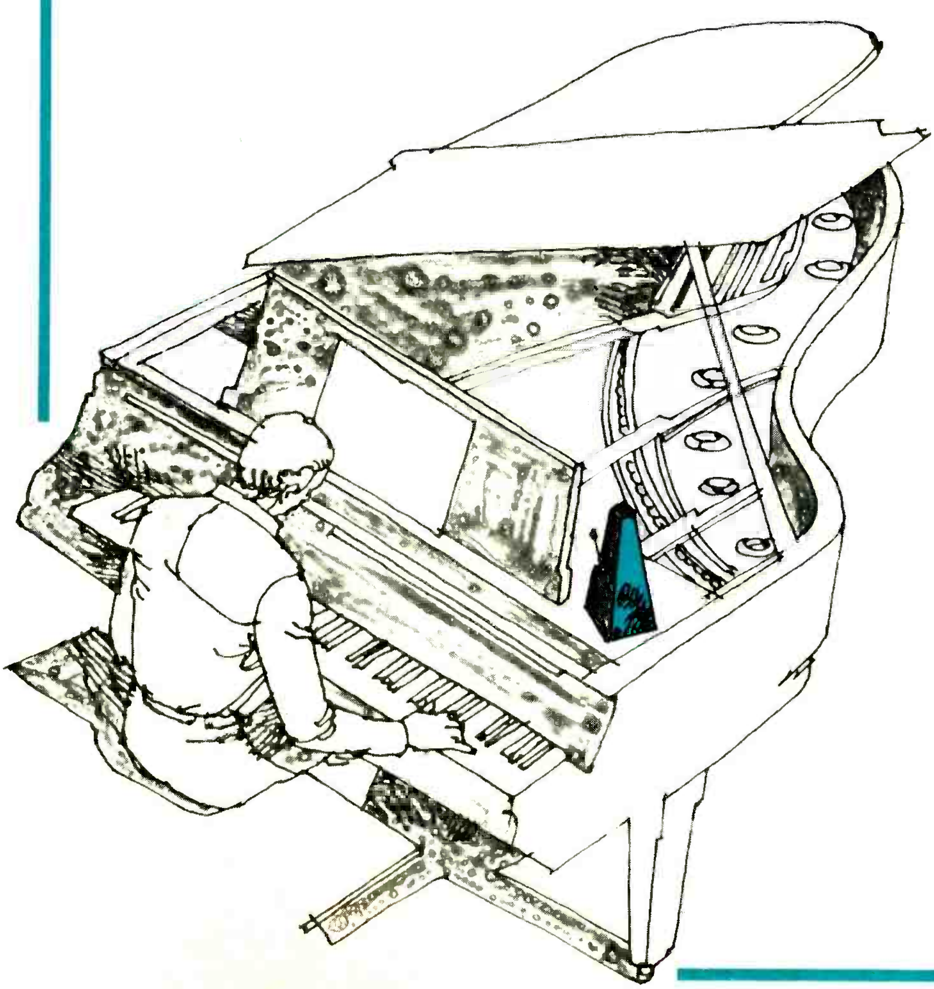
You can fashion the sensor from pieces of flexible aluminum strip stock as shown in Fig. 2. Alternatively, you can use a reed switch and magnet (or any other type of sensor that provides an open circuit when the door is open).

Mount the circuit box in a location where you can get to the arming switch within the delay time. During operation, should the alarm be tripped and allowed to operate for more than two hours, replace the battery. If the circuit is operated only on standby, it is good practice to change the battery every six months or so. ◈

BY MILTON L. CHESTNUT

BUILD THE ULTIMATE METRONOME

Provides accented beats to make tuning and syncopation easier.



A METRONOME, whether mechanical or electrical in operation, provides some sort of audible signal on a fairly stable time basis. The drawback of such devices is that there is no provision for accenting certain beats in a measure. The Ultimate Metronome described here overcomes this disadvantage by providing accented beats. A switch is used to select accents on the basis of 1 in 1 up to 1 in 7. (1 in 15 is possible with a slight alteration.) Beats are indicated visually (LED) and audibly. The metronome can be built for about $8.

How It Works. As shown in Fig. 1, the main timing signal is generated by *IC1* connected as an astable multivibrator. The length of time that pin 3 is low (near zero volts) is determined by *R3* and *C4*, while *R3*, *R4*, *R5*, and *C4* determine how long pin 3 is high (near +5 volts). By adjusting *R5*, the output frequency can be varied from 30 to 1000 pulses per minute. Capacitor *C5* is used to bypass the external modulation input, while *R1* is a pull-up for the input to *IC2*. The latter is a monostable multivibrator that delivers a pulse whose width is determined by *R2* and *C3*. The pulse width is independent of the input trigger and, with the values shown, is about 250 microseconds. This insures that both the speaker pulse and the *IC3* counter input pulse will always have the same duration regardless of the trigger rate.

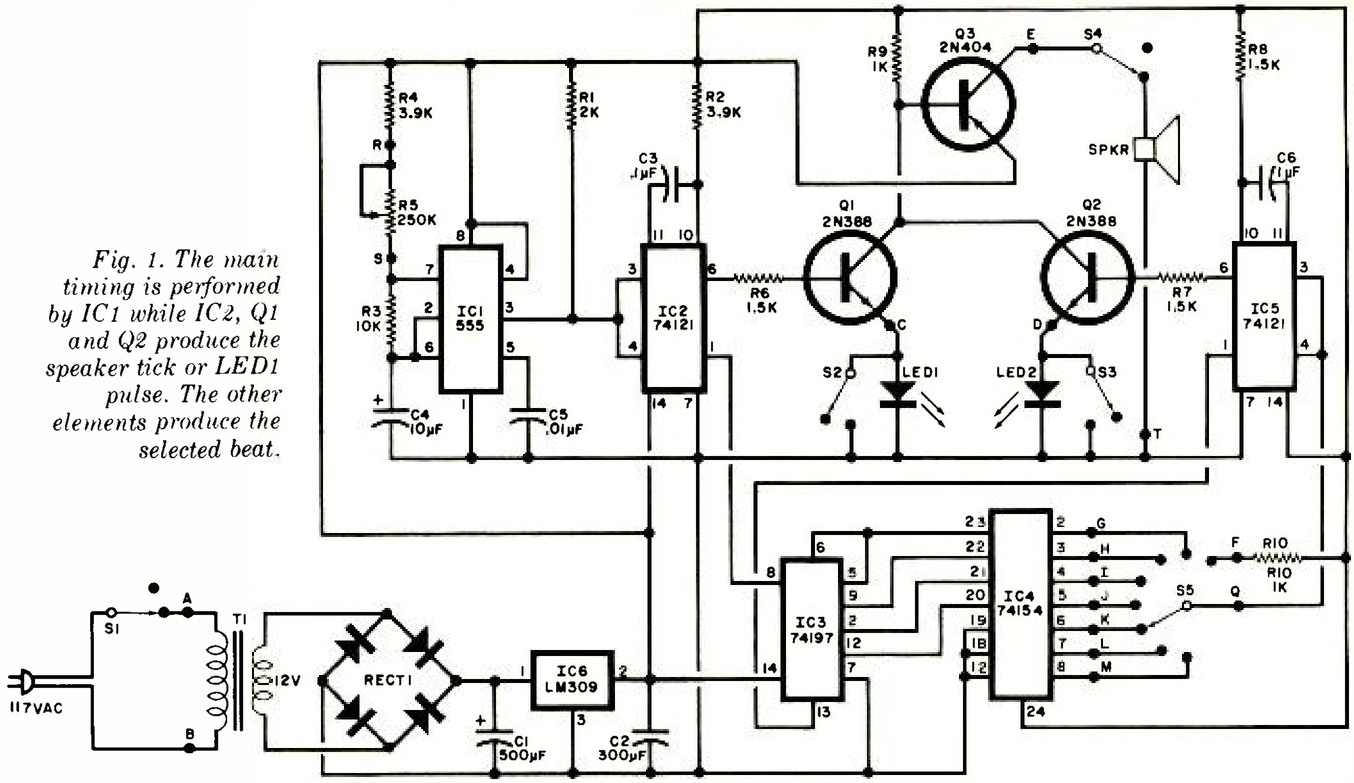


Fig. 1. The main timing is performed by IC1 while IC2, Q1 and Q2 produce the speaker tick or LED1 pulse. The other elements produce the selected beat.

PARTS LIST

C1—500-µF, 16-V electrolytic capacitor
C2—300-µF, 10-V electrolytic capacitor
C3—0.1-µF, 50-V ceramic disc capacitor
C4—10-µF, 6-V low-leakage electrolytic capacitor
C5—0.01-µF, 50-V ceramic disc capacitor
C6—1-µF ceramic capacitor
IC1—555 timer
IC2,IC5—74121
IC3—74197
IC4—74154
IC6—LM309, 5-V, 1-A regulator
LED1,LED2—Red light emitting diode
Q1,Q2—General-purpose transistor npn (2N388 or similar)
Q3—General-purpose transistor pnp (2N404 or similar)
R1—2000-ohm ½-W, 10% resistor
R2,R4—3900-ohm, ½-W, 10% resistor
R3—10,000-ohm, ½-W, 10% resistor
R5—250,000-ohm, linear-taper potentiometer
R6,R7,R8—1500-ohm, ½-W, 10% resistor
R9,R10—1000-ohm, ½-W, 10% resistor
S1 to S4—Spst switch
S5—Single-pole, 8-position, nonshorting rotary switch
SPKR—8-ohm, 2" speaker
T1—12-volt, 300-mA transformer (Radio Shack 273-1385 or similar)
Misc.—Suitable enclosure, line cord, grommet, switch knob, mounting hardware, etc.

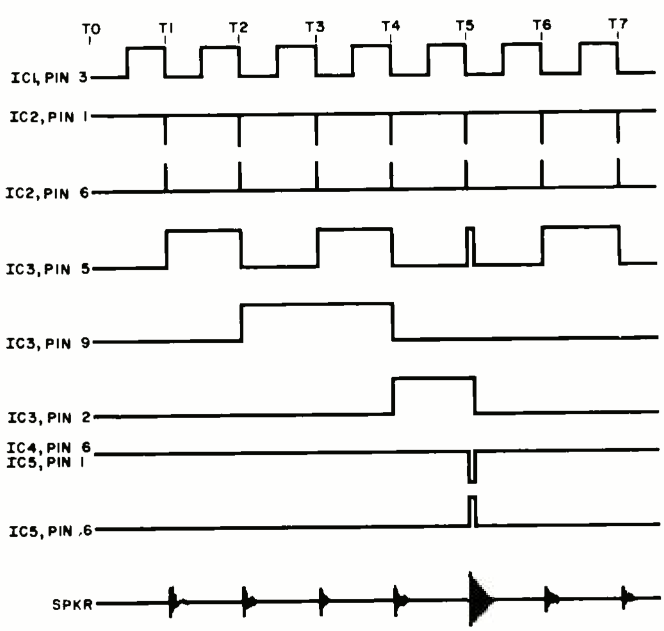


Fig. 2 Timing waveforms for the metronome.

The positive-going pulse from *IC2* (pin 6) drives *Q1* into conduction and, when *S2* is open, causes *LED1* to glow. When *Q1* conducts, it also forward-biases *Q3*, causing a current surge through the speaker (when *S4* is closed). This provides the main beat.

To generate the accented beat, the output from *IC2* (pin 1) is fed to the clock-1 (pin 8) input of *IC3*, a binary-counter/latch. As shown in the timing diagram in Fig. 2, the *IC3* output on pin 5 changes state with each input pulse. Pin 9 changes state every other input pulse, pin 2 every fourth input pulse, and pin 12 every eighth input pulse (not shown in Fig. 2). These four outputs thus make up a 4-bit binary count of the number of input pulses to *IC3*.

The four outputs are applied to *IC4*, a 4-to-16 decoder. The sixteen outputs of *IC4* provide binary combinations from 0000 to 1111 of decimal 0 to 15. With the circuit shown in Fig. 1, only the first 7 of these outputs can be selected by *S5*. The timing in Fig. 2 assumes that *S5* is set to position 5 so that the accent pulse will occur every 5 beats.

The signal selected by *S5* is used to trigger *IC5*, a monostable multivibrator that operates like *IC2* except that the timing components (*R8, C6*) are selected to produce an output pulse of about 1 ms (instead of the 250 µs of *IC2*). When pin 6 of *IC5* goes high, *Q1* is driven into saturation, causing *LED2* to glow (*S3* open) for about 750 ms after *Q1* has stopped conducting due to the main beat. This action causes the speaker to produce a louder tone. When pin 6 of *IC5* goes high, pin 1 goes low, resetting *IC3* to a zero output. The next pulse from *IC2* then counts as the first beat of the next series of pulses. This same action takes place regardless of the beats per minute or the setting of *S5*.

When *S5* is in the F position, the trigger input of *IC5* (pins 3 and 4) is held high by *R10* to prevent any possibility of a stray accented beat. This also permits the use of the circuit as a conventional metronome. With *S5* in position G, every beat is accented to provide a volume increase. As mentioned before, other outputs of *IC4* and other positions of *S5* can be used to select accented beats up to a rate of 1 in 15.

Construction. Any type of construction can be used to build the metronome; and surplus or junkbox components will do. However, the LED's should be selected for similar light output. The size of the transformer given in the Parts List will fit on a pc board. Mount the finished board in a small enclosure with the switches, *R5* and LED's on the cover. Punch some holes in the cover for the speaker.

Calibration. Close *S1* and *S4* and set *R5* to midscale with *S5* in position F. Count the number of beats per minute (checking the operation of *LED1* at the same time). Calibrate the dial of *R5* accordingly. At higher speeds, use the accented beat to count. For example, with a 1-in-5 accent, count 27 accented beats in 60 seconds with *R5* set for 135 beats per minute.

LED1 is for the main beat, while *LED2* displays the accented beat. If you don't need these indicators, they and their associated switches can be omitted. ◈

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Diagrams courtesy Blonder-Tongue Labs., Inc..

GUIDE TO CHOOSING TV & FM ANTENNAS

BY JULIUS GREEN

IT DOESN'T matter how good your TV or FM receiver is, if you are in a difficult reception area, your antenna system has to be satisfactory. Choosing an antenna that will fill your needs requires an understanding of antenna characteristics and a knowledge of local reception conditions. Using any other criteria will almost certainly lead to an improper choice.

In buying an antenna, remember to consider it as a system consisting of the basic antenna, mounting and erecting hardware, transmission line, and signal booster/splitter (if needed). Everything in the system, from the antenna to the input terminals on your receiver, must be selected to provide maximum signal transfer. Although this is important for any type of TV reception, it becomes increasingly so when dealing with color and fringe areas.

There are many electrical and mechanical characteristics of antennas that are important to making an intelligent choice.

By The Numbers. The one specification that is almost always included in the description of an antenna is the number of elements it has. As a rule, for a given design, the greater the number of elements, the greater the antenna's gain and the more signal captured. For all-band antennas, the numbers of vhf and uhf elements are generally specified separately.

Most reputable antenna manufacturers and retailers give an honest element count, but it pays to know how to count them properly. This may not be as simple as it sounds because of the configurations of some modern antennas. For example, the log-periodic type (Fig. 1) has its elements angled forward to improve high-frequency response. The antenna is fed at the front end and uses a double boom (instead of transposing the feed line that connects to the various elements). Connecting the individual antenna rods to the upper and lower boom elements effectively transposes or crosses the feedline connections. The two boom elements are insulated from the supporting mast. The design of the antenna, as well as the angle at which it is drawn, might make it dif-

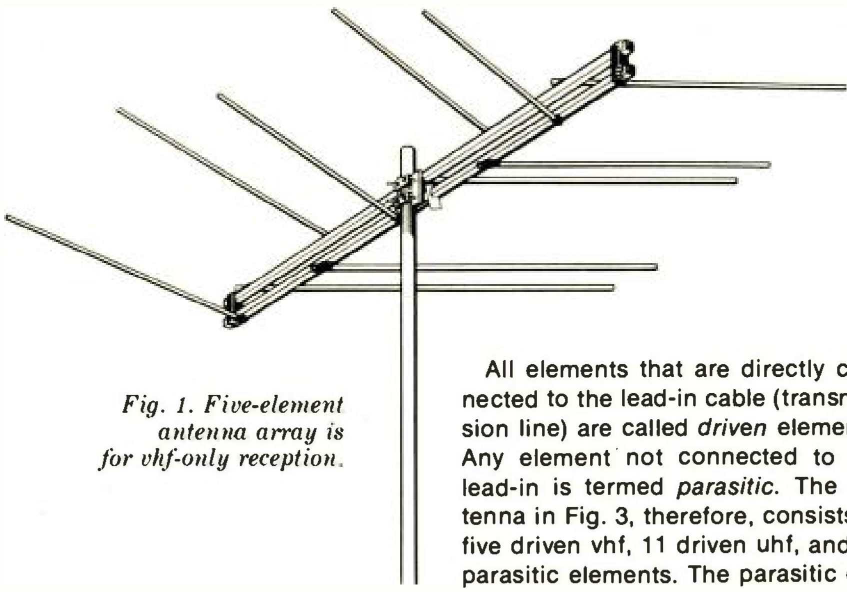


Fig. 1. Five-element antenna array is for vhf-only reception.

ficult for a person not familiar with this antenna to make a proper element count.

A reputable manufacturer and retailer would list the antenna in Fig. 1 as a five-element array. Each of the two rods that make up a single element is connected to the top and bottom of the boom. (A single element is a dipole consisting of two antenna rods.) If you were to view this antenna directly from top or bottom, the five-element structure would be very clear. One way to count the number of elements is to tally the number of rods on one side of the boom. Alternatively, you can count all elements on the boom (in the case of Fig. 1, both booms) and divide the number by two.

In Fig. 2 is illustrated an all-channel (vhf/uhf) TV antenna. The vhf section, located at the rear of the boom, consists of the long element rods and is similar to the antenna in Fig. 1. Forward of the vhf section is an array of element rods that make up the uhf section of the antenna. Note that the uhf rods are much shorter than those for vhf. If you count the number of rods visible on one side of the boom, the tally should come to 16 elements. Five of these are in the vhf section and the remaining 11 are in the uhf section.

The all-channel antenna illustrated in Fig. 3 consists of three sections. At the rear is the usual vhf section containing five elements. In the center is the 11-element uhf section. Sticking out in front is a 10-element array of uhf directors. The directors are passive elements that are not connected directly to the antenna lead-in as are the other two antenna sections. Even so, they help to increase the gain on the uhf TV channels.

All elements that are directly connected to the lead-in cable (transmission line) are called *driven* elements. Any element not connected to the lead-in is termed *parasitic*. The antenna in Fig. 3, therefore, consists of five driven vhf, 11 driven uhf, and 10 parasitic elements. The parasitic elements are electrically coupled to the other uhf elements by induction. All told, this antenna has 26 dipole elements.

A chart that relates the gain of a TV antenna to its overall boom length is shown in Fig. 4. This chart is for vhf/FM antennas only; for vhf/FM/uhf antennas, subtract 1.5 dB from the figures given along the vertical axis. Note also that this chart assumes a high-quality antenna, with elements spaced about 12" (30.5 cm) apart on the boom.

Importance of Gain. One of the most important antenna specs to look for is gain. As with most electronic devices, antenna gain is stated in decibels (dB). When comparing gain specifications, be sure that you know what reference signals were used to derive the gain figures.

The usual reference is the signal delivered by a simple half-wave dipole that is resonant at the frequency of the particular channel at which the antenna's gain is measured. The antenna in Fig. 2 has a gain of about 1.3 dB on Channel 2. The gain rises smoothly to about 3.3 dB at Channel 6 as shown in Fig. 5. Then on the high-band vhf channels, this antenna's gain is about 3.6 dB on Channel 7 and rises to about 5 dB on Channel 13. A gain of 6 dB would mean that the antenna delivers twice the voltage or four times the power compared to the levels delivered by a single dipole cut to the specific frequency of the channel on which you want to specify the gain.

The uhf portion of the antenna in Fig. 2 has a gain between 6 and 10 dB over the entire uhf TV range (Channels 14 through 83).

Occasionally, a manufacturer quotes gain figures with reference to a theoretical isotropic antenna instead of a simple dipole. Such an antenna receives signals equally from all directions, while a standard full-size dipole receives in a figure-eight pattern. The dipole has a 2.16-dB gain over the theoretical isotropic antenna. This means that, to compare different antennas with gains stated at different references, you have to add 2.16 dB to the stated dipole-reference figures or subtract 2.16 dB from isotropic antenna reference figures.

Front-to-Back Ratio. The conventional dipole antenna receives signals equally well from transmitters located to the front and rear (along a line perpendicular to the axis of the antenna). Little or no signal is received along the axis of the antenna. By adding more and more properly designed and connected elements to a basic dipole, the antenna becomes more and more directional, favoring reception from the front at the expense of the rear. Hence, a multi-element antenna array can also be defined by a "front-to-back ratio" (F/B). An Electronics Industries Association (EIA) committee has tentatively defined F/B as the ratio in decibels of the gain of the peak of the main forward lobe to the gain of the peak of the largest lobe in the rear.

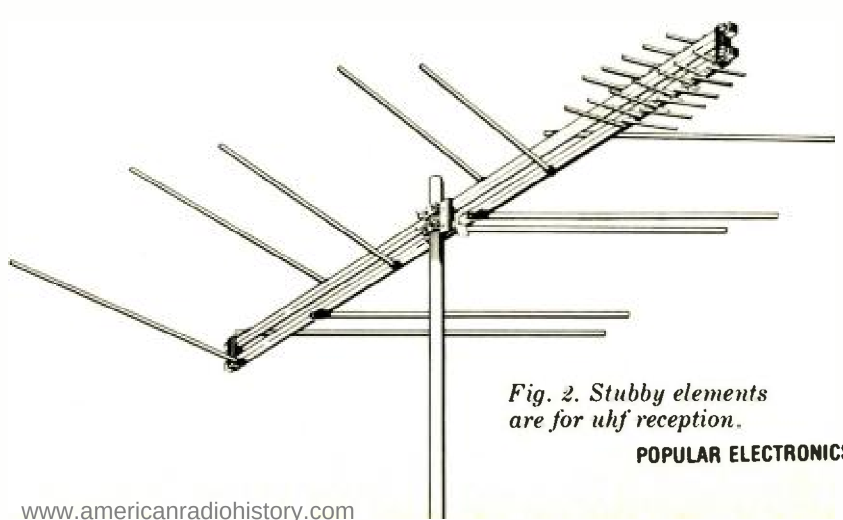


Fig. 2. Stubby elements are for uhf reception.

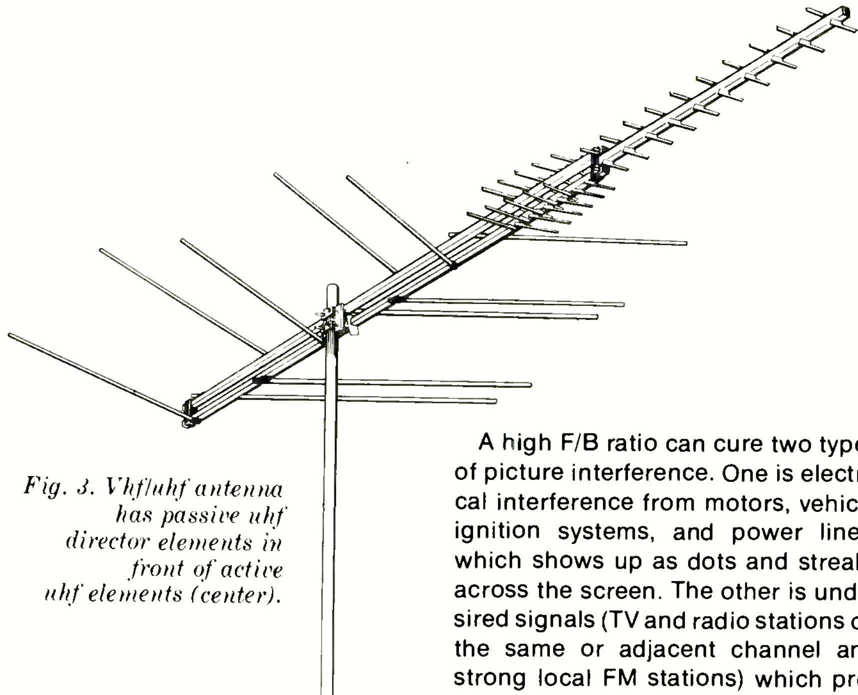


Fig. 3. Vhf/uhf antenna has passive uhf director elements in front of active uhf elements (center).

By measuring the angle between the two points at which the field strength voltage is 70% of maximum, the antenna's beamwidth can be measured. At these points, the power received is 50% of maximum, or 3 dB down. In general, the greater the gain of an antenna, the greater its directivity and the narrower is beamwidth. In addition to more desired signal delivery to the receiver, a highly directional antenna is less prone to picking up electrical interference (noise) and undesired signals off to the sides.

The directional characteristics of the antenna in Fig. 2 are shown in polar form in Fig. 5. This antenna has a beamwidth of about 76° on the vhf low, 31° on the vhf high, and 58° on the uhf bands. If the beamwidth is very narrow, the antenna must be precisely aligned with the distant transmitting antenna. Hence, if you're in a fringe reception area with transmitters located in different directions, your narrow beamwidth antenna system will have to include an antenna rotator to aim the antenna in the proper directions. An antenna with a broad beamwidth usually has lower gain and is less critical to align.

In addition to the main lobe, there are frequently a number of side and rear lobes which can pick up unwanted signals. It is possible to align such antennas so that a null between lobes is in line with an interfering signal. Of course, this may mean that the main lobe is slightly off-axis with the transmitter, with a loss of gain.

A high F/B ratio can cure two types of picture interference. One is electrical interference from motors, vehicle ignition systems, and power lines, which shows up as dots and streaks across the screen. The other is undesired signals (TV and radio stations on the same or adjacent channel and strong local FM stations) which produce a fairly regular herringbone or "venetian-blind" pattern. However, the improvement can occur only if the source of the interference is to the rear or sides of the antenna. If the interference originates between the transmitter and receiver antennas and within the beamwidth pattern of the latter's major lobe, some other means must be used to clear up the problem.

System Impedance. The impedance of a TV antenna is usually 300 or 75 ohms. Maximum signal transfer from antenna to TV receiver can occur only if the impedance of the antenna is matched with the impedance of the line and the impedance of the line is, in turn, matched to the input impedance of the receiver.

In a mismatched system — such as when a 75-ohm lead-in cable is used to couple a 300-ohm antenna to a receiver's 300-ohm input — some of the signal being picked up by the antenna will not be transferred to the lead-in. What is more, that portion of the signal that does find its way into the lead-in encounters a mismatch at the receiver end. As a result, the signal bounces back and forth along the line, and standing waves are set up, with peaks and dips that do not move along the line. There is a consequent power loss and improper operation; and an antenna with a narrow beamwidth and high gain may actually deliver much less signal strength than is possible.

If you must use 75-ohm coaxial cable between a 300-ohm antenna and a 300-ohm receiver input, use impedance matching transformers at both ends of the line. While such transformers may introduce losses on the order of 1 dB, the results will be much better than if you left a mismatch in the system.

Selecting a Lead-in. Among the factors that determine the type of lead-in to use in your antenna system are interference environment, line losses, ease of installation, durability, and cost. Where interference pickup must be kept to an absolute minimum,

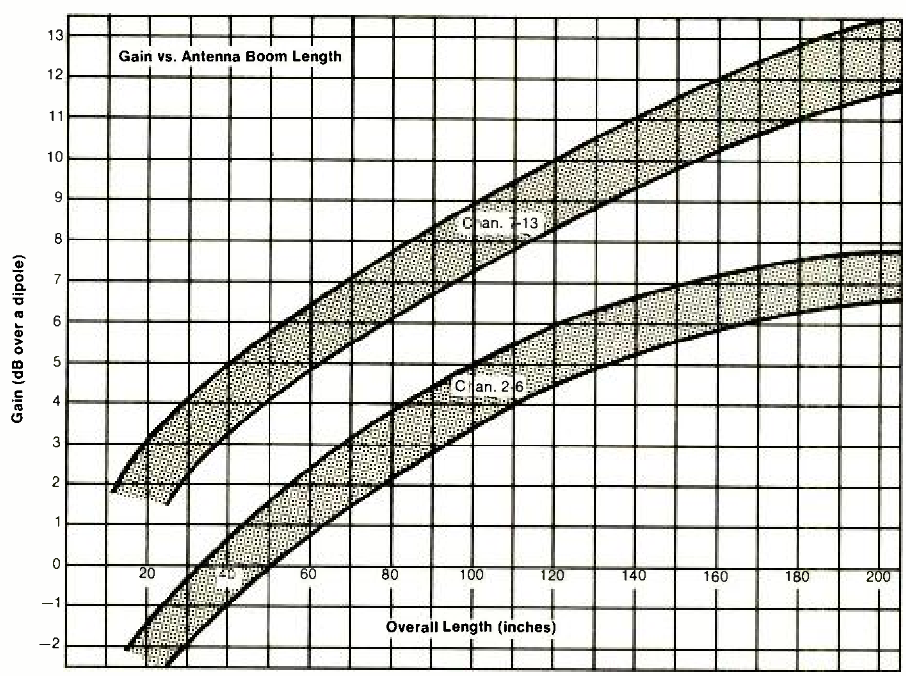


Fig. 4. Chart relates antenna gain to overall boom length.

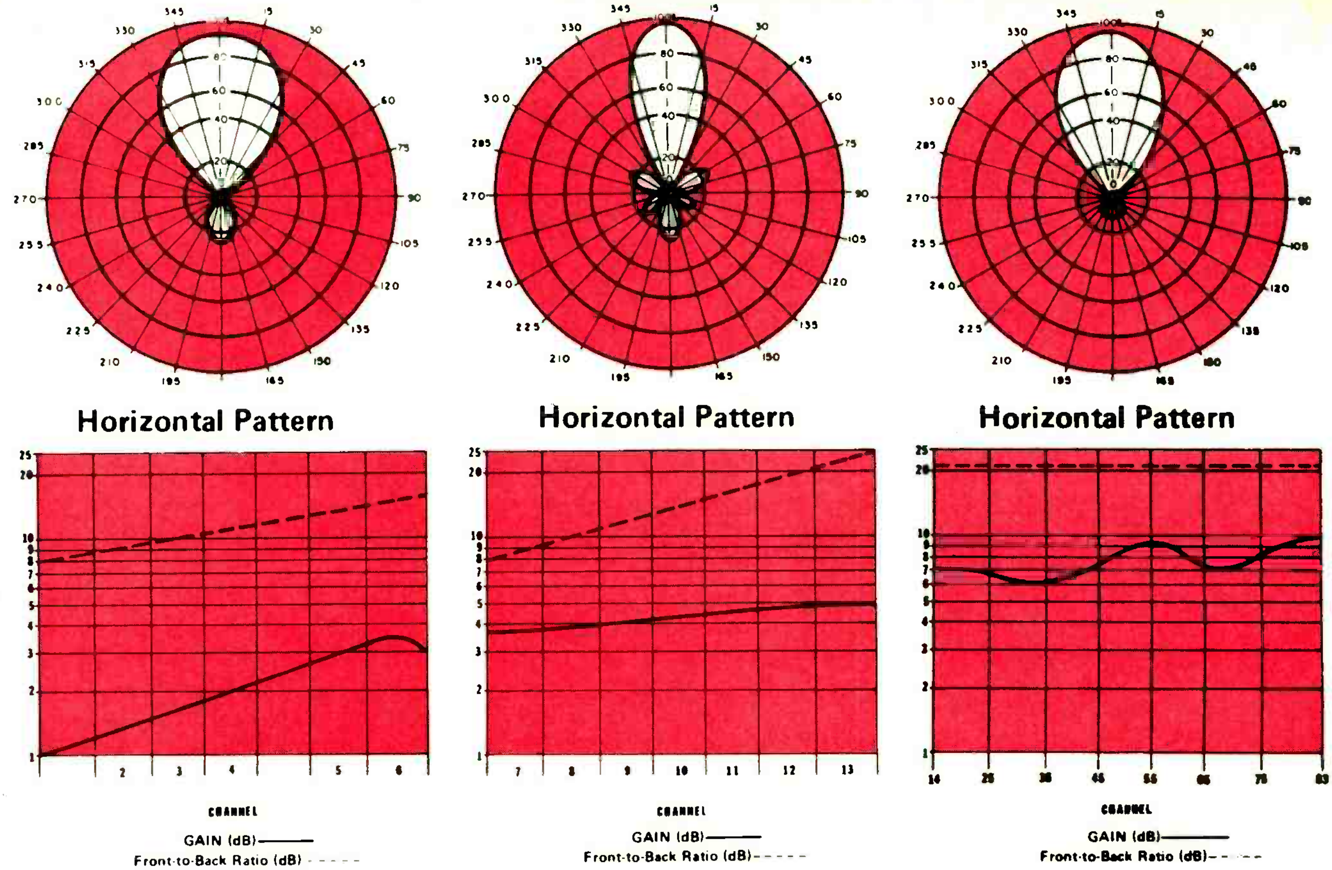


Fig. 5. Upper diagrams illustrate polar, while lower diagrams illustrate rectangular plots of gain and F/B ratio for low-vhf, high-vhf, and uhf sections of an all-channel antenna.

75-ohm coaxial cable is better than 300-ohm twinlead, but the former is more lossy. Coax is also superior when it comes to ease of installation and durability. The one main advantage to twinlead is that it has lower loss (when dry) than coax.

If your reception location is in an urban area or near power lines, the limiting factor on picture quality will most likely be interference from appliance motors, ignition noise, and corona from power lines. In this case, a shielded coaxial cable should be used. The shielded line, in combination with an antenna that has a good F/B ratio, will also minimize herringbone and venetian-blind interference from undesired TV and FM signals. Properly installed, a coaxial cable feedline will outlast your TV receiver.

In the cases where the lead-in run is very long and local reception is free of interference but weak in signal strength, a quality 300-ohm twinlead line will result in minimum losses and reduce picture snow and confetti. When you install the twinlead line, you will have to use standoffs to keep it several inches away from all metal objects. After installation, the line should be inspected periodically for deterioration.

One piece of advice when it comes to selecting lead-in cable: Don't compromise on quality. When the extra cost — only pennies per foot — is weighed against the labor involved in replacing the lead-in at frequent intervals, the use of low-quality line is only poor economy.

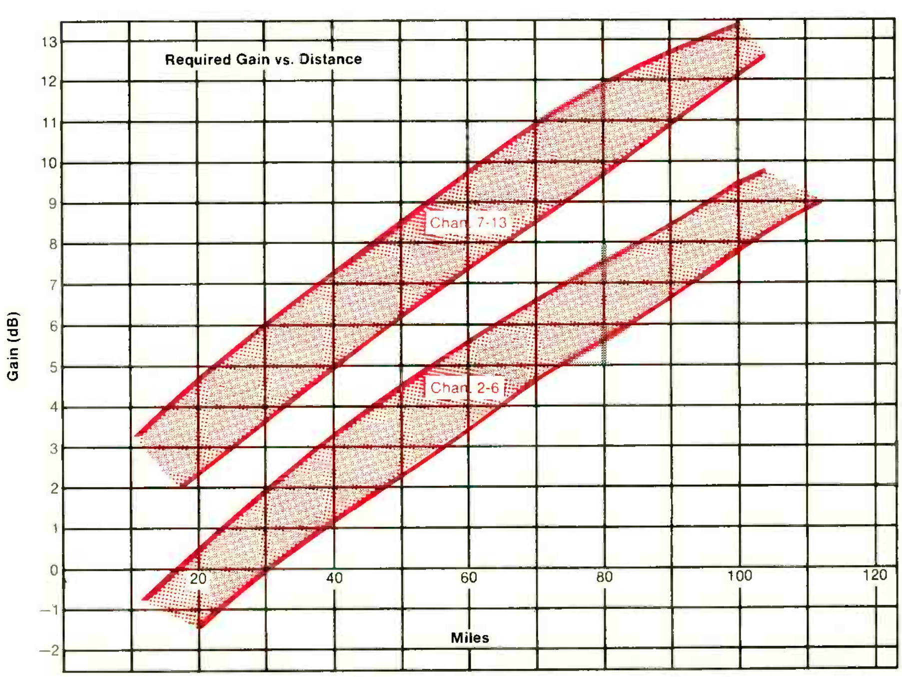


Fig. 6. Approximate required antenna gain is related to operating range.

Operating Range. It is almost impossible to accurately predict the actual operating range of a given antenna because of variables in terrain, signal conditions, etc. Over flat, unobstructed terrain, the operating range will always be greater than if TV signals must follow a path through dense foliage, a large grouping of buildings, and around hills and mountains. Of course, the distance from the transmitting antenna and how much power is being radiated are important. The sensitivity of your TV receiver will make a difference too.

A rough guide to typical operating range over average terrain for the simplest and least expensive vhf-only antennas is about 25 miles (40 km). The highest gain vhf/uhf antennas often have a usable range limit of 80 to 100 miles (130 to 160 km). Needless to say, these ranges are for typical rooftop antenna installations. They can be considerably increased if you mount the antenna atop a tall multi-section mast or tower. If you can mount your antenna above the height of the tallest nearby structure, you'll get the maximum benefit for your local signal conditions.

The graph shown in Fig. 6 relates the approximate gain required to the distance (operating range) of a TV antenna. A snow-free picture should be obtainable at a distance of about 60 miles (90 km). At 80 miles (130 km) and beyond, there is usually rapid deterioration in reception conditions, especially on the high vhf band, due to lack of line-of-sight conditions.

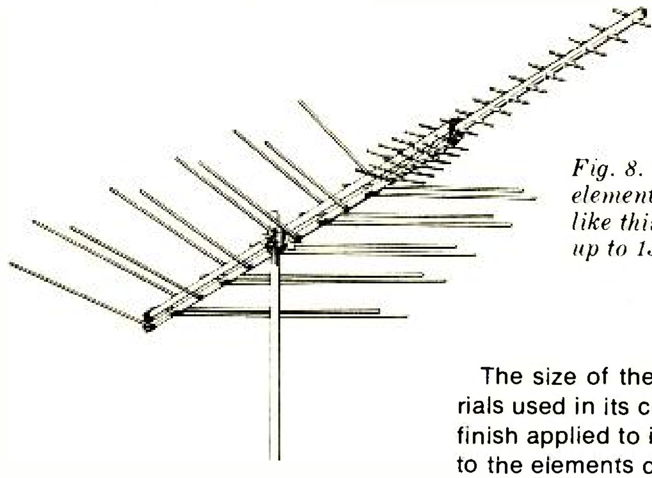


Fig. 8. Complex multi-element antennas like this can have booms up to 13¼' long.

Signal Boosters. Poor picture quality as a result of weak signals and thermal noise, can usually be remedied with the aid of a signal booster (preamplifier). the improvement obtained will depend on the gain of the booster and the length of the lead-in. The signal-to-noise ratio (S/N) of the antenna itself generally being fairly good, you can install the booster at the antenna, at the TV receiver, or anywhere along the lead-in that proves convenient. (The use of a booster is also recommended whenever you plan to use a single antenna system to feed two or more TV and/or FM receivers, whether or not only one receiver will be turned on at any given time.)

If your lead-in is picking up interference signals, mount the booster at the antenna end of the line. By increasing the gain of only the desired signal, the booster effectively improves the S/N ratio of the system. Bear in mind that, if the antenna is picking up interference directly, no amount of signal boosting will clear up the problem; any boosting of the signal will also result in an equal boost in the noise and produce a constant S/N.

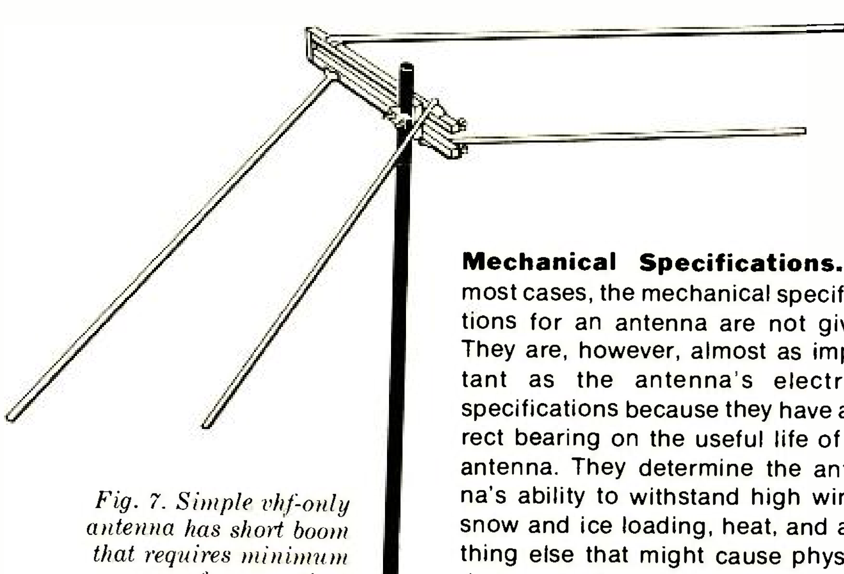


Fig. 7. Simple vhf-only antenna has short boom that requires minimum space for mounting.

Mechanical Specifications. In most cases, the mechanical specifications for an antenna are not given. They are, however, almost as important as the antenna's electrical specifications because they have a direct bearing on the useful life of the antenna. They determine the antenna's ability to withstand high winds, snow and ice loading, heat, and anything else that might cause physical damage to the antenna.

The size of the antenna, the materials used in its construction, and the finish applied to it to make it resistive to the elements determine the antenna's durability. Wall thickness of the tubing used for the boom and elements should be given special attention. The thicker the walls, the more durable the antenna.

Once you know exactly where you're going to mount the antenna, make sure that it will be unobstructed by nearby obstacles. Select an antenna with the proper electrical characteristics and a boom length to fit your needs. The longer the boom, the more elements it can accommodate and the heavier the antenna. TV antenna booms range in length from 25" (0.64 m) for the simple two-element vhf antenna shown in Fig. 7 to as much as 159" (4 m) for the elaborate 31-element all-band antenna shown in Fig. 8.

The turning radius of a TV antenna becomes important when you plan to use a rotator. The antenna must be allowed to swing around in a full circle without encountering obstructions. You can measure the turning radius from the tip of the longest vhf element (farthest to the rear) to the pivot point, or the point where the antenna's boom fastens to the mast.

A Look At Prices. While it's not exactly a "specification," price should be an important—and well-understood—consideration. Be sure you know exactly what's included in the quoted price of an antenna. In most cases, the stated price is for the antenna alone. However, in a few cases, it might include some mounting hardware, perhaps a short mast, sometimes a length of lead-in cable, and, in some rare cases, a vhf/uhf or vhf/FM/uhf splitter.

Be prepared to pay premium prices for premium-quality antennas. Top-quality materials and construction cost more, but they will prove a sound investment in the long run. ◈

Product Test Reports

ABOUT THIS MONTH'S HI-FI REPORTS

Stereo receivers in a given price range tend to have very similar specifications and features, as well as a strong physical resemblance to each other. However, among this large group of components, some are "more equal than others". The Nikko Model 7075 is an excellent example of unusually high performance from one of the lesser-known brands.

Modern receivers and amplifiers are equipped to interface with a wide variety of signal processing accessories. The Pioneer Model SF-850 electronic crossover is a highly versatile two- or three-way adjustable filter, which is placed in the signal path ahead of the power amplifiers. Driving each of the speaker groups in a multi-way system from its own amplifier avoids most of the distortion attributed to passive crossover networks, and the Pioneer system gives the user a wide choice of crossover frequencies and filter slopes.

The other product tested is an octave-band graphic equalizer. The remarkably compact MXR equalizer adjusts the response for each channel in 10 separate frequency bands. In the real world, our listening rooms, speakers, and program sources are rarely "flat" in their frequency characteristics, but this handy accessory can go a long way toward correcting any response aberrations.

—Julian D. Hirsch

NIKKO MODEL 7075 AM/STEREO FM RECEIVER

Medium-priced receiver, excellent performance.

HIRSCH-HOUCK LABS REPORT

The Nikko Model 7075 AM/stereo FM receiver features a full complement of operating controls, extensive use of integrated circuits, and performance of the highest order. The audio amplifiers are rated at 38 watts/channel into 8 ohms with both channels driven over a frequency range of 20 to 20,000 Hz, with less than 0.5% total harmonic distortion (THD). The FM tuner's sensitivity is rated at 1.9 μV, the alternate-channel selectivity at 65 dB, and distortion at less than 0.2% in mono and 0.4% in stereo.

The receiver's extensive use of IC's results in a relatively inexpensive product. Following three pairs of linear-phase ceramic i-f filters in the FM tuner section, a single IC supplies virtually all the required gain, limiting, muting, and quadrature detection. Another IC, a phase-locked loop (PLL), supplies multiplex detection, while still another IC performs all the functions of the entire active portion of the AM tuner. In the audio section, an operational amplifier IC serves as a feedback-type tone-control amplifier. The power amplifiers are composed of discrete elements and employ direct coupling all the way to the speakers. The outputs are complementary symmetry.

Supplied in a walnut-veneered wood cabinet, the receiver measures 19″ W × 16″ D × 6⅜″ H (48.3 × 40.6 × 16.2 cm) and weighs approximately 26.4 lb (12 kg). Price is $399.95.

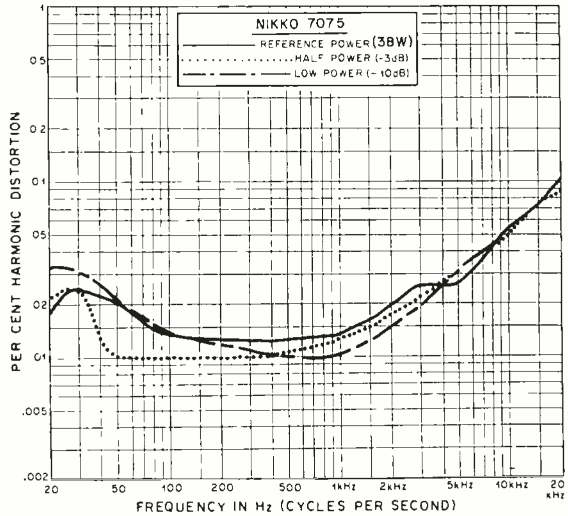
General Description. The receiver's front panel is conventional in appearance with a satin gold finish and matching control knobs and switch levers. A "blackout" dial area across the upper portion of the panel has behind it the blue-illuminated FM and AM dial scales, large center-channel FM tuning and relative signal-strength meters, and illuminated legends that identify the selected program source. The last correspond to the settings of the input SELECTOR switch: AM, FM, PHONO, MIC, AUX, and DUB (for copying from one tape recorder to another). A red STEREO indicator above the dial area comes on when a stereo FM signal is received.

Lever switches control the POWER, LOW and HIGH cut filters, LOUDNESS compensation, FM MUTING, STEREO/MONO mode select, and TAPE MONITOR functions, the last from either of two decks that can be connected via jacks on the rear of the receiver. The SPEAKERS control allows selection of either, both, or neither of two pairs of speaker systems to the amplifier's outputs. (A PHONES jack next to it is always energized.)

The BASS and TREBLE tone controls, concentric for left and right channels, have 11 detented positions. The VOLUME and BALANCE controls, the latter detented at its center position, are also concentrically mounted. A MIC jack is also provided on the front panel for driving both amplifier outputs from a single dynamic microphone.

In addition to all the usual signal input and output jacks, the rear apron of the receiver also has a DIN connector that parallels the functions of the TAPE jacks. There is also a group of four jacks and a 4CH ADAPTOR slide switch for driving a quadraphonic adaptor and returning its front-channel outputs to the receiver's power amplifiers. The speaker connectors are insulated spring clips.

One of the three accessory ac outlets on the rear apron is switched. Rounding out the connector comple-



ment on the rear panel are antenna terminals for 300- and 75-ohm FM antennas and a wire-type AM antenna. (There is also a pivoted ferrite rod AM antenna.) Pushbutton circuit breakers protect the speaker outputs and the power-line input.

Laboratory Measurements. Following a preconditioning period, the amplifiers delivered 48.5 watts/channel into 8-ohm loads at 1000 Hz before clipping. Into 4- and 16-ohm loads, the output power measured 62.4 and 32 watts, respectively.

At 1000 Hz, the measured THD was about 0.01% at outputs between 1 and 20 watts. It rose to 0.018% at 40 watts and to 0.035% at 50 watts output. The IM distortion was about 0.06% from less than 50 mW to about 45 watts output. It reached 0.1% at 50 watts output.

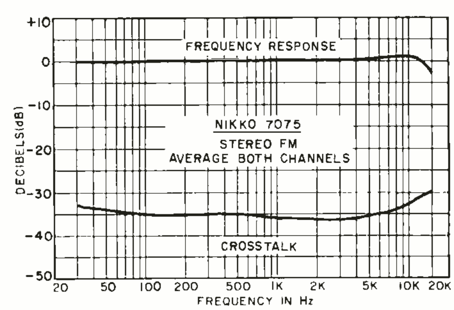
At the rated 38-watt output level, and at lower power outputs down to about 4 watts, the THD was between 0.01% and 0.015% between 100 and 1000 Hz. It increased to 0.1% at 20,000 Hz and was 0.03% at 20 Hz. To develop a reference 10-watt output, 80 mV was required at the AUX input, 1.7 mV at the PHONO input, and 1.3 mV at the MIC input. The corresponding S/N ratios, referred to 10 watts output, were 82, 74, and 56.5 dB, respectively. The phono inputs overloaded at a very safe 140 mV, while the microphone input overloaded at 120 mV.

The characteristics of the tone control system were rather unusual, since the first two or three positions of boost and cut (especially in the treble) changed the frequency response only slightly, while the last two positions had a much greater effect. In fact, we would consider the bass boost range to be somewhat excessive, since the maximum boost was 22.5 dB at 35 Hz. It is unlikely that any speaker system or listening environment would require such drastic equalization. Also the amplifiers could easily be driven to distortion if maximum boost were used.

The filters had gradual 6-dB/octave slopes, and their −3-dB response frequencies were at 200 and 4000 Hz. The LOW filter, in particular, cut out considerable program content while removing rumble and low-frequency noise. The loudness contours produced a moderate bass boost and a slight treble boost at low volume settings.

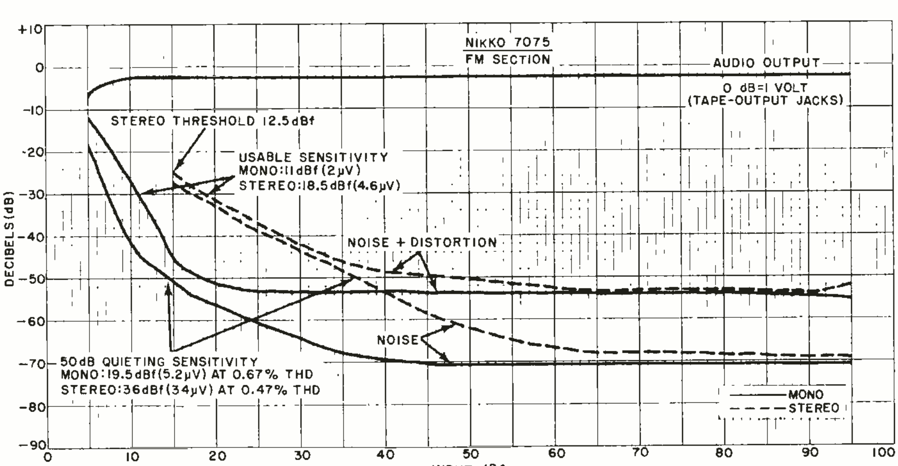
The RIAA phono equalization was accurate to within ±0.5 dB from 40 to 20,000 Hz. Interaction with cartridge inductance caused a gentle downward response slope beginning at several kilohertz, reaching −1.5 dB between 10,000 and 15,000 Hz before rising to +2 or +3 dB at 20,000 Hz. The MIC frequency response was down 6 dB at 77 and 7700 Hz, relative to the 1000-Hz level.

The IHF usable sensitivity of the FM tuner was 11 dBf (2.0 μV) in mono and 18.5 dBf (4.6 μV) in stereo. The 50-dB quieting sensitivity in mono was 19.5 dBf (5.2 μV), with 0.67% THD. In stereo, it was 36 dBf (34 μV), with 0.47% THD. The distortion at 65 dBf (1000 μV) input level was 0.2% in mono, 0.21% in stereo. The S/N at that level was 70.6 dB and 68.3 dB in mono and stereo, respectively. The stereo FM frequency response was ±1 dB from 30 to 13,000 Hz. It was down 3 dB at 15,000 Hz. Channel separation was exceptionally uniform, measuring 33 to 36.5 dB from 30 to 10,000 Hz and 30 dB at 15,000 Hz. The AM frequency response was down 6 dB at 120 and 5000 Hz.

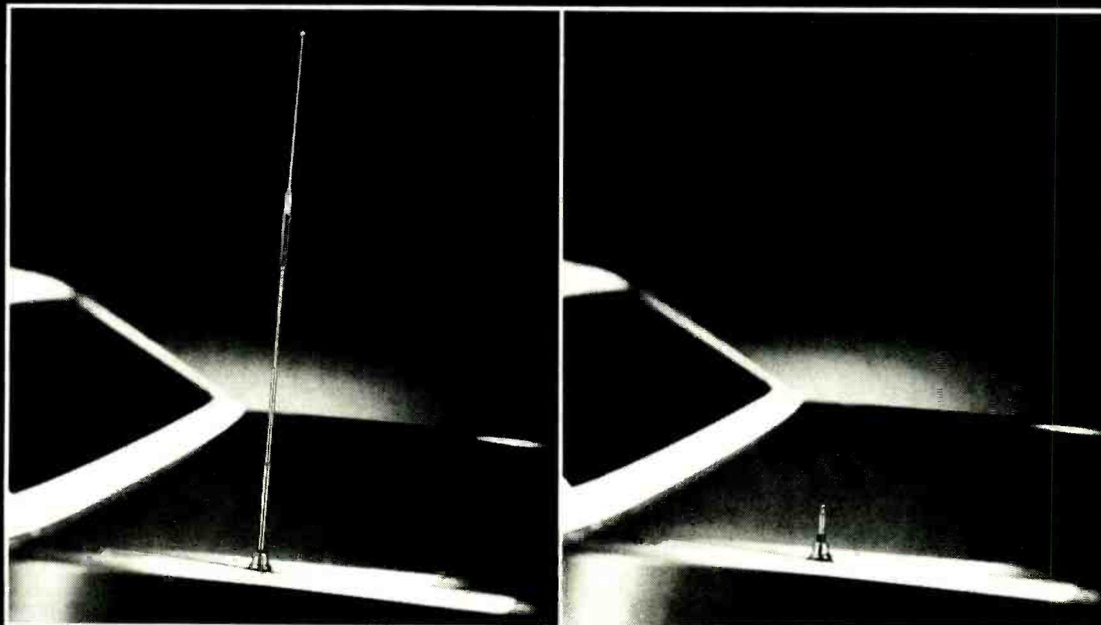


The FM capture ratio was 1.6 dB, and AM rejection was an excellent 73 dB. The image rejection and alternate-channel selectivity figures of 86 and 75 dB also represent very good performance. Adjacent-channel selectivity (called for in the latest IHF standards, though we have not measured it regularly in the past) was 5.4 dB. Adjacent-channel selectivity is usually far worse than the more important alternate-channel reading, but we feel the 5.4-dB figure measured for this receiver is somewhat below par, although it is of importance in only those rare cases where you want to listen to a station only 200 kHz removed.

The FM muting action occurred smoothly between 5.5 and 11 dBf (1



WHEN THIS ELECTRIC CB ANTENNA DISAPPEARS,



SO DOES THE CHANCE OF A RIP-OFF.

INTRODUCING THE TENNAPOWER DISAPPEARING CB ELECTRIC ANTENNA.

Thefts are CB's biggest problem.
With millions of CBers on the road, more and more thieves are turning their attention to the CB-equipped automobile as a prime and lucrative target. And thieves have learned to recognize a CB-equipped car by the telltale CB whip antenna it invariably sports. Take a look on any highway—each CBer is flying his whip antenna as a virtual flag.

Remove the CB whip antenna and you reduce the chance of theft.
With this simple truth in mind, Tenna designed a no-compromise CB antenna that "wouldn't be there" when it wasn't needed. Existing designs weren't good enough. Magnet mounts are inconvenient. Disguise antennas are poor performers. So Tenna came up with something new.

How Tenna created a no-compromise CB antenna that disappears.
Tenna motorized the antenna so it could elevate and retract electrically. And they decided on a center-loaded design, the most effective for reliable mobile CB use. One adjustable for optimum SWR. It took a powerful special "skinny" center-loading coil to make everything work, and Tenna's engineers developed a coil that disappears. So with the flick of a switch, the antenna extends to its full length for top performance and turns on the CB radio, automatically. But flick the switch again and it disappears into the fender, turning the radio off. And these antennas are built with top-quality materials for years of reliable service. Now the kind of workmanship that makes us the world leader in motorized AM-FM car antennas goes to work for you on the Citizens Band.

Where to find the TennaPower Disappearing CB Electric Antenna.
Don't look in a parking lot. It there's one there, you won't see it. Check with a dealer who sells CB or car stereo. Most of them will install your TennaPower Disappearing CB Antenna, or you can do it yourself. But one way or another, put one in soon. After all, you have a lot to lose.

Tenna Corp.
Cleveland, Ohio 44128

CIRCLE NO. 60 ON FREE INFORMATION CARD

We'd like to compare our
But there's no

(Simulated TV Reception)

COMPARE OUR TRAINING PROGRAMS: NTS Electronics programs are considerably different from those of other schools, and, we believe, better designed to prepare you for entry-level opportunities in the field of your choice. For example, our Master Course in Electronics Technology includes over 170 lessons; another school offers fewer than half that many in a course with the same title.

Our course includes 26 kits to build an Electro-Lab, a Solid-State Digital Computer-Trainer with transistor-diode logic circuits; a 5" wide-band solid-state Heath Oscilloscope; a Heath FET-VOM, and slide rule. Their course offers 10 kits to build a private label VOM and 2 experimental circuit chassis.

And even though you need an oscilloscope to perform their experiments, they don't provide it. You have to buy your own. And their course does not even include a Digital Computer-Trainer. The closest thing to our program they offer costs over $200 more than ours. Another school's course in Electronics Technology offers even fewer lessons, and kits to build only a VOM. That's all. Think it over, and check it out, course by course, program by program. There's no comparison.

COMPARE OUR EQUIPMENT: NTS selected Heath equipment because of Heath's international reputation as a prime designer of commercial and professional electronic equipment in kit form. Cooperation between Heath and NTS assures you of highest quality components, design, function and training. What's more, Heath equipment is the kind you'll meet in the field - not limited to training only. For instance, the Heath GR 2000 25" (diagonal) Color TV included in our Color TV courses is acclaimed as ahead of its time in features and engineering. And the Heath AM-FM

and 2 μV), and the stereo switching threshold was 12.5 dBf (2.3 μV). Pilot carrier leakage into the receiver's outputs was 73 dB below 100% modulation.

User Comment. This was a thoroughly pleasant and satisfactory receiver to use. No operating "bugs" appeared during our extensive use tests. The controls operated smoothly and positively, and the sound quality was excellent.

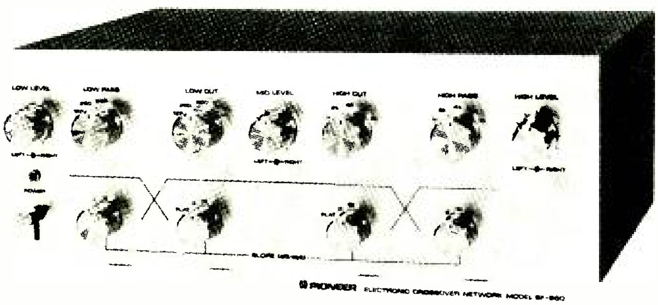
Although the manual supplied with the receiver was quite complete, it made no reference to the 4CH ADAPTOR feature. The schematic diagram reveals, however, that this circuit is really the equivalent of the separate preamplifier output/main amplifier input facility found in many receivers today. Setting the switch to 4CH interrupts the signal path at the appropriate point. Obviously, this feature can be used equally well for installing graphic equalizers, signal processors, electronic crossover networks, etc., into the system.

The FM dial calibrations are linearly spaced, but markings appear only at 2-MHz intervals. In spite of this wide spacing, the calibration was accurate, and we had no difficulty tuning to any desired frequency without guesswork. The FM sound was notably free from background hiss and was the audible equal of any FM sound we have heard in our laboratory location. The muting action was free from noise bursts and revealed only a slight "thump" as it cut in and out.

Our experience with the Model 7075 convinces us that this receiver is easily the equal of others we have used at or near its price and with respect to the features and listening quality it provides.

PIONEER MODEL SF-850 ELECTRONIC CROSSOVER

Active crossover gets most out of speaker systems.



Passive crossover networks, it has been claimed, can degrade the performance of the speaker systems in which they are used. Nonlinear distortion can be created by the iron-core inductors and electrolytic capacitors in many speaker systems. Some power loss is also inevitable in the windings of inductors. Because of the large inductors and capacitors required, achieving a low woofer crossover frequency (200 Hz or lower) can be quite expensive. Although there is some difference of opinion as to the desirability of using crossover slopes steeper than 6-dB/octave, those networks that provide 12- and 18-dB/octave slopes require prohibitively expensive (for a low-cost speaker system) close-tolerance components.

All the difficulties encountered with passive crossover systems can be overcome by using an active crossover system and using separate amplifiers for the various drivers in a speaker system. Active crossover filters are inexpensive (using components that do not have to cope with high power) and essentially distortionless. They also have the virtue of making it easy to adjust cutoff frequencies and slopes. One such active crossover system is the Pioneer Model SF-850 that accomplishes virtually all the crossover operations needed for a two- or three-way stereo speaker system. Separate selectors are provided for the woofer/midrange and midrange/tweeter transitions.

The Model SF-850 measures 13¾" W × 13" D × 5½" H (35 × 33 × 14 cm) and weighs 12 lb 6 oz (5.6 kg). Price is $199.95.

General Description. The low-pass switch for the woofer has frequencies of 125, 250, 500, 700, and 1000 Hz, while the frequencies for the tweeter's high-pass switch are 1000, 2000, 4000, 6000, and 8000 Hz. The corresponding low- and high-pass filters for the midrange driver have matching cutoff frequencies. For each of the cutoff selectors, a separate SLOPE switch provides a choice of 6-, 12-, or 18-dB/octave slopes. This makes it possible to use different slopes for the separate drivers, which might be advantageous from a sonic point of view or merely to protect the tweeter against excessive low-frequency drive levels.

The slope controls for the midrange section also have FLAT positions. This offers complete flexibility for the two-way system, since the crossover frequency to the tweeter can be set at any of the frequencies from 125 to 8000 Hz. Each of the three frequency-band outputs has its own level control (concentric for the two channels). This is vital for any electronic crossover system to achieve the correct frequency balance with drivers of different efficiency. On the rear apron of the chassis are a pair of input and three pairs of output (woofer, midrange, tweeter) jacks and two switched and one unswitched ac outlets.

The crossover system's specified gain is rated nominally at unity. Maximum insertion loss is stated at less than 2 dB with any settings of the crossover controls. Input and output impedances are nominally 100,000 and 1000 ohms, respectively. The rated maximum output is 3.5 volts; S/N, referred to the rated output, is better than 85 dB; and harmonic distortion is specified at 0.3% or less.

Laboratory Measurements. During our tests, we plotted a number of response curves using different crossover frequencies and slope settings. In every case, the attenuation at the indicated crossover point was within 1 dB of the ideal 3-dB value. The gain, as specified, was 1.0 in the passbands at the maximum level-control settings.

We could not measure the output noise, which was well below the 100-μV limit of our test equipment. This corresponds to better than 80 dB referred to 1 volt, or more than 91 dB below the rated output. Both harmonic and intermodulation (IM) distortion were very low at any usable output level. They measured less than

0.025% up to 1 volt output and about 0.1% at the rated 3-volt output. The output clipped at slightly greater than 5 volts.

User Comment. Since we did not have a two- or three-way speaker system that provided separate access to the individual drivers, we simulated a three-way system with three different full-range loudspeakers. Each speaker was driven by its own power amplifier. The crossover system was connected between the preamplifier and three power amplifiers.

As we experimented with different combinations of crossover frequencies and slopes, it became obvious that a hit-or-miss or arbitrary selection of parameters, by means of a fixed passive crossover network, would be unlikely to produce the optimum performance of which the speakers are capable. Not only did the choice of crossover frequence make an appreciable difference in the sound, but we usually heard at least as much difference between different slope settings.

For the loudspeaker/speaker system experimenter, we can think of no accessory as useful as a fully adjustable electronic crossover system like the Model SF-850. The need for two or three amplifiers when using an electronic crossover system might seem to be a drawback, but it should be understood that only the woofer normally requires a powerful amplifier with a very good low-frequency response and that the midrange and tweeter drivers normally require much less power. In fact, lower-power amplifiers are strongly recommended for the tweeter, which can easily be damaged by excessive driving power.

Whether or not bi- or tri-amplification has inherent sound advantages is not a question we will attempt to answer here. However, one thing is certain: there is no simpler or more convenient means of getting the most out of such a system than by using an active electronic crossover system. And the Pioneer Model SF-850 crossover system does everything claimed for it and does it very well indeed.

CIRCLE NO. 81 ON FREE INFORMATION CARD

MXR STEREO GRAPHIC EQUALIZER

Highly effective, moderately priced, 10-octave-band equalizer.

Graphic equalizers are acknowledged to provide an effective means of modifying the frequency response of a home audio system. Usually, slide-type potentiometers are used on a graphic equalizer to vary the response at different frequencies. The positions of the pot "knobs" roughly outline the frequency response curve of the equalizer, which accounts for the "graphic" part of the device's name.

In a sense, these equalizers are actually highly versatile tone controls. Practically speaking, a graphic equalizer should have at least five separate control frequencies; some of the more elaborate models have seven control frequencies. A much more desirable form, however, is the octave-band equalizer, which generally divides the audio range into 10 bands. A good example of such an equalizer is the very compact and relatively low-cost octave-band equalizer from MXR Innovations. This equalizer has excellent performance characteristics, 10 frequency controls, and provides a boost and cut range in excess of 10 dB for each of its two stereo channels.

The MXR graphic equalizer measures 9¼" W × 7¼" D × 2" H (32.5 × 18.4 × 5.1 cm) and weighs 4.5 lb (2 kg). It sells for $199.95 in the consumer version. (There are two electrically identical versions of the graphic equalizer. The consumer version uses phono-type input and output jacks and provides the tape monitor facility that would otherwise be eliminated when the equalizer is connected into a hi-fi system. The professional version uses standard phone jacks and does not supply tape monitoring facilities.)

General Description. The MXR equalizer is finished in satin aluminum with a pebbled black vinyl front panel to provide a pleasant contrast. In addition, it has walnut end panels.

On the forward section of the top panel are 22 small white knobs, 20 of which permit adjustments of the slide potentiometers and the remaining two provide the means for separately setting the gains of the two stereo channels. The center frequencies of the filters are plainly marked in front of the slide controls (31, 62, 125, 250, 500, 1000, 2000, 4000, 8000, and 16,000 Hz). Scales that extend across the control surface provide a means for indicating the approximate amount of boost and cut for each filter over a range of ±12 dB.

On the rear apron are the line inputs and outputs and the tape recording inputs and outputs that replace the normal amplifier tape monitoring circuit. A slide switch replaces the usual program source with the tape playback output, while another switch bypasses the equalizer circuits. Since the equalizer draws negligible power and can safely and economically be left on at all times, there is no power switch.

The published specifications for the equalizer are in terms of professional program levels. The maximum output is rated at +15 dBm into 600 ohms, or +22 dBm into a high-impedance load. The gain is nominally unity; ±1 dB from 20 to 20,000 Hz with the controls centered. The equivalent noise is rated at 95 dBm down. The stated input impedance is 47,000 ohms, while the output is designed to drive loads of 600 ohms or greater. The harmonic and IM distortion are rated at 0.05% or less at 0 dBm (0.775 volt).

Laboratory Measurements. The

frequency response characteristics agreed very closely with the specifications and panel markings when we tested the equalizer. It is possible to correct response in a single octave with little effect at frequencies only one octave removed. By using several controls simultaneously, one can shape almost any desired response curve. The positions of the control knobs actually do represent a valid picture of the response curve.

The measured total-harmonic distortion (THD) at 1000 Hz was the residual of our test equipment (less than 0.003%) for outputs up to about 0.2 volt. It increased smoothly to 0.05% at 8 volts output, just below the clipping level of 8.3 volts into a high-impedance termination. At 20 Hz, the THD was slightly higher—0.01% and 0.35% at 1- and 8-volt output levels.

The slewing rate of the equalizer set a limit on performance at the highest audio frequencies. At 20,000 Hz, the distortion rose from less than 0.005% at 10 mV to 0.035% at 0.1 volt and 0.71% at 1-volt output. The maximum output at 20,000 Hz was about 2 volts. The IM distortion, measured with 60- and 7000-Hz signals mixed in a 4:1 ratio, was between 0.06% and 0.07% from 0.8 to 8 volts output. It was less at lower levels.

Although we did not measure the response of the equalizer outside the audio band, the square-wave risetime of 25 µs indicates that the final rolloff is not far beyond 20,000 Hz. The output noise in a wideband measurement was barely detectable on our meter at approximately 90 µV, which is 81 dB below 1 volt or 79 dB below MXR's reference level of 0 dBm. No doubt, the application of a weighting curve would have brought our measurement into closer agreement with the published specification, but the level would be an unmeasurable value.

User Comment. Laboratory measurements cannot adequately describe the true value of a good octave-band equalizer in a hi-fi system. A good equalizer can make a poor speaker system sound tolerable, a good speaker system sound very good, correct for room acoustics to some extent, reduce turntable noise, etc. Though a really good tone-control system can do some of these jobs to a limited extent, no such system can do the jobs as well as an octave-band equalizer.

The MXR is one of the best equalizers designed for the consumer market we have ever used. Of course, the equalizer's compact size groups the controls very close together so that much care must be exercised when making adjustments. (There are also no detents on the controls, and it is necessary to view the controls from directly overhead to avoid parallax errors.) However, this is a small price to pay for a full-range, highly effective device that rarely, if ever, requires readjustment after initial setup. You do not touch up the settings of the equalizer's controls to compensate for the deficiencies on a given record or tape after the system has been equalized for the speaker system, room acoustics, and cartridge being used. Instead, you make minor program corrections with the existing tone controls on the hi-fi system's amplifier.

In addition to being an excellent performer, the MXR equalizer is priced in a range that most hi-fi system owners can afford. In today's market, this equalizer represents a realistic investment for a device that is highly practical.

SBE MODEL 12SM OPTI/SCAN DIGITAL SCANNING RECEIVER

Programming card gives simple choice of about 16,000 frequencies.

THE SBE Opti/Scan scanning monitor receiver has a digital frequency synthesizer that eliminates the need for crystals. Up to 10 channels in the Public Service Bands can be programmed onto special plastic cards that slide into a slot on the front of the receiver. An optical "reading" system then "tells" the receiver what channels to scan. Any of some 16,000 different frequencies in the ranges of 30 to 50, 150 to 170, 450 to 470, and 490 to 510 MHz can be selected in any sequence and combination. Several differently programmed cards can be used to change channel frequencies instantly.

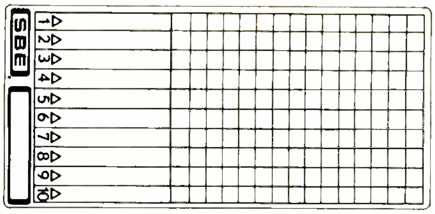
Except for the lack of a priority channel, the receiver offers all the usual scanner features: manual/automatic scanning select, channel indicators and lockout switches, variable squelch and volume controls, external-speaker jack, and rescan delay. The receiver can be ac line or nominally 12 volt, negative-ground dc powered. The maximum power drawn from the ac line is rated at 15 watts, while current drain from a 13.8-volt dc source is specified at 0.8 ampere.

The receiver measures 10" W × 7¾" D × 2¾" H (25.4 × 20 × 7 cm) and weighs 7.5 lb (3.4 kg). Price $369.95.

General Information. Based on a visual inspection of the receiver, we would say that it has multiple conversion, the last to 455 kHz. The last i-f stage has a ceramic filter to provide selectivity. Separate r-f front ends are provided for the low and high vhf and the uhf bands.

A 40" (102-cm) telescoping antenna plugs into a connector on the rear of the receiver for receiving in the low- and high-vhf ranges. A separate 6" (15.2-cm) whip antenna plugs into a separate jack to provide reception on the uhf bands.

The programming cards provide binary information for the two-state logic levels required by the digital frequency synthesis system to develop the heterodyning frequencies for each channel. As supplied, the cards are optically opaque. The user programs them according to simple instructions in the manual.



Close-up of programming card.

The maximum frequency coverage is limited to a 20-MHz spread for each band. However, the receiver can be specially ordered from the factory to cover only the 140-to-160, 470-to-490, and 492-to-512-MHz portions of the vhf and uhf bands. This means that coverage can encompass the 2-meter amateur radio band.

Measurements. In general, our performance measurements on the receiver fell within the published specification figures. Sensitivity measured 0.5 µV average for 12 dB SINAD. The squelch range was from 0.25 to 330 µV. Adjacent-channel selectivity was 50 dB down at 25 kHz. Modulation acceptance was ±7000 Hz. The audio output power measured 2 watts (rated 3 watts) into 4 ohms at the start of clipping with 2% (rated 10%) THD at 1000 Hz.

We noted several unwanted-signal responses with signals at 100-to-1000-µV levels (40 to 60 dB above 1 µV). With actual on-the-air reception, such responses occasionally appeared from signals that were 3 to 4 MHz lower than the desired frequency on the 150-to-174-MHz band, where most of the radio activity in our area takes place. This situation appears to be due to overload or spurious mixing products with the synthesizer, rather than the result of an i-f image. In any event, this should present few problems in most areas of the country.

User Comment. Two programming cards are supplied with the receiver. (More can be ordered separately.) Each consists of two layers of plastic bonded together. About two-thirds of the area on each card is given over to a "window" matrix made up of 15 columns and 10 rows. To the left of the matrix are 10 blank spaces labelled with the numbers 1 through 10 in which are entered the frequencies for the selected channels. A small blank space near the SBE logo can be used for identifying the card.

Programming starts by deciding on the frequencies you want to monitor. Then you look up the binary codes for each frequency in the tables in the manual. After entering the frequencies and, beside them, the binary number code that applies to each, the actual programming of the card can be done. Note that each frequency has a 15-digit binary code, which corresponds exactly with the number of columns in the window matrix.

After entering the frequencies in the blank spaces on the card next to the channel numbers, all tabs indicated by 0's in the binary codes are removed from the matrix. Wherever a tab is removed, a transparent space will allow light to pass through, which the receiver's optical reading system will recognize as a logic 0.

The adhesive-backed tabs can easily be removed from the card with a fingernail, pointed instrument, or tweezers. The tabs can be saved, by sticking them to the rear page of the manual, should a card have to be reprogrammed or an error in the coding have to be rectified.

Using a program card is very simple. It goes into the reader slot on the front of the receiver, matrix foremost and SBE logo facing upward. However, should the card be fed in upside down, the scanner will still tune the proper frequencies, but the scanning sequence will be in reverse order.

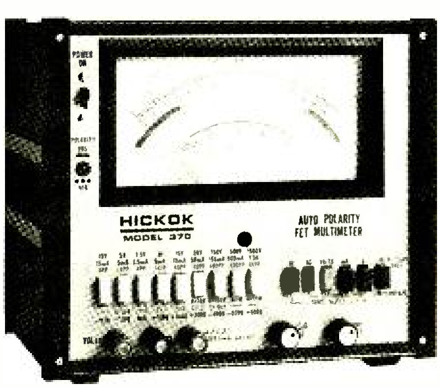
The rescan time delay of the receiver is about a second. Scanning time through all 10 channels is also about a second. Pushbutton switches are used for the channel lockout function and MANUAL and SCAN select, while standard rotary pots are provided for VOLUME and SQUELCH adjustments.

The good signal sensitivity of this receiver provided very good reception results when we used the plug-in whip antennas supplied with the receiver. For mobile and outdoor external antennas, 50-ohm systems are recommended. We rate the audio quality from the top-facing speaker built into the receiver as excellent.

CIRCLE NO. 83 ON FREE INFORMATION CARD

HICKOK MODEL 370 ANALOG MULTIMETER

High-impedance multimeter also measures capacitance.



AT A TIME when it appears that digital instruments have completely taken over the test and measurements scene, it comes as a pleasant surprise to see a top-quality analog multimeter on the market. The Hickok Model 370 is a bench-type, ac-powered auto-polarity FET (high-impedance) multimeter designed along the classic lines of "laboratory" test instruments. It features a large 5" (12.7-cm) rectangular meter movement with seven relatively uncrowded scales and an antiparallax mirror backing.

The multimeter can measure all the usual ac and dc voltages and currents and resistances. It can also be used to measure decibels and capacitance. The latter function can be found in some moderately priced digital instruments, but it is a rarity to be able to measure capacitance as high as 10,000 µF with any but the most sophisticated analog multimeters. All function and range selections are accomplished with pushbutton switches, another rather radical departure from the traditional multiposition rotary switches used in analog VOM's.

The Model 370 measures 8½" W × 7" H × 6" D (21.6 × 17.8 × 15.2 cm) and weighs 4 lb, 12 oz (2.2 kg). It sells for $189.00.

General Description. The front panel below the meter movement contains 15 pushbutton switches that control the entire operation of the multimeter. A LED indicator serves as both a "pilot lamp" and an auto-polarity indicator when the instrument is used in the dc mode.

The full-scale voltage ranges on both ac and dc are 0.15, 0.5, 1.5, 5, 15, 50, 150, 500, and 1500 volts. On dc, the input resistance is 10 megohms and accuracy is 2% of full scale. In the ac mode, which is rms calibrated (average responding), the input impedance is 10 megohms shunted by less than 75 pF. The frequency response goes out to at least 50,000 Hz, and worst-case accuracy is 5% of full scale. Calibration of the multimeter is accomplished in nine ranges, using two scales, from 0.4 to 4000 volts peak-to-peak.

There are nine decibel ranges from −30 to +65 dB, with 0 dB defined as 1 mW across 600 ohms. Input impedance is 10 megohms shunted by less than 75 pF. As on ac volts, the decibel frequency response goes out to at least 50,000 Hz.

To provide a broad resistance range, the instrument provides eight measuring ranges whose center-scale values are 10, 100, 1000, 10,000, 100,000, 1 meg-, 10 meg-, and 100 megohms. In this mode, the open-circuit potential is selectable for either low-power (0.15-volt) or high-power (1.3-volt) testing, except on the RX1 range. Accuracy on all resistance ranges is 3% of full scale.

The capacitance-measuring mode is broken up into six ranges to cover from 500 pF to 10,000 µF with a measuring accuracy of 5%. A 0.15-volt 60-Hz drive signal is applied to capacitors under test. Electrolytic capacitors are also biased at +1.2 volts.

Nine ranges are provided for measuring both ac and dc currents, with full-scale values of 0.15, 0.5, 1.5, 5, 15, 50, 150, 500, and 1500 mA. In the dc mode, the accuracy is 3% of full scale; while on ac, the worst-case accuracy is 5% when measuring voltages at frequencies between 60 and 1000 Hz.

Overload protection on the dc and ac (including decibel) voltage ranges is provided by a 1500-volt protected input. A fuse and a circuit breaker take care of any possible damage to the ac and dc current-measuring circuits and the resistance and capacitance functions.

User Report. The Model 370 multimeter is as impressive looking as its specifications imply. Because of its high input impedance and excellent low ranges, we found it to be eminently suitable for testing and troubleshooting solid-state circuits.

The large meter movement has plenty of area behind the pointer for scales that are easy to read and interpret, especially with the aid of the mirror backing. As a result, it was quite easy to interpret measurements accurately. The scales are clearly identified. The separate voltage and current scales are colored black and located above the arc of the mirror. The resistance and capacitance scales are green and red, respectively. These four scales are the most often used and are longer than the other scales as a result of being farthest from the movement's pointer pivot.

The decibel scale has a zero-center mark. The scale extends from −10 on the left to +5 on the right. The peak-to-peak voltage scales are located nearest the pointer pivot and are colored red. As you read ac voltage in rms on the upper voltage scale, you can simultaneously read its peak-to-peak value on the lower scale.

The clearly identified pushbutton switches are color coded the same as the scales to which they apply. They operated smoothly and positively, without any evidence of binding or wobble. The LED indicator glows steadily when power is turned on. Then, when the instrument is set to the dc function, it glows steadily when the test probes are properly polarized with the circuit under test or blinks when the polarity is reversed. This auto-polarity feature (there is no need to transpose test probes when the LED is blinking) saves a lot of time and manipulation during testing.

Being able to measure capacitance with this multimeter is a really handy feature we would like to see incorporated into more multimeters. The Model 370 has an unusually high upper capacitance range that permits checking out the large-value capacitors normally used in solid-state circuits.

During our normal use tests, we also made some checks on the instrument's accuracy using high-tolerance precision resistors and a laboratory voltage standard. In addition, we compared the measurements we obtained with this multimeter in the capacitance range to a high-accuracy DMM's readings. In all cases, the measured accuracies were well within the published specifications.

CIRCLE NO. 84 ON FREE INFORMATION CARD

MAC'S SERVICE SHOP

Mobile Communications:

CB vs. 2-METER FM

By John T. Frye, W9EGV

THE cool air in the service shop felt good to Barney as he stepped inside from the hot, humid weather outside.

"Hi, Bart," he greeted the graying man sitting in a wheelchair chatting with Mac. "Why the antenna farm sprouting from the roof of your hotrod out front?"

"You like my guttermounts?" Bart asked with a grin. "The short one is a CB loaded whip, and the long one is a 2-meter 5/8-wave vertical. I'm planning on doing some travelling, and I'm checking out the relative effectiveness of these two modes of mobile communication for drivers in general and physically handicapped drivers in particular. Since that bout with polio, I figure I'm a representative 'worst case' of the latter group. Even a flat tire on my hand-controlled car means I must have help."

"What rigs are you using?"

"The CB rig is a deluxe synthesized 23-channel job with incremental tuning, mechanical filter, S-meter, 0.5-microvolt sensitivity, r-f noise blanker, speech compression, 4 watts of r-f output, and a pi-network. I can plug a little 5-watt horn speaker into a jack on the back of the set and stick the speaker on the car-top with rubber suction feet and have my own portable PA system—a form of short range communication that has come in very handy on a couple of occasions.

"The 2-meter rig is a hand-held transceiver with switchable r-f outputs of either 2 watts minimum or 1 watt maximum. It measures about 10″ × 3½″ × 2″ and weighs 2 lb., 4 oz with a self-contained 14.4-V, 500-mAH NiCd battery. It has two ceramic i-f filters, provides 0.5 watts of audio output, and has a sensitivity of 0.7 µV for 20 dB quieting. There is provision for five sets of transmit/receive crystals, and I have three simplex and two repeater sets installed at present. These include the national simplex frequency at 146.52 MHz and the old 146.94 MHz, plus the local repeater on 147.78/.18 and the popular 146.16/.76 that will access repeaters in neighboring Indianapolis, Fort Wayne, Lafayette, and Chicago. When I start travelling, I plan to replace two of the simplex channels with .34/.94 and .22/.82 that my knowledgeable 2-meter friends recommend.

"There are probably two dozen hand-held transceivers on the market, and each has special features to recommend it; but I chose this one because it and the accessories available made it particularly suited for my needs. I can take it with me in my wheelchair, in the motel, and in the car. Those accessories include an external dynamic mike with PTT switch, a dc power cord with cigarette lighter plug, earphone, leather carrying case, a flexible rubber-ducky antenna that can replace the normal telescoping antenna, and a dual-rate battery charger into which the transceiver is dropped for charging at a normal rate of 50 mA and a trickle rate of 15 mA. On squelched receive it draws 30 mA; so when it is operating in the charger set to a normal rate, the net charge is a trickle charge. That's a handy feature for long-term monitoring, say in a motel room."

"Sounds to me like you're giving CB a 2/1 power advantage."

Before answering, Bart pulled a black, metal-cased object from his coat pocket and handed it to Barney. It measured about 4¼″ × 3″ × 1⅞″ and had an SO-239 coax fitting extending from either side and two wires coming out a grommeted hole in one end. The wires were attached to a cigarette lighter plug. Closer inspection revealed the object was actually a large finned heat sink with a shallow (1″ deep) cover snapped over the flat side.

" 'It matters not how great their size; depend on me, I'll equalize,' " Bart quoted." Barney, this is an amplifier tha I bought as a kit and assembled on a furnished pc board that's fastened to the back side of the heat sink beneath the cover. It's a solid-state vhf amplifier utilizing a high-power Motorola module, and it covers the 135-to-175-MHz band. It's completely self-contained and requires no tuning or setup. With a minimum driving power of 100 mW, it will put out 20-25 watts with a supply of 12 to 13.6 volts dc. You just insert it in the antenna feedline, plug it into the cigarette lighter socket, and you're in business. It's assembled for the r-f input you intend to use. In my case, I wired it for 1 to 3 watts, but attenuator resistors are furnished for inputs of 250 mW or less, 250 to 500 mW, and 500 mW to 1 watt. Within limits, power out is a function of power in; so when I have my handheld transceiver on the lower output level, I get 12 watts out of the amplifier. This jumps to 25 watts when I switch the transceiver to 2 watts output. That means I have a choice of 25 watts, 12 watts, 2 watts, or less than 1 watt for my 2-meter tests; but I usually run full power when trying to make an initial contact."

"I suppose you have to take the amplifier out of the feedline when you want to run the hand-held barefoot, don't you?" Barney asked.

"Not at all The unit contains a little carrier-operated relay (COR) that only inserts the amplifier into the feedline when both a carrier is present at the input and power is fed to the amplifier. When no carrier is present, as on receive, the antenna connects through the COR contacts straight to the receiver. If the cigarette lighter plug is pulled out, the COR is not operated by the transceiver carrier and the RF goes, unamplified, to the antenna."

"Okay, Bart, now you've told us about the equipment you're using, what about your findings?" Mac interrupted. "If you need help or just information on the highway, are you better off with CB or 2-meter FM?"

Which Is Better? "Let's talk about CB first," Bart answered. "The chief thing it has going for it is the sheer number of CB units in use—something like six million sets—and the fact that they are all concentrated on 23 channels in a single band. One out of every 28 American families has one or more CB sets, and 1 out of 5 longhaul trucks is CB equipped. While only about 2 million or so CB licenses are valid today, this doesn't tell the story. Many licenses usually cover several transceivers, and there are probably more unlicensed CB users than licensed. This last, though, is changing, probably because the license fee has dropped from $20 to $4 and the FCC is cracking down on violators. In the last year 9000 CB violators have been belted with fines ranging from $100-$300. For repeat cases, licenses have been revoked and fines up to $10,000 levied. CB license applications that were running less than 15,000 a month in 1972 are now up to 500,000 a month.

"Yes, CB is becoming more respectable. REACT teams, as well as state and local police, monitor Channel 9, CB's emergency channel; and it's estimated 5.2 million calls are made yearly on that channel. Missouri has installed CB radios in all 750 of its highway patrol cars, and in Indiana the state police operate several mobile units under the call of KFP2179; and they hope this year to install CB sets in all of the state police posts. Other states are taking similar action. In addition to Channel 9, some state units monitor the old 'Trucker Channel 10,' or the 'New Trucker Channel 19.'

"But CB has disadvantages, too. The band is crowded, and popular channels are jammed with heterodynes and interferring signals. The AM receivers are subject to both natural and man-made noise. Often signals skipping in from 750 to 2000 miles away will be so strong that talking across town is nearly impossible. This condition will worsen as Sunspot Cycle 21 progresses. Some CB stations run far more than the legal 4 watts output and overload the front ends of nearby receivers, "bleeding" across a half-dozen channels each side of the offending signal."

"We don't have these troubles on two meters," Barney said smugly. "FM receivers reject static and man-made noise. While skip is not unheard of on two meters, it happens rarely compared to the 11-meter CB band, and even then it produces no squealing heterodynes. A ham license is a hard-won and cherished possession, and the vast majority of hams abide by the rules and regulations of the FCC. If one accidently puts out a broad and interferring signal, he hears about it immediately from fellow hams before the Friendly Candy Company, hopefully, can take note."

"All true," Bart agreed, "but probably repeaters are the main advantage 2-meter FM has over CB. There are over 2000 repeater licenses extant, and new applications are coming in at the rate of a dozen a week. These machines run considerable power, and their antennas are put just as high as possible to take advantage of the line-of-sight propagation of 2-meter signals. If a signal from your hand-held or mobile transceiver can access the repeater, the full power and ideal antenna site of the latter is at your command. If that repeater is on a mountain top, as is often the case on the coasts, your hand-held's signal may be heard for a radius of a hundred miles by anyone monitoring the repeater channel. Some repeaters even use satellite receivers linked to the repeater receiver by vhf or uhf to extend the weak-signal pickup. The satellite inputs are sampled by a scanning or 'voting' device that selects the most noise-free signal for feeding to the repeater receiver.

"A lot of good commercial service technicians are attracted to the 2-meter band, and some of the repeaters they set up are unbelievably sophisticated. A few will respond only upon receipt of a special tone-coded command, thus restricting their use to the subscribers. Upon a different command, they will transmit time, weather, and road conditions. Many repeaters have autopatch facilities so that if the mobile or hand-held unit is equipped with a touch-tone pad, the owner can place a telephone call through the repeater to tell the wife he will be late for supper or to report an accident directly to the police. Note, however, he cannot engage a motel room, order a radio part, or engage in any other commercial activity on the ham band. He can do so on CB as it is intended for personal and business use.

"In all honesty, though, two meters has some disadvantages, too. On a watts-per-dollar basis, 2-meter equipment is more expensive than CB. My CB set costs $200, but if you are willing to sacrifice a few features you can get a good set for around $150. The hand-held job, complete with accessories and crystals for five channels runs about $350. On top of that, repeaters are expensive to set up and operate, and this money must come from the hams using them, either through club dues or subscriptions.

"But in spite of all the work, money, and dedicated cooperation hams pour into repeaters," Bart concluded, "there just aren't enough hams monitoring their 45-odd simple and repeater frequencies during the weekday daylight hours out here in the sparsely settled flat lands to insure reliable interception of signals from passing mobiles. There are only 255,000 hams spread out over their many bands and they have various interests. I greatly doubt if 100,000 of them operate on two meters. The picture is undoubtedly different on the coasts where people and repeaters are more concentrated, but I plan to travel the width and breadth of the country; and I can't afford a hatfull of crystals or an expensive synthesizer to hit the many repeater frequencies shown in a repeater directory. Things may be different if proposed FCC changes regarding a 'no code' vhf phone ham license go through. That opens up a lot of possibilities. But for now, I've repeatedly called on .52 and .94 and on the frequency of a local repeater for road information with only the repeater identification or its squelch-tail for a reply.

"On the other hand, I seldom need to make a second call on CB Channels 10 or 19, in the city or out on the highway, to get an immediate answer. I enjoy the ham contacts I do make, and I believe hand-helds and repeaters constitute the wave of the future. I certainly plan to take my hand-held transceiver with me wherever I go, but when I need help or information, I'll reach first for the CB mike.

"There are times, though," Bart said with a grin, "when both a belt and suspenders are not enough. My ham friend, Joe, and his son-in-law, a non-believer in electronic wizardry, were going to Florida in a truck camper last year. About 30 miles west of Chattanooga on I24 a rod went out through the side of the motor. 'No sweat,' says Joe. 'I've got nine channels in my 2-meter transceiver and all 23 in my CB set; so I'll just summon help.' An hour or so later, after vainly yelling himself hoarse on all channels of both transceivers, Joe unstrapped his trail bike from the front of the truck and rode off to get help. His son-in-law has never let him forget this." ◈

Solid State

BUILD YOUR OWN SONAR SYSTEM

By Lou Garner

SONAR — the name alone has an exciting quality, whether you're old enough to remember World War II, young enough just to have read about it in history books, or simply a viewer of the late-late TV movies. You have visions of determined, steely-jawed destroyer skippers searching relentlessly for killer U-boats. You hear the "ping-ping-ping" background sound as a tense and sweating American submarine commander attempts to elude an enemy patrol. Now, with a little skill, a dash of patience, a single IC, and a few accessory components, you can build your own sonar — not a military version, to be sure, but a practical down-to-earth (water?) instrument which can be used as a submerged object detector, depth finder, or fish locator, or, with a few modifications, for underwater data transmission and remote control applications. If you're not a yachtsman (yachtsperson) or fisherman (fisherperson), you can use the same IC to assemble an air ranging version called *sodar* (for SOnic Detection and Ranging) suitable for remote sensing, collision avoidance, and intrusion or burglar alarm systems.

Utilizing a number of novel circuit design techniques, engineers at the National Semiconductor Corporation (2900 Semiconductor Drive, Santa Clara, CA 95051) have developed a monolithic IC which contains all the essential electronic circuitry for a complete sonar system within a chip area of only 80 by 93 mils. Affectionately dubbed *the fishfinder* by the firm's application engineers, the device, type LM1812, was released just recently for general distribution, although it has been in production on a semi-custom basis for over a year. Joining the manufacturer's growing family of special-purpose devices, which includes the LM3909 LED flasher, discussed in last year's July and October columns, and the NSL4944 universal LED, examined in our May issue, the LM1812's unusual circuit contains a 12-watt ultrasonic transmitter and a selective receiver featuring a 10-watt display driver. Despite its high peak power capabilities, the IC, in an 18-pin Epoxy B molded DIP, can be operated without an external heat sink in most applications.

Designed for use on standard 12-volt dc sources, the

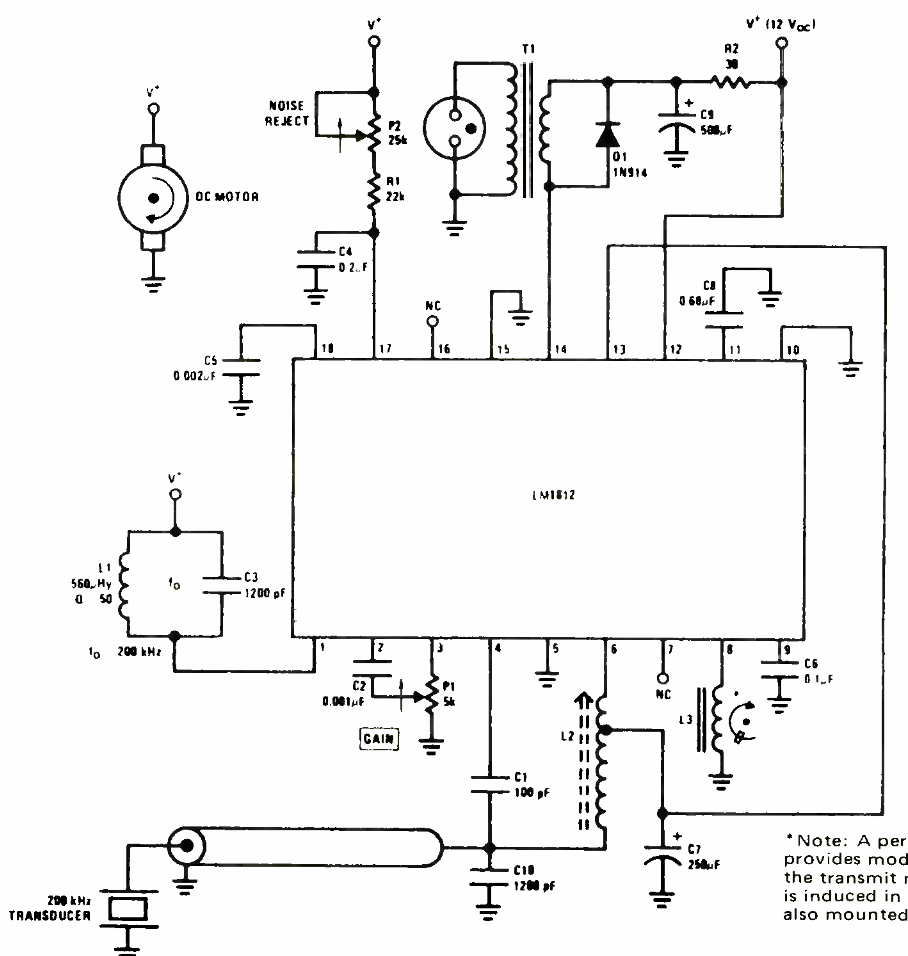


Fig. 1. A typical sonar system circuit. The component values are for operation in water.

*Note: A permanent magnet attached to a rotating wheel provides modulation pulses to pin 8. The time duration for the transmit mode is controlled by the voltage which is induced in a stationary pick-up coil. The neon display is also mounted on this wheel.

LM1812 has a maximum supply voltage rating of 18 volts, coupled with a maximum power dissipation of 600 mW. Its specified operating temperature range is from 0°C to +70°C. Under normal operating conditions, its receiver section has a typical sensitivity of 200 μV p-p, with its display driver supplying a maximum current of 1 A for 1 ms. The unit's transmitter power output stage is capable of delivering a 1-A, 1-μs pulse to a suitably matched load. Although generally used with a neon bulb or LED output display device, the LM1812 can be used in conjunction with a clocked digital readout or a CRT display.

A basic sonar system using the LM1812 is illustrated in Fig. 1. As in most conventional sonar systems, the basic design employs the "echo-ranging" principle—that is, the system transmits short, high-intensity ultrasonic pulses at fixed intervals and detects any resulting echos. In practice, the LM1812 transmits pulses of about 200 kHz for approximately 80μs through its external transducer, which also serves as a pick-up device. Between pulses, the receiver section is activated to detect any returning signals reflected by solid surfaces, such as a lake or river bottom, schools of fish, or submerged objects. These echo signals are detected and amplified, then used to drive the output display. The time differential between the original transmitted pulse and any returning signals is directly proportional to the distance from the object(s) causing the echo, permitting the output display to be calibrated in distance units (feet or meters) rather than time intervals.

A single resonant circuit, *L1-C3,* time-shared by both the receiver and transmitter sections, establishes the system's exact frequency of operation, thus eliminating the need for special alignment procedures and insuring that the two sections track over a relatively wide temperature range. The system's *transmit* mode is activated with the application of an externally generated positive-going timing pulse to the modulator control, pin 8. At this point, the gated oscillator is switched on, developing a controlled sinewave signal across resonant circuit *L1-C3*. Simultaneously, the second r-f stage is gated off, momentarily disabling the receiver section. The sine-wave signal is internally amplified and squared, then applied to a one-shot multivibrator, where each leading edge triggers the generation of a 1-μs pulse. Applied to the power amplifier, each pulse drives the stage into saturation, resulting in high-efficiency class-C operation. The amplified 200-kHz output signal is then coupled to the piezoelectric transducer by means of an impedance matching step-up auto-transformer, *L2*. The final transmitted signal, then, is a narrow burst of 200-kHz sonic energy. At the end of each timing pulse, the transmitter stages are deactivated and the receiving section gated *on*. During this period, and until the next timing pulse is applied, returning (echo) signals picked up by the transducer are applied to the receiver through coupling capacitor *C1*. An external gain control, *P1*, is provided between the first and second r-f amplifiers, coupled to the second stage through dc blocking capacitor *C2*. From here, the amplified signal is applied to a threshold detector which responds only to signals above an established level. Impulse noise is rejected by the combined action of the pulse train detector and integrator stages. The two circuits require a reasonable number of signal cycles for operation. If there is not a continuous train of pulses in the amplified signal (if 2 or 3 are missing, for example), representing a valid echo, the pulse train detector will "dump" the integrator, discharging the integration capacitor to ground. On the other hand, if the signal is valid, the display driver is switched on, activating the display device. An additional protective circuit momentarily disables the receiver if the display driver is kept on for too long a time period; this is accomplished by feeding back a signal from the display predriver stage to integration capacitor *C8* which, in turn, furnishes a control bias to the duty-cycle control transistor.

Although the circuit's basic operation is the same whether it is used for sonar, data communications, or remote control, the external drive and output circuitry must be altered to meet individual system requirements. Generally, much less power is needed for communications and remote control applications than for echo ranging since the latter requires signal transmission over twice the distance (to the target and back). In remote-control systems, the display unit might be replaced by a relay or control device, such as an SCR or power transistor. On the other hand, if the LM1812 is used for communications, a high-impedance detector and audio amplifier should be connected to pin 1 for reception, with another used for modulation. Of course, a single amplifier can be used, if prefer-

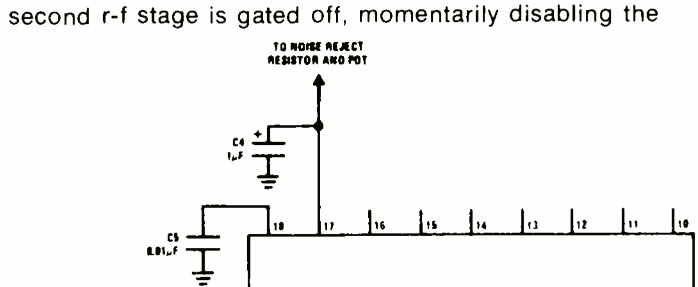
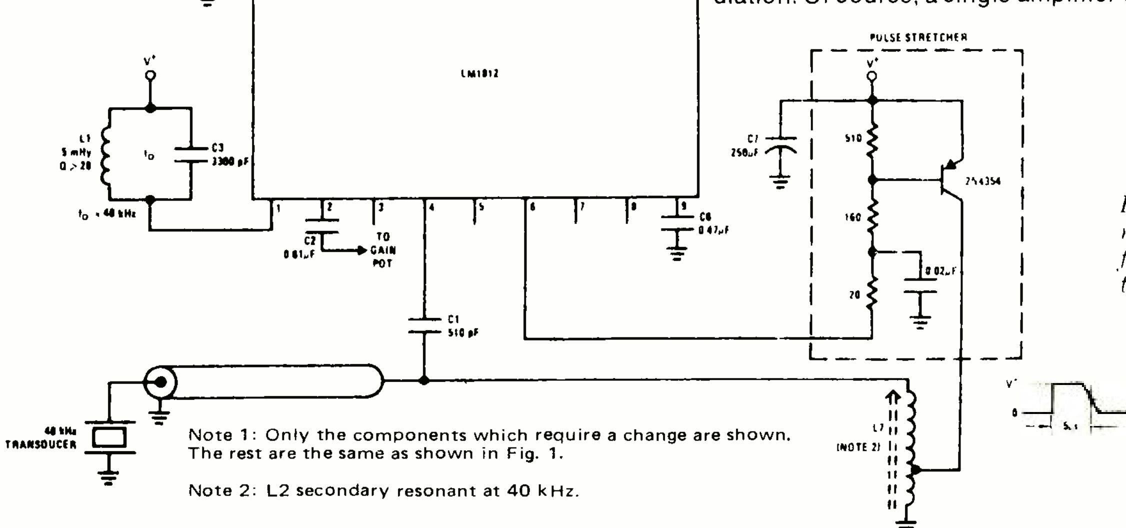



Fig. 2. Circuit modifications needed for a Sodar (air transmission) system.

red, switched back and forth between the modulator and receiver sections for transmission and reception. Variable rate pulse or other modulation techniques may be used for digital data or code communications.

Naturally, some means must be provided for measuring the time interval between the transmitted and echo pulses when the LM1812 is used in a sonar system. Any of several techniques may be used, including digital control and a clocked readout or an oscilloscope display with a calibrated linear sweep, but one popular method is illustrated in Fig. 1. Here, a small permanent magnet and a neon bulb are mounted near the rim of a wheel, with slip rings provided for applying a voltage to the bulb. The wheel is rotated by a constant-speed dc motor. The magnet serves to generate modulation pulses inductively as it passes a fixed pickup coil, *L3*. The neon bulb serves as the display device, driven by the receiver's output stage through transformer *T1*. Shunt diode *D1* is included to suppress switching transients, while a series filter, *R2-C9*, is provided to limit excessive current build up in the transformer's primary under rapid flashing conditions. The transformer must provide a substantial voltage step-up (from 12 to 100 volts or more) to insure flashing the bulb. In operation, the wheel's position at which the initial pulse is transmitted is considered "0," while the arc length traveled by the bulb before it flashes an echo represents the time required for the ultrasonic pulse to travel to the target and back. Since this time period is directly proportional to target distance, a fixed calibrated scale can be positioned around the wheel to indicate distances in feet or meters. Within system sensitivity limits, the sonar's maximum scale range is determined by the repetition rate of the transmitted pulses, for echoes can be received only during the intervening intervals. With a system design similar to the one shown in Fig. 1, then, the scale range is determined by the display wheel's rotational speed (hence motor rpm), for this determines the pulse rate.

Considering the relative attenuation of high-frequency ultrasonic signals in water and in air, a much lower operating frequency is recommended when the LM1812 is to be used in air transmission systems, such as sodar—typically 40 kHz rather than 200 kHz. The basic circuit modifications needed for operation in an air medium are given in Fig. 2. A different transducer is required, of course, together with a matching drive coil, *L2*. In addition, bypass and coupling capacitor values should be increased as indicated and the tuning elements (*L1* and *C3*) changed to achieve 40-kHz resonance, while an external "pulse stretcher" must be added to lengthen the drive pulse from 1 to 5 µs. Driven by the LM1812, the pulse stretcher consists of a simple RC integration network and pnp power driver. Except for these few changes, the circuit arrangement and component values are identical to those of the system shown in Fig. 1.

When using the LM1812 in practical designs, special attention must be given to ground loops and common coupling paths due to the close proximity of transmitter and receiver circuits in the same package. Three ground pins (5, 10, 15) are provided on the device to simplify layout problems, but the ground path(s) still must be adequate to handle peak currents of as much as 2 amperes when the transmitter and display are energized simultaneously. Local sources of high-energy impulse noise, such as lightly loaded motors, if not shielded properly, can cause erroneous display signals or "blips." Ideally, these noise

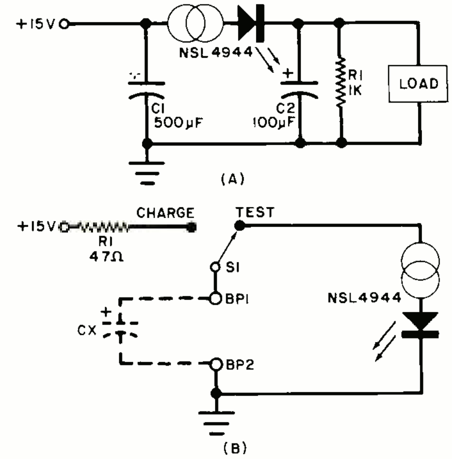


Fig. 3. Some applications for NSL4944: (A) Decoupling filter; (B) Capacitor tester.

pulses should be filtered at the source, but their effects can be minimized by connecting a small capacitor (about 30 pF) across the first r-f stage (between pins 3 and 4) to reduce amplifier bandwidth. Finally, for optimum overall performance and maximum efficiency, the transducer driver coil (*L2* in Figs. 1 and 2) should be designed to resonate at the proper frequency (200 kHz for water and 40 kHz for air systems) with the sum of all output circuit capacitances, including distributed wiring, that of the coax cable feeding the transducer, and the transducer itself.

Reader's Circuits. Submitted by Peter Lefferts (1640 Decker Ave., San Martin, CA 95046), the two circuits given in Fig. 3 illustrate additional applications for the versatile NSL4944 universal LED. Both designs utilize the LED's unique current regulation characteristic, both are suitable for home projects, both use standard components, and both are noncritical as far as layout and lead dress are concerned. Referring, first, to Fig. 3A, this decoupling network can be used wherever stage isolation is required, as when powering a preamp in an audio amplifier. Essentially a standard pi filter network with a constant current LED used in place of a resistor or inductance, the circuit attenuates power supply ripple by some 60 dB while attenuating back-coupled signals more than 70 dB. The only critical factor is the load current, which must be within the LED's capability, yet, at the same time, large enough to insure LED operation within its constant-current mode — typically about 13 mA. If the load requirements are unusually small, as with some FET preamps, a shunt load resistor (*R1*) is needed to increase the LED's current to within the optimum range. The dc voltage drop across the LED is a little over 2 volts. The second circuit, Fig. 3B, is an extremely simple tester for large electrolytic capacitors. Control switch *S1* is a center-off, spdt toggle, lever, rotary or slide switch; series resistor *R1* is a ½-watt unit, and *BP1* and *BP2* are standard binding posts. In operation, the test capacitor, *Cx*, is connected to terminals *BP1* and *BP2* with correct dc polarity. Switch *S1* is thrown first to the *charge* position, charging the capacitor from the dc source through series limiting resistor *R1*, then to the *test* position. The constant-current LED will discharge the capacitor from 15 volts to 2 volts *linearly*, staying lit during this period. If a typical 13-mA NSL4944 is used, a 1000-μF capacitor will discharge in just one second. Variations in the characteristics of individual LED's can be compensated by adjusting the supply voltage to a value just two volts more than the *actual* LED current in mA (i.e., an 11-mA LED would require a 13-volt supply). By estimating (or measuring) the discharge time, an experienced user can check capacitors with values from about 500 μF to over 100,000 μF (from ½ to 100 seconds). Leakage can be estimated by charging the capacitor a second time, waiting for one discharge period, then testing. With a nominal LED (13 mA), a 10% *decrease* in discharge time would indicate a leakage of 1.3 mA for the test unit. If the LED fails to light when *S1* is thrown to its test position, the capacitor is either shorted or open.

Device/Product News. Currently, microprocessors seem to be dominating the technical news front. Fairchild's Microsystems Division (1725 Technology Drive, San Jose, CA 95110), for example, has introduced a new microprocessor design kit on a fully assembled circuit board which comes complete with a connecting cable for power supply and terminal hookup. The circuit board contains Fairchild's 3850 F8 CPU device, the 3851 program storage unit circuit, the 3853 static memory interface circuit and eight 2102 static RAM's (1 kilobyte of memory). The complete kit is priced at $185.00 in small quantities.

Both Signetics, Inc. and Motorola Semiconductor Products have slashed the prices of their microprocessors. Signetics has reduced the price of its Model 2650 general purpose, 8-bit, 5-volt, TTL compatible n-channel μP from $72.00 to $26.50 in small quantities (1-24). Motorola has reduced the price of its type 6800 8-bit n-channel device from $69.00 to $35.00 in 1-9 units. The firm also has dropped the price of its MC6860 modem from $32.00 to $17.00 in small quantities. ◈

Computer Bits

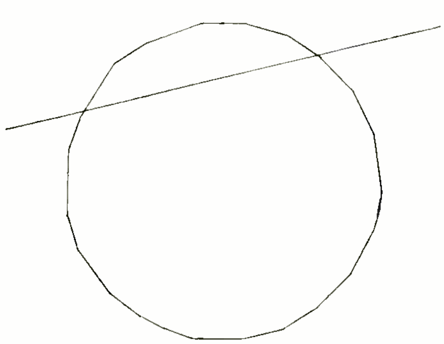
By Hal Chamberlain

COMPUTER GRAPHICS

MORE and more of the sophisticated computer applications that were once reserved for big computer systems are being successfully pursued by hobbyists. Sooner or later, after the novelty of having "your very own computer" has worn off, the typical hobbyist will settle down and concentrate on one or two particular applications for his computer. In many cases, hardware specific to the chosen application will be built or purchased and increasingly complex software will be written to get the best performance possible out of the hardware.

The conceivable applications of hobby computers are almost too numerous and diverse to list. However, one application that might interest all computer hobbyists is computer "graphics".

What Is Computer Graphics? In a nutshell, computer graphics is a general term referring to the equipment and programs used for *pictorial* input and output rather than the usual alphanumeric input/output. Computer graphics is very useful for game-playing boards, artistic pursuits, architectural and engineering drawings, plotting mathematical curves, amateur slow-scan TV, and of course impressing your friends. Graphics can also be an integral part of other hobby computer applications. Interactive computer games is one obvious example and electronic music is another where graphics might be used to enter and plot waveforms or envelope shapes.



Circle and line drawn on vector display 30 × 30.

If the user can control the pictorial display in real-time (the picture changes immediately when so commanded), the system is said to have *interactive* graphics capability. This is obviously very useful in action computer games such as Space War where objects are constantly moving around on a screen under both computer and player control. Interactive capability is also useful in artistic and drawing situations when editing of the picture is done.

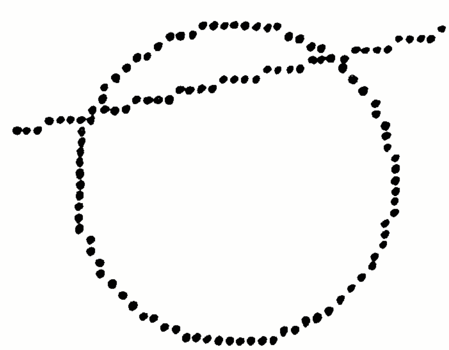
Computer Graphics Hardware. Perhaps everybody with any exposure to commercial computers has at one time experimented with "printer pictures." These are created with standard characters printed at selected places on a printout page. Input of the image data is usually done by an imaginative and patient operator. The results are quite coarse and have to be looked at from across a room to be appreciated. For more practical results, specialized graphics hardware is needed.

The most common graphics output devices are CRT (cathode ray tube) displays and mechanical plotters. CRT's have the advantage of much lower cost and interactive capability. Plotters, of course, produce an image on paper that can be saved for later use away from the computer.

Graphic input devices are much more diverse. The most common are special "function keyboards" and potentiometer dials. A function key may, for example, erase a previously designated line from the image when depressed. Two potentiometers can be programmed to move an object around the screen in horizontal and vertical directions. A "joystick" can replace two controls and provide greater ease of movement control. Light pens are used to "point out" or select an object that is being displayed. With proper programming, the operator can seemingly draw images directly on the CRT screen. A "graphic tablet" allows one to trace a paper drawing into the computer's memory. A digital TV camera such as the Cyclops (POPULAR ELECTRONICS, February 1975) can also be used for graphical input.

There are two fundamental methods of displaying or drawing a picture with a computer. Any image can be broken up into a number of dots as is done in newspapers or television. If the brightness or size of the individual dots can be controlled, then grey-scale pictures can be displayed. Images can also be broken up into straight lines of various lengths and angles. Although grey-scale display using lines is uncommon, it is possible. Computer graphics output equipment uses both methods on CRT displays and plotters. Let us compare these two output methods.

The earliest computer graphic displays were called "point plot" displays. These consisted of a modified oscilloscope and two digital-to-analog converters. A digital-to-analog converter (DAC) accepts binary numbers from a computer and translates them into corresponding dc voltages. One DAC would be connected to the x-axis deflection input and the other to the y-axis input on the oscilloscope. The computer program could display a dot at any point on the screen by giving its x and y coordinates. An image could be drawn by displaying the proper dots one at a time in rapid sequence. A later improvement in display circuit technology allowed straight lines to be drawn between points. This greatly increased the pos-

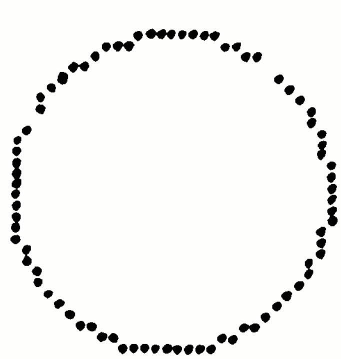


Circle and line drawn on raster display 30 × 30.

sible image complexity since one command from the computer could replace literally hundreds of individual dots. Displays capable of drawing lines from one point to another are called *vector* displays and the lines themselves are called vectors. Usually, when a computer professional talks about graphic displays, he means vector displays.

A major advantage of both point-plot and vector displays is that the amount of computer memory necessary to hold the image depends mainly on the image complexity (the number of points or lines actually displayed). Display resolution can be very high, with only a small increase in memory usage. For example, take a simple image containing 100 disjointed lines. A low resolution hobby display using only 8 bits for x and y coordinates would require four bytes for each line or 400 bytes in all. A high-resolution commercial display may use 12 bits for x and y resulting in a 600-byte display list. The first display has about 65,000 (256 x 256) addressable points. The second has nearly 17,000,000 possible points with only a 50% increase in storage requirements. It should be noted that the apparent resolution (sharpness) of a vector display may be high, even if the end point resolution is rather low. This is because the lines drawn are absolutely straight and their width is limited only by the electron beam focus.

An important consideration in point-plot and vector displays is speed. Since the points or lines are plotted one at a time, a complex image may require a significant amount of time to draw. If redrawing of the image is not done fast enough, then it may fade away from the CRT screen between "refreshes" and appear to flicker. Usually the display itself limits drawing speed; but, in a hobby system the computer may be the limiting factor. Use of special phosphors with a long persistance characteristic in the CRT slows image fading and allows a greater number of lines to be drawn without flicker. If the flicker can be tolerated, very complex images can be drawn even on a simple display.



Circle on raster display with line erased.

A new type of dot display that has only recently become practical for computer graphics is the *raster-scan* display. In this type of display the electron beam is constantly scanning through a large matrix of dots in much the same way as a television receiver. In fact, raster-scan displays of interest to hobbyists actually use a television receiver modified for direct video input. To form an image, the computer must turn the beam on when it is scanning the desired dots and turn it off otherwise. The scanning speed in a TV receiver is so fast however that direct program control of the beam is almost never possible. Instead, a portion of the computer memory is read out by the display controller in step with the scanning beam and memory bits control whether or not the beam is turned on. Thus one bit in memory is required for each *possible* point on the display regardless of whether it is turned on or not. Additional bits for each display point may be used for grey scale or even full color.

A major advantage of raster-scan displays is that the display screen may be an ordinary television receiver. The rest of the display controller can be as simple as one or two circuit boards that plug directly into the computer. A vector display requires a fair amount of analog circuitry using op amps and an oscilloscope for the actual display. Although a suitable oscilloscope is already owned by many hobbyists, a large-screen display suitable for group viewing requires a special deflection yoke and high-power deflection amplifiers.

A primary disadvantage of the raster-scan technique is that the amount of memory necessary to hold the image depends on display resolution rather than image complexity. A 128-by-128 point matrix, which is an absolute minimum for graphics, has 16,384 points. At 8 bits per byte, 2K bytes of computer memory will be required to hold an image no matter how simple it is. Merely doubling the resolution to a 256-by-256 matrix quadruples the memory requirements to 8K bytes. Adding grey scale or rough color capability may quadruple the memory requirements again. It is this

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need for large amounts of memory that made raster-scan graphics prohibitively expensive in the past, when memory costs were 10 to 100 times more than they are now.

For some graphics applications such as engineering drawings, even a 256-by-256 resolution will not be enough. Grids of 512-by-512 or even 1024-by-1024 are used for serious graphics work. Although home televisions can theoretically handle 500-by-500 resolutions when modified for direct video input, the 30-Hz flicker of individual dots when viewed at close range may be objectionable. Higher resolutions require the special yokes and deflection amplifiers again.

While a vector display is far superior for line drawings, a raster scan display is best for pictorial material. Amateur slow-scan TV applications, weather-satellite picture reception, and computer art are all best accomplished with a raster-scan display. In particular, the TV Dazzler (POPULAR ELECTRONICS, February 1976) can produce some really spectacular patterns. Either type of display can do a good job on game boards. A graphic display of either type can often replace a TV typewriter since text characters are really just graphic shapes.

Computer Graphics Software. Even the most sophisticated graphics hardware is useless without software to run it. A vector display is normally connected to several parallel output ports on the computer. Data sent to one pair of ports may cause the display to draw a line from where it was last to the new x and y positions specified by the data. The same program action using another pair of ports may just move the beam without drawing. Ordinary output instructions are used to send data to the display generator. A complete image is drawn by outputting data associated with each line until all lines are drawn. The program must continuously execute a loop to keep the image refreshed on the screen.

Image data for a vector display can be generated in three different ways. The simplest is to have the data stored in a display list in memory. A very simple program loop is used to work through the list and send data to the display. With some kinds of simple images it may be possible to compute the data in line. The x coordinate of a waveform display for example would always increase the same amount for each waveform point displayed. This technique can save a lot of space in the display list but does slow down image refresh. In a system with graphic input devices, data can be read from an input and sent directly to the display without storing it in memory. In most graphic applications, a complete image can be drawn using a combination of these techniques.

A raster-scan display can only run from a display list in memory. Also the display controller automatically runs through the list to generate the display. The computer program is only responsible for storing the proper data patterns in the display list. Thus the program is free to do other tasks without having to constantly refresh the display.

The real software job in computer graphics is generating the data to be displayed. One obvious way is to work up the list by hand. This is quite straightforward using graph paper and the computer keyboard. The desired image is first drawn on the graph paper. Then, in the case of a vector display, the coordinates of the line's endpoints are read off and entered into the computer memory. With a raster display, all of the dot positions covered by the image will have to be entered. Although simple, this method hardly makes much use of the computer.

The real value of graphics is realized when the program computes a display list from pertinent data about the image rather than a line-by-line description of it. Consider a routine that would accept an image name (cube, pyramid, etc.), its size, and its position in three-dimensional space. The routine would then generate a display list to show that object in perspective on the two-dimensional screen. Changing a parameter and calling the routine again would generate a new list with the object in the new position. Motion can be programmed by changing the position slightly each time the image is refreshed. The calculations involved are really rather simple for line images and vector lists.

With a raster display, a subroutine is needed to accept line endpoints as input data and set bits in the display list to display the line. If the lines are always horizontal, vertical, or at 45-degree angles, the routine can be quite simple. A more complicated routine is needed if lines at any angle are to be handled.

It is also frequently desirable to edit

images on the display. The operator may want to add lines, delete lines, or move lines. With a vector display list, additions are handled by adding the extra lines to the end of the list. Deletions can be accomplished by replacing the deleted line coordinates with a null line such as a zero distance move. If the list gets too big during editing, a "garbage collection" routine can compress the null lines out of the list. A line change can be easily made right in the list.

Making additions to a raster display list is also easy; just set the bits covered by the added line or object. A deletion might be handled by calling the line generation subroutine with the endpoints of the line to be deleted and have it reset the bits covered by the line, thus erasing it. All lines crossed by the deleted line will have little gaps left over. The same problem occurs when a line is moved since it must first be deleted and then added elsewhere. The only real solution to this problem is to have two display lists. One is a vector list and the other is the raster list that is actually displayed. Editing is done on the vector list. Whenever any change is made to the vector list, the raster list is first cleared. Then it is completely regenerated from the vector list by repeatedly calling the line generation routine. Unfortunately, complete regeneration is slow, which restricts the kind of motion that can be programmed on a raster display.

In conclusion, graphics is one of the most creative applications for a hobby computer. It is simple enough to get gratifying results with only a little effort yet has the potential of keeping the most serious hobbyist occupied for years. Graphic output is readily appreciated by those with no computer experience and at the same time is appreciated by the experts. ◈

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Louisville Area Users of Microprocessors, Steve Roberts, Cybertronics, PO Box 18065, Louisville, KY 40218.
North Carolina
Triad Amateur Computer Society, Greensboro and Winston-Salem (NC) area. Doug Drye, (919) 373-0040.
Triangle Area Computer Club (temporary name), Raleigh, Durham, and Chapel Hill (NC) area. Russell Lyday, (919) 787-4137.

Inside Basic Electronics

FIXED AND VARIABLE RESISTORS

THE FUNDAMENTAL ground rules of electronics are simple enough: electronics deals with the flow of electrons, called *current*. *Voltage* is the pressure that causes electrons to flow, while *resistance* impedes the flow.

Though all material possesses resistance, resistors in electrical and electronic applications are designed to introduce some desirable amount of resistance to current flow, perhaps to obtain a specific voltage drop. In contrast, insulators may have a resistance as high as 10^{14} ohms, virtually stopping all current flow.

Resistors are considered to be passive devices. That is, they do not generate energy, but merely convert applied electrical energy into heat. Nor are resistors intended to be influenced by frequency, though resistance can change at high frequencies (say, much over 100,000 hertz).

Resistors are specified by three factors: resistance value (ohms), tolerance (a percentage) and power or heat dissipation (watts).

Resistance Value & Tolerance. The small size of fixed carbon and deposited-metal resistors makes it prohibitive to have resistance and tolerance information printed on their cylindrical bodies. As a result, the use of circumferential color-coded bands was adopted to indicate ohmic value and tolerance at a glance.

Ten colors are used in the code to signify 0 through 9 for each of the first three bands. The third band is a multiplier (the number of zeros to be added). A fourth band can be missing, silver or gold. If missing, the resistor has a 20% tolerance; if silver or gold, the tolerance is 10% or 5%, respectively. Thus, a resistor with bands of brown, black, yellow, and silver has a value of 1 (brown), 0 (black), 0000 (yellow) and a 10% (silver) tolerance. That is, it is a 100,000-ohm ±10% resistor. A 1000-ohm resistor with a 10% tolerance will actually have a resistance somewhere between 900 and 1100 ohms.

Power. Power, in watts, tells us how much heat a resistor can safely dissipate with unrestricted air circulation over normal temperature variations specified by the manufacturer. Exceeding this will either destroy the component or cause it to permanently change value, even when cooled.

To operate a resistor safely when the temperature exceeds its norm, the power rating should be *derated*. For example, if a 2-watt carbon composition resistor is operated at 120°C when the maximum should be 80°C, the power rating should be reduced by 40% to 0.8 watt. In practice, it's a good idea to operate a resistor at less than half its rated power. Also, the resistor should have at least one diameter of space between it and another heat-dissipating component when mounted.

Fixed Resistors. There are many types of resistors manufactured with values that cannot be varied:

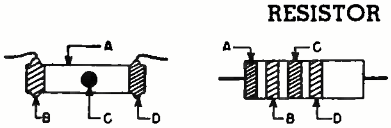
Carbon Composition. Electronics hobbyists are most familiar with this type, made of carbon and a binder, formed into a short rod and having wire connection leads (pigtails) on the ends. They're inexpensive (about 13 cents each for ½-watt units), widely available, highly reliable and unaffected by frequencies below vhf.

Standard types are available in resistance ranges of 1 ohm to 22 megohms; tolerances of 5%, 10% and 20%, maximum power ratings of ⅛ watt, ¼ watt, ½ watt, 1 watt and 2 watts. They rapidly increase in resistance at temperatures much above 60°C; but they have a low temperature coefficient (TC) within a normal operating temperature range. The TC is usually +0.1% which means that a 1000-ohm resistor at 20°C will increase to 1050 ohms at 70°C.

Resistance changes from an effective dc value when operating much above 100 kHz due to a variety of reasons, including the shunt capacitance of the resistor's short body. Noise is a consideration, also, in applications such as hi-fi and communications. A carbon-core resistor, for example, generates electronic noise that can reduce the readability of a signal or even mask it completely.

Wirewound Resistors are used where carbon composition types are not suitable—in high-power close-tolerance and high-stability applications, for example. They are made by wrapping a length of resistive wire around a ceramic core, which is then dipped in enamel to isolate the wire from the outside world. Precision wirewound resistors that are commonly available to hobbyists have 1% tolerances, values from 1 ohm to 300 kilohms, and power ratings from 1 to

RESISTOR COLOR CODE



(A) (B)

RETMA COLOR CODE CHART

COLOR	VALUE	MULTIPLIER
Black	0	1
Brown	1	10
Red	2	100
Orange	3	1000
Yellow	4	10,000
Green	5	100,000
Blue	6	1,000,000
Violet	7	10,000,000
Grey	8	100,000,000
White	9	1,000,000,000

TOLERANCE CODE

Gold—±5% Silver—±10%
No Color—±20%

The ohmic value of a resistor can be determined by means of the color code. There are two standard methods of indicating this value.

In Fig. A, the body (A) and end (B) indicate the first and second digits of the value while the dot (C) indicates the multiplier to be used. The tolerance of the unit is indicated by the end color (D). For example, if the body (A) is green the number is 5; if the end (B) is grey the second number is 8. If the dot (C) is red the multiplier is 100 or two zeros should be added. The resistor is then a 5800 ohm unit. If the end (D) has no color, the tolerance is ±20%.

In Fig. B, the first two stripes indicate the first two digits; the third stripe the multiplier; the fourth stripe the tolerance. Thus, if stripe (A) is green, (B) is grey, (C) is red, and (D) is silver, the resistor is a 5800 ohm, ±10% unit.

50 watts. Typical costs vary from $0.85 to $5.60 in single-lot quantities. Power wirewounds can handle from 3 to 225 watts (depending on construction), and range from 0.5 to 100 kilohms with 5% tolerances. They cost between $0.70 and $4.00 in single-lot quantities.

Wirewound resistors hardly contribute any noise to circuits, but they are not used at frequencies above the audio range because their characteristics change with frequency.

In applications where wirewound characteristics (stability, precision, reliability, and low noise) are required *as well as* good high-frequency performance, film resistors are often used. These are made by depositing carbon or metal films on a ceramic substrate. The thickness of the film (proportional to the amount of material deposited and the deposition time) determines the resistance. There are two categories of film resistors, thick (the resistive film is greater than one-millionth of an inch thick) and thin (the film is less than 10^{-6} inches thick).

Thin carbon-film resistors range from 10 ohms to 10 megohms, in quarter- and half-watt ratings and 1% tolerance. They usually are priced from $0.95 to $2.20 individually. Thin-metal film models range from 10 ohms to 1.5 megohms, with tolerances of 0.1 to 1%, and power ratings of ½ and 1 watt. Some can be bought singly at $0.95 to $1.40, but others (notably close-tolerance and high-resistance models) are available only in lots of 10 or more at $1.35 to $2.50 each.

Thick-film resistors offer many of the advantages of thin-film components, but are lower in cost (in many cases competitive with carbon composition types), are more durable, and can handle higher power levels. Besides thick-film carbon resistors, there are a number of metal types that fall into this class. Among them are metal oxide, metal glaze, cermet and bulk property types. Metal-oxide and metal-glaze resistors come in power and semi-precision varieties. Semi-precision types have tolerances of 2 and 5%, can dissipate between ¼ and 2 watts, with resistance values of 10 ohms to 1.5 megohms. Power models have 5 and 10% tolerances, power ratings of 2 to 115 watts, with resistance values of 10 ohms to 4.2 megohms.

Cermet types are rated to 10 watts, with 1% tolerance and resistances of 10 ohms to 10 megohms. Bulk property resistors vary from 30 ohms to 100 kilohms, with tolerances of 0.1 to 1% and power ratings of 0.3 to 0.75 watts. In general, thick-film resistors can be substituted for carbon-composition types without paying a premium price — their cost is fairly close (and in some cases competitive) to that of carbon compositions. Thick-film components can replace thin-film resistors (their noise contribution is small and high-frequency performance is good) at a substantial savings.

Variable Resistors. It is often desirable to have a resistor that can change its resistance over a specified range. For example, the volume control of a radio is a variable resistor which allows a given amount of signal to reach the speaker. Variable resistors can respond to many phenomena—some change resistance when a control shaft is rotated, others are affected by heat, light, or the voltage impressed across them.

Potentiometers are carbon composition, wirewound, or metal-film resistors formed in a linear or circular configuration. In circular potentiometers, a "wiper" contacts the resistive element. By turning the control shaft (mechanically linked to the wiper), a given amount of resistance is set between it and each of the two resistive terminals (see Fig. 1). As the shaft is turned clockwise, R_A increases while R_B decreases. If the wiper is connected to one resistive terminal, the

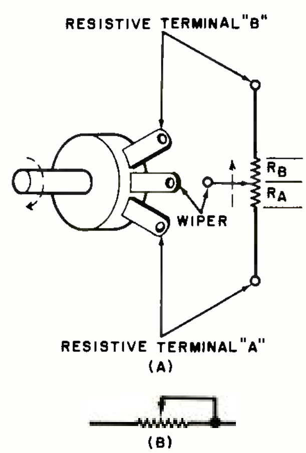


Fig. 1. Potentiometer operation.

potentiometer (or "pot") becomes a two-terminal variable resistor. Pots are specified by a resistance value, power rating, and tolerance. The resistance figure denotes the total resistance between terminals A and B (R_A + R_B). The power and tolerance ratings are analogous to those of a fixed resistor.

The control shaft typically rotates a total of 330°, and is made for either knob or screwdriver adjustment. Some pots have a power switch which is turned on in the first 20° of rotation, and some are ganged — with as many as four separate units controlled by the same shaft. Another variable in circular pots is the taper, which can be linear or logarithmic. That is, the way the values R_A and R_B vary with the amount of angular rotation. In linear pots, R_A and R_B vary directly with the rotation angle. If the shaft of a 10-kilohm, linear-taper pot is rotated 165° (out of a possible 330°), both R_A and R_B equal 5 kilohms. Other angular rotations will give proportional values of the two resistances. Log-taper pots, on the other hand, will give a logarithmic increase in R_A rather than a linear one. These are chiefly used in audio circuits, as volume and tone controls, because of the ear's logarithmic response.

Circular general-purpose pots are available with resistance of 500 ohms to 2 Megohms, with tolerances of 10 or 20%. Power dissipation runs up to 3 watts. They are generally used as panel-mounted controls, but some miniature models are made for printed circuit board installation. Cost ranges from $0.50 to $2.50 each. Precision circular models are available, in either one- or ten-turn configurations. They range from 100 ohms to 400 kilohms, with tolerances of 5, 3, or 1%, and power dissipations up to 5 watts.

Pots are available in two other configurations—rectangular and sliding-contact wirewound. Rectangular trimmer pots are ideal for pc board applications. They consist of a screw-driven sliding contact (wiper) which moves along a resistive winding. The three terminals are in the form of small pins (the middle one is the wiper). Most rectangular trimmers are wire-wound types, but metal-film units are also made. Common rectangular trimmers have 10 or 5% tolerances, half- or one-watt power ratings, and maximum resistance ratings of 10 ohms to 5 megohms. Since rectangular pots are ten-turn units, resistances can be set with great accuracy. Their prices vary from $1.75 to $6.00 each.

Sliding-contact wirewound pots look like a common wirewound resistor with two important differences. First, a portion of the enamel coating is missing, allowing access to a band of the resistive wire. Also, an adjustable-tension ring is slipped over the body of the resistor, which can tap the resistive element at any point. Once the desired resistance is obtained, a tension screw or knob on the ring is tightened, holding the tap at that point. These variable resistors are used in high-wattage applications, such as power supplies. They are available with maximum resistances of 1 to 100,000 ohms, with power ratings of 12 to 100 watts, and a tolerance of 10%. They typically cost from $1.30 to $2.50 each.

Other Variable Resistors. The thermal- and light-sensitive properties of certain elements are employed to produce heat- or light-variable resistors.

Thermistors (thermal-sensitive resistors), which are used to protect power transistors in audio amplifiers, and as temperature transducers, may decrease or increase their resistance as temperature rises. Their coefficient of resistance (if negative, resistance goes down as temperature increases; if positive, resistance increases with temperature) specifies how resistance will change for a one-degree Celsius change in temperature. They are also rated in catalogs by their resistance at 25°C, and by giving the ratio of resistances at 0°C and 50°C. Values vary from 2.5 ohms to 1 megohm (room temperature), with power ratings from 0.1 to 1 watt.

Photocells (light-sensitive) resistors) are used in electric-eye circuits, streetlight control, and similar applications. They are rated by specifying their resistance at low and high light levels. These typically vary from 600 ohms to 110 kilohms (bright), and from 100 kilohms to 200 megohms (dark). Power dissipation lies between 0.005 and 0.75 watts.

Pressure-sensitive resistors are also used by hobbyists. The two most common examples are strain gauges and carbon microphones. As the resistive element is physically deformed, its resistance varies. If a constant voltage is impressed across a carbon microphone element, a variable current, which is an electrical analog of the voice, will be generated. Most have resistances of 500 ohms or so in the absence of compression.

A final variety of variable resistors you are likely to encounter is the voltage-sensitive resistor (Varistor). It is chiefly used to protect equipment from power-line surges by limiting the peak voltage across its terminals to a certain value. Above this voltage, the resistance drops, which in turn makes the voltage decrease. Catalogs specify voltage-variable resistors by power dissipation (0.25 to 1.5 watts) and peak voltage (30 to 300 volts). Varistors typically cost $2.00 to $6.00 each.

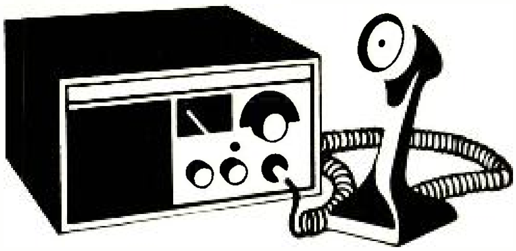
Resistors and Ohm's Law. How are voltage, current and resistance related? A simple expression links these three parameters, and is called *Ohm's Law*. This states that the voltage across a resistor is proportional to the current flowing through it and its resistance. Mathematically expressed, it appears as $E = IR$, where E is measured in volts, I in amperes, and R in ohms. It can be manipulated to appear as $I = E/R$ and $R = E/I$. For example, if we know that 2 amps is flowing through a ten-ohm resistor, what is the voltage across it? By Ohm's Law, $E = 2 \times 10$ or 20 volts.

The power dissipated by a resistor as heat is easily found by using the formula $P = EI$, which can also be expressed (by virtue of Ohm's Law) as $P = I^2R$ or $P = E^2/R$. Referring to our example, how much power is dissipated (in watts) by the ten-ohm resistor? Well, $P = EI$ (20 x 2 or 40 watts), but $P = E^2/R$ (400/10) and $P = I^2R$ (4 x 10) will give us the same results for power calculations.

Resistors and Heat. Resistors can be affected by many agents, especially heat and moisture. The moisture problem (resistance can decrease if the resistive element is moistened) can usually be corrected by drying out the resistor in a warm, nonhumid environment. Resistance changes caused by heat, whether it is generated by the resistor itself or by a soldering iron, are usually permanent. If it is heavily overloaded, the resistor might actually burn up.

Two precautions should therefore be observed. Always use a resistor which can handle twice the amount of power that it will generate. The power formulas $P = EI$, $P = E^2/R$, and $P = I^2R$ will determine this value. Also, use as little heat as possible during soldering. Leave "pigtails" of at least ¼-inch between the resistor body and the circuit tie point.

The power dissipation ratings given to resistors assume the component will have an unrestricted air flow around it, and that its operating temperature will be close to a median figure for safe operation. ◈



CB Scene

By Ray Newhall, KWI6010

A CB PRIMER

CITIZEN'S BAND radios are the hottest items in the electronics marketplace these days. The rig manufacturers are forecasting a banner sales year; some say that well over five million sets will be sold before the end of 1976. Millions of citizens will be introduced to the CB scene for the first time.

Almost every day I am asked questions such as: "Which rig is the best?", "How many channels do I need?" and "Is it difficult to get a CB license?" This column will attempt to answer these and other questions you might ask before getting "on-the-air" for the first time.

Selection of a Rig. I wouldn't attempt to recommend a particular rig. There are several hundred very fine rigs among the brands and models available this year. If you are looking for a new CB rig and don't know what to buy, take your time, review the test reports and specifications in the Popular Electronics, CB Handbook, 1976, which will be on your newsstand soon, and evaluate as many new models as possible.

There are a few common-sense guidelines to keep in mind when selecting a rig:

- Buy a new rig, rather than a used one. There are several reasons for this. There have been tremendous technical advances during the past two years, and since mid-1974 all CB rigs have been required to meet minimum performance specifications to qualify for "type acceptance". Type acceptance is now mandatory for all new rigs being sold. While older transceivers without type acceptance can still be operated legally, they must be off the air by November 23, 1978.
- You will probably want to buy a 23-channel rig even though you do not currently plan on using more than one channel. If you are thinking of buying a smaller, five- or six-channel transceiver, you should at least have channels 9 and 11, since they are officially designated as the emergency and calling channels respectively. In a mobile unit you will want to have channel 19, the frequency most generally used between vehicles on the highway. Channel 13 is a popular channel for marine use, but keep in mind that channel usage varies considerably from one locality to the next.
- The maximum allowable power that a CB rig may supply to its antenna terminal is 4 watts. Be certain that your new rig is rated at maximum power. It is only flea-power to begin with and you'll need every bit of it to make yourself heard over the noise of other distant CB'ers on the band. Keep in mind, however, that 3.5 W is, for all practical purposes, the same signal level as 4 W.
- When you buy your new rig be certain to get a signed and dated sales slip. Record the serial number on the sales slip and put the slip in a safe place. If you should later need warranty service or if your rig is ever stolen you will need that sales slip and the serial number.

Making It Legal. It is a violation of Federal law to operate a radio transmitter (other than one type-accepted for use under Part 15) unless you are legally authorized to operate it. The penalties for illegal operation can amount to fines of several thousand dollars and a jail sentence. A CB license does not require any test or other qualifications other than that the applicant be a citizen of the US and 18 years or older. The application must be filed on FCC Form 505 (usually packed with your new set), signed and mailed along with a filing fee of $4.00 to the Federal Communication Commission, Gettysburg, PA, 17326. Your license, when issued, will be valid for a period of five years.

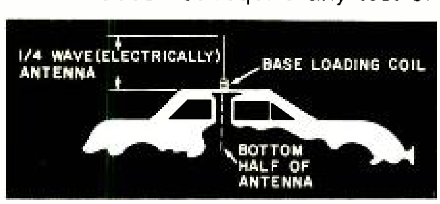


Fig. 1. Car provides half of half-wave antenna with ¼ on top.

Because of the tremendous growth in popularity of CB Radio, the FCC has been receiving a half a million or more applications each month; they are swamped! It has sometimes taken up to eight weeks for applications to be processed. (Don't write them to inquire, that will slow it down even more.) Do not operate your transmitter until your license form and call sign have been returned to you. There has been a rumor circulating for several months that the FCC has authorized a six-month period of grace, during which time you may operate by using the last four digits of your Social Security Number as a Call Sign. This rumor is false.

However, the FCC has recently announced a new system of temporary authorization using Form 555-B. Details and a copy of the form are on pages 98 and 99.

Installing Your New Rig. The April issue of Popular Electronics includes an article describing the installation of a mobile unit, and another article on the installation of base antennas. I will not repeat that information here, but I would like to comment upon the selection and installation of mobile antennas, since about 80% of the new installations will be mobile.

There is a great deal of misinformation regarding antennas and their installation passed among CB'ers and the CB Clubs. The best advice I can give you is to buy a good-quality commercial CB mobile antenna and follow the manufacturer's installation instructions carefully. There is more to the installation of a high-performance mobile antenna than you might guess. An inefficient antenna installation can rob you of 50% or more of what little power you have available from your CB transmitter. Selection of a proper location for your mobile antenna requires a little basic knowledge and some planning.

Most mobile antennas are known technically as "¼-wave whips", and they require mounting on a metal sur-

(Continued on page 100)

United States of America
Federal Communications Commission

FCC FORM 555–B
April 1976

Temporary Permit

Class D Citizens Radio Station

1 Instructions

- Use this form only if you want a temporary permit while your regular application, FCC Form 505, is being processed by the FCC.
- Do not use this form if you already have a Class D license.
- Do not use this form when renewing your Class D license.

2 Certification

Read, Fill In Blanks, and Sign

I Hereby Certify:

☐ I am at least 18 years of age.

☐ I am not a representative of a foreign government.

☐ I have applied for a Class D Citizens Radio Station License by mailing a completed Form 505 and $4.00 filing fee to the Federal Communications Commission, Box 1010, Gettysburg, PA. 17325.

☐ I have not been denied a license or had my license revoked by the FCC.

☐ I am not the subject of any other legal action concerning the operation of a radio station.

Name ______________________ Signature ______________________

Address ______________________

Date Form 505 mailed to FCC ______________________

If you cannot certify to the above, you are not eligible for a temporary permit.
Willful false statements void this permit and are punishable by fine and/or imprisonment.

3 Temporary Call Sign

- **Complete the blocks as indicated.**

Use this temporary call sign until given a call sign by the Federal Communications Commission.

K ☐ ☐ ☐☐☐☐☐

Initial of Applicant's First Name — Initial of Applicant's Last Name — Applicant's Zip Code

4 Limitations

Your authority under this permit is subject to all applicable laws, treaties and regulations and is subject to the right of use or control by the Government of the United States.
This permit is valid for 60 days from the date the Form 505 is mailed to the FCC.

You must have a temporary permit or a license from the FCC to operate your Citizens Band radio transmitter.

Do Not Mail this form, it is your Temporary Permit.

See the reverse side of this form for a summary of operating instructions.

HOW TO USE TEMPORARY PERMIT FORM 555-B

Just recently, in response to complaints about long delays, the FCC announced a system of temporary licensing which allows an owner to use his CB transceiver before the regular station license is issued. The Temporary Permit, Form 555-B, will be valid for 60 days, and is to be filled out and kept by the *user* at the same time that he submits his Form 505 license application. The new form is simple and straightforward to use.

A temporary call sign is determined by the new CB'ers initials and zip code. As with all CB licenses, the first letter of the three-letter prefix is *K*. So, if John Jones of New York, N.Y. 10016, is working with Form 555-B, his temporary call sign is *KJJ 10016*. The Temporary Permit should *not* be mailed, but retained by the CB'er during the interim operating period.

In announcing this new system, the FCC stresses that the number of available forms is severely limited, but photostatic copies can be used. For this reason, we are reproducing a copy of the new Form. If you are applying for a CB license for the first time, simply photocopy both sides of Form 555-B and fill it out. This should be done at the time you mail your Form 505 license application. Retain the photocopy—it will give you temporary authorization to operate your transceiver, and is valid for 60 days from the time you mail Form 505.

FEDERAL COMMUNICATIONS COMMISSION · USA ·

Welcome to the Citizens Radio Service

Citizens Band Radio is a shared communications service with many people using the same frequencies and channels.

The guidelines provided in this form are not intended as a substitute for FCC Rules, but as a general reference to those operating practices and procedures which will benefit you and other users of Citizens Radio.

Your compliance with these guidelines and your consideration for the rights of others in your radio service is necessary if the full potential and enjoyment of Citizens Radio is to be realized.

Using Your Citizens Radio Station

(See Part 95 of FCC Rules & Regulations for complete instructions on authorized station use.)

1 **Who May Operate Your Citizens Radio Station?**

You, members of your immediate family living with you, and your employees,while on the job.

2 **How Many Transmitters Does this Permit Authorize?**

A maximum of five (5).

3 **Can the FCC Inspect My Station?**

Your station and station records must be available for inspection by an authorized agent of the FCC.

4 **Where Should I Keep This Permit?**

Keep it in a safe place. Post photocopies at all fixed station locations. Indicate on photocopies the location of this permit. Attach a card with your name, address and temporary call sign to each transmitter .

5 **How Shall I Identify My Station?**

Identify transmissions in English with your temporary call sign.

6 **How Can I Use My Station?**

Use it for private short-distance radio-communications for your personal or business activities. Channel 9 is reserved solely for emergency communications and to assist motorists.

Prohibited Communications Include:

- Activities contrary to law
- Transmitting obscene, indecent or profane messages
- Communicating with non-Class D stations
- Intentional interference to other radio stations
- Transmitting for amusement, entertainment, or over a public address system
- Transmitting false distress messages
- Advertising, selling, or for hire

7 **How High Can My Fixed Station Antenna Be?**

See Section 95.37 if your antenna will be over 20 feet above ground. Additional information is available in SS Bulletin 1001-h.

8 **May Amplifiers Be Used With My Transmitter?**

'Linear' amplifiers are absolutely prohibited. 'Power' microphones may require adjustments to your transmitter

9 **Who Can Make Adjustments to My Transmitters?**

Adjustments affecting proper operation may be made only by, or under the supervision of a licensed first or second-class radio operator.

face to function properly. These antennas will not work properly when mounted on wood or fiberglass, as on a boat or a camper. There are special "½-wave whips" available for those applications. As I drive along the highway, I notice many antennas which have not been planned for maximum effectiveness, probably because the owner was not aware of the simple rules to follow in installing the antenna.

All ¼-wave mobile antennas used for CB are "electrically" dimensioned to about 108 inches in length, or one quarter of the 11-meter wavelength at 27 MHz. Since the 108-inch length (nine feet) is a bit inconvenient to be used on most vehicles, many people have shortened them by use of a coil, or "load". A loaded antenna is not as efficient as a full-length whip, but its smaller size makes it possible to mount it in a more effective location which makes up for the power loss by providing a better "ground plane".

The ground plane acts like a mirror which reflects the antenna, so that it looks like a half-wave dipole to the transmitted signal (Fig. 1). Like any mirror, an irregular surface breaks up that image. If the ground-plane is only partially complete or if it is not at right angles to the main axis of the antenna, the radiation pattern will be distorted and the antenna will not load properly. The antenna will assume directional properties and its overall efficiency will be degraded.

It should be obvious that the "best" location for a mobile antenna would be dead center on the horizontal roof of the vehicle (directly over the dome light where we can gain access through the headliner). But most of us do not like to punch holes through the roof of our $5,000.00 automobile, so we often use trunk lid mounts instead. When mounted on the centerline of the vehicle, these are nearly as efficient as a roof-mount. Some CB'ers use gutter or cowl mounts, but these are not quite as effective because they disturb the symmetry of the radiation pattern. A bumper mount is usually the least desirable, even though it may permit the use of a full 108-inch whip.

Antenna Tuning. Antenna efficiency is normally measured by determination of its "Standing Wave Ratio". An SWR meter is used for this purpose. The SWR is measured by comparing the power passed through the transmission line in the forward direction (from the transmitter toward the antenna) with the power reflected back to the transmitter. A properly matched and loaded antenna will show an SWR close to 1:1, but because it is not possible to achieve 100% efficiency, the reading will be somewhat higher than that. If the antenna can be tuned to an SWR of less than 1.5:1 it will be pretty well matched and the antenna system will function at better than 95% efficiency.

However, if the SWR is 3:1 or more it is badly matched and may, indeed, damage the transmitter. There is probably either a bad connection in the transmission line or the ground-plane is not loading the antenna properly.

Most mobile antennas have provision to make fine adjustments in length. When tuning it to a higher frequency, the antenna must be shortened; and when tuning it lower, it is lengthened. The direction of tuning can be determined by comparing the SWR at the high-frequency end of the band with the SWR at the low end of the band. The length of the antenna should be adjusted until the lowest SWR is obtained at center frequency of the band, or channel 11 for Class "D" CB. With a loaded "shorty" antenna, the antenna length adjustment can be critical to an eighth of an inch or less.

In making these measurements, the SWR meter is placed in the transmission line, usually at the transmitter antenna terminal. The meter is first calibrated by adjusting it for full-scale deflection in the forward direction. Then, without disturbing the adjustment, the meter is switched to the reflected mode, and a reading is taken directly from the SWR scale. An adequate SWR meter can be purchased for $15.00 to $25.00, but you might try borrowing one from your CB dealer. At any rate, you should tune the antenna at the time it is installed, and again every six months or so, to insure that it remains in good shape.

There are many "old-wives-tales" about ways to tune a CB antenna. Many CB'ers insist that you can tune the antenna by cutting the transmission line to a proper length; it is true that you can apparently lower the SWR in this manner, but the real mismatch has not actually been affected. No more power will be transmitted to the antenna than before. The antenna is the radiator, and it is the antenna which must be tuned.

The transmission line which connects the rig to the antenna should be kept as short as possible, and it should be "clean", with as few connectors as possible. Many mobile antennas are designed to work with a specific length of line, so be sure to consult the manufacturer's instructions. Fifty-ohm shielded cable is used almost universally in CB hook-ups. The small RG-58/U is adequate for distances up to 30 or so feet; but for longer distances, the large RG-8/U or equivalent should be installed. Always use the proper PL-259 and SO-239 connectors to join the cable. Don't try to splice transmission cable with solder and tape; you may disturb the impedance match and introduce losses.

Now Enjoy It. If you have followed the relatively simple advice above, by this time you should have a rig which will "get-out" as well as any other legal rig in your area. However, do not use it until you know how to do so properly. Part 95 of the FCC Rules and Regulations regarding CB operation is no longer available on a subscription basis. Instead send $1.50 to the Superintendent of Documents, Government Printing Office, Washington DC 20402, requesting Document No. 004-0000-00324-1. This is a separate volume containing only Part 95 and was released May 5, 1976.

The FCC Rules and Regulations have been relaxed considerably within the past few months (see CB Scene, February 1976), so that they are now easier to understand and follow. The main points to remember are . . .

- You *must* identify using your call letters at the beginning and the end of each exchange of communications, whether or not you want to use a nickname or "handle."
- If you use Channel 11 as a calling frequency you must switch to another frequency as soon as you have established contact.
- You must not use Channel 9 for any purpose other than assisting a mobile station (directions, etc.) or emergency messages.
- If you are communicating with another *station*, as opposed to other units of your own station, you must observe the "five minutes on, one minute off" rule.

Above all, be *courteous*, and remember that now more than one out of every thirty Americans uses CB. It could be one heck of a mess if we all tried to talk at the same time! ◈

Operation Assist

If you need information on outdated or rare equipment—a schematic, parts list, etc —another reader might be able to assist. Simply send a postcard to Operation Assist, Popular Electronics, 1 Park Ave., New York NY 10016. For those who can help readers, please respond directly to them. They'll appreciate it. (Only those items regarding equipment not available from normal sources are published.)

DeForest type F-5 radio. Need schematic, power requirements, and operating instructions. William Anliker, Box 35, Bagdad, AZ 86321.

U.S. Navy Model RGB-2, CHC-46140 receiver. Built by Hammarlund, covers 0.54-30 MHz. Jim Brooks, 116 South Center St., Bardstown, KY 40004.

Aiwa Model TP-1012 open-reel tape recorder, serial 153107. Schematic, manual, or any information. Randal W. Davis, 2015 Chestnut, Fort Worth, TX 76106.

Gonset Model 3311 FM automotive converter. Schematic and alignment instructions. David J. Bopp, Box 119, Oceanport, NJ 07757.

Meissner Traffic Master. Dial, tuner unit, or any coils wanted, or source for same. L. Marks, 14 Avenue Rd., Kingston, Surrey, England.

Ampex Model FR-100A, 14-channel tape recorder or 15,000 series tape deck. Documentation and schematics. Carol Ascolillo, Park Lane, North Windham, ME 04062.

Hammarlund HQ-129-X receiver, **Heath** AT-1. Schematics. Information on whereabouts of DX100, property of W3ZHV. Mon. Valley ARC. XW8CRO/5, 608 E. Farmers Rd., Seagoville, TX 75159.

U.S. Govt. receivers, types AN-GRR5 and R-392 (Collins). Radio amateur or technician wanted for alignment. NE PA area. James B. Fromel, 62½ Cist St., Buttonwood, Wilkes-Barre, PA 18702.

Harman-Kardon Model CA-100 "Commander" PA amplifier. Source or specifications for mike input transformers. XE-4 level equalizer, XT-4 line match transformer, and CPE-3 phone/tape preamp. Phil Anzel, Box 3952, University Station, Laramie, WY 82071.

ARP Axxe synthesizer. Schematic, parts list, pc artwork. Scott Bell, 7752 Montgomery Rd., Apt. 29, Cincinnati, OH 45236.

Realistic Model TRC-X23 CB transceiver. Schematic, photofact listing, any available information, or a working or nonworking set for cross reference. Tom M. King, 169 Lakeside Dr., Guilford, CT 06437.

Sears Model 5248 tape recorder, chassis 38152480. Instruction book, parts list. Yagista 2-volt storage batteries (sealed type). Source or importer address. Roy O. Kroeger, 3335 Eastern Ave., Davenport, IA 52807.

Squires & Sanders Model SS-310 CCTV camera. Schematic and service information. Allen Rees, Box 1271, Norman, OK 73069.

U.S. Navy oscilloscope TS-34/AP, NOA-s-1562, 1530 CW, O and R Ax 232. Any available information. Jonathan Huber, 520 Lincoln St., Boonton, NJ 07005.

Clough-Brengle Model OCA r-f signal generator serial 2601. Need schematic and manual. R.P. Hurlbut, 250 Verobeach Blvd., Weston, Ont. Canada M9M 1R6.

Candle Model MT510A black-and-white 4-inch TV. Service manual and schematic. Al's Radio and TV, 9 Leonard Rd., Hyannis, MA 02601.

Dictograph Model HFMT-M-100 music system. Need schematic and parts list for the Williamson-type amplifier circuit serial 16966/106 or similar. Unit uses Collaro RC 456 changer. Ben Layton, 6344 Laura Ave., St. Louis, MO 63136.

Atwater Kent Model 20, **Tri-City Radio Electric Supply Co.** Model W-41 one-tube regenerative receiver. Any restoration information available. Sam Canup, 902 S. Goliad, Rockwall, TX 75087.

Research Associates, Inc. Model TR-32-12 transistorized power supply, 6-32 V dc at 12 amps max. Operating/assembly manual or schematic. James DeMarr, 108 Laurel Ave., Gwinhurst, Wilmington, DE 19809.

Aetna Radio transceiver serial CX 367414. Contains 1A7, 1N5, 1H5, 1T5, and one unknown tube. Tim Childs, 3606 Tecumseh River Rd., Lansing, MI 48906.

Electronics Library

COMPUTER PROGRAMMING HANDBOOK

by Peter A. Stark

This is a handy guide to computer programming and data processing written for the beginner with no special background in the field, including higher math. The 25 chapters are divided into five sections: General, Machine Language Programming, Symbolic Programming, Programming and Mathematical Techniques, and Problem-Oriented Languages. Although the format is that of a classroom text, there is no reason someone studying on his own can't benefit from the information presented. The author has provided examples of the various processes he discusses so that, even without access to a computer, the reader can pick up a lot of the tricks of the trade which will make his actual confrontation with a keyboard easier.

Published by Tab Books, Blue Ridge Summit, PA 17214. 503 pages. $8.95 soft bound.

THE RADIO AMATEUR'S HANDBOOK FIFTY-THIRD EDITION

Fundamental theory and practices as well as the latest technical developments in radio communications are covered in this standard reference work. Transmitters, receivers, oscillators, power supplies, antennas, transmission lines and active devices are discussed. Communications modes such as CW, AM, SSB, and FM (with a special section on repeaters) are examined in depth. Tested circuit designs complement theory. Revised sections include receiving equipment, television interference reduction, test instruments, power supplies, speech processing, and station assembly. Among the new construction projects are a regulated power supply, a 2-kilowatt, 2-meter amplifier, a communications receiver with digital readout, a calibrated field strength meter, a two-band solid-state transmitter, and a coupler for balanced lines.

Published by the American Radio Relay League, Inc., Newington, CT 06111. 704 pages. $10.00 hardbound, $6.00 soft cover (US and Possessions).

ELECTRONIC PROJECTS FOR MUSICIANS

by Craig Anderton

A number of the author's electronic music projects have appeared in these pages. Here he gets it all together in a series of "how-to" chapters, nineteen easy-to-build circuits, troubleshooting hints, and sources of additional information. The text is illustrated with sketches of everything from electrolytics to needlenose pliers so a musician with no electronics background can build accessories for his instrument. A six-minute demo record of electronic effects is bound into the book so that the musician-builder can compare how his project should sound with how it does sound.

Published by Guitar Player Productions, P.O. Box 615, Saratoga, CA 95070. 132 pages. $6.95 soft cover.

OPERATIONAL AMPLIFIERS: THEORY AND SERVICING

by Edward Bannon

State of the art coverage of operational amplifiers is presented, with emphasis on practical circuit analysis, design, and application. Op amp theory and troubleshooting techniques are explained so that those with a marginal technical background will understand the subject matter. Practical instrumentation application are given with analysis of each circuit. Among the specialized applications covered are function generators, inductor simulation, automobile speed control, fuel injection, and non-skid circuits.

Published by Reston Publishing Co., Box 547, Reston, VA 22090, 195 pages. $13.95 hard cover.

Experimenter's Corner

By Forrest M. Mims

THE AVALANCHE TRANSISTOR

THIS month we're going to take a close look at a rarely used phenomenon, the transistor operating in the avalanche mode. You can build an avalanche transistor demonstration circuit for under a dollar (less power supply)—for a lot less than that if you use junkbox components you probably have on hand.

Normally a bipolar (pnp or npn) transistor is made to conduct between its collector and emitter leads by placing a small signal on its base. This is how virtually all bipolar transistor amplifiers, oscillators, and switching circuits are made to operate.

Collector-emitter conduction can also be achieved automatically and *without* an input signal by simply placing a voltage which exceeds the collector-emitter breakdown voltage (BV_{CEX}) across the collector and emitter leads. This causes a spontaneous avalanche of carriers and the transistor conducts until the current flow through it drops below what is called the holding current (I_h).

A few rather specialized and hard-to-find transistors such as the 2N3034 and 2N3507 are especially suited for avalanche operation, but many readily available and low-cost switching transistors can also be used in an avalanche mode. I have had excellent results with such common types as the 2N914, 2N2222, 2N3643, 2N3904, 2N4400, 2N5188, HEP50, and many others.

There are lots of applications for avalanche transistors including oscillators, waveform generators, pulsers, and high speed switches. We'll examine an oscillator circuit later, but first let's consider the basic avalanche transistor circuit shown in Fig. 1.

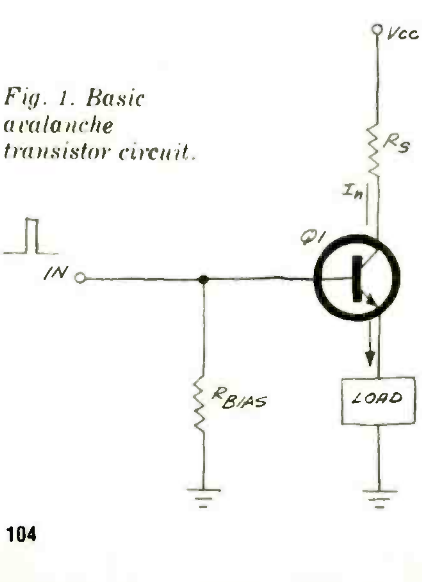


Fig. 1. Basic avalanche transistor circuit.

Supply voltage V_{cc} is set to 10 or 15 volts below *Q1*'s BV_{CEX}. When a small input signal is applied to *Q1*'s base, the resultant base-emitter current stimulates the onset of avalanche and the resistance between *Q1*'s collector and emitter terminals drops to a few ohms or so within a couple of nanoseconds. Then *Q1* will remain in the avalanche mode so long as the forward current through it exceeds I_h.

You can actually build the circuit in Fig. 1, but you'll need a pulse generator to operate it. Figure 2 shows a slightly modified version of the circuit that is easier to operate since it repetitively avalanches on its own. The modification simply consists of hanging a capacitor between the collector of *Q1* and ground and the result is a simple but effective relaxation oscillator. Here's how it works.

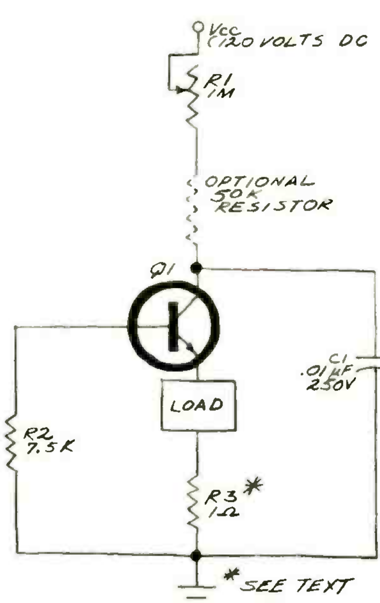


Fig. 2. Easily assembled relaxation oscillator.

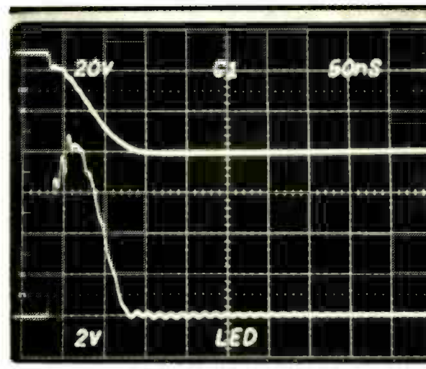


Fig. 3. Operation of Fig. 2 circuit driving an LED.

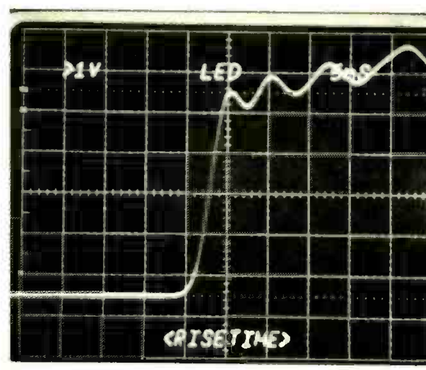


Fig. 4. Expanded view of lower trace in Fig. 3.

Though V_{cc} is higher than *Q1*'s BV_{CEX}, *R1* limits current flow below that necessary to achieve breakdown and *Q1* stays off. Simultaneously, *R1* allows *C1* to charge, and *Q1* avalanches as soon as the charge on *C1 reaches its* BV_{CEX}. Then *C1* discharges through *Q1* and any other components which happen to be in the way. When *C1*'s charge drops to a point where the forward current is below *Q1*'s I_h, *Q1* ceases to avalanche, *C1* begins charging again, and the cycle repeats.

The best way to see the sledge hammer efficiency of this little circuit is to look at the scope picture in Fig. 3. The top trace shows the charge on *C1* just prior to, at, and after it reaches the BV_{CEX} of *Q1*. In this case *Q1* has a BV_{CEX} of about 50 volts. The bottom trace shows the relatively clean output pulse across current monitoring resistor *R3*. The pulse is not perfect, but it's not easy to produce a 60-nanosecond

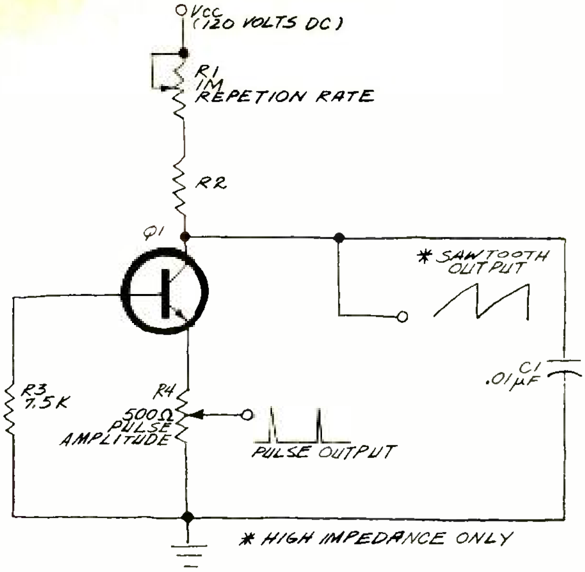


Fig. 5. How to use an avalanche transistor oscillator as an ultra-fast pulse and sawtooth generator.

pulse (½ amplitude points) with a peak amplitude of 8.4 amperes using only four active components. You can get a pulse with an amplitude of 25 amperes or more by using an avalanche transistor with a high BV_{CEX}.

Incidentally, the circuit in Fig. 2 has an incredibly fast risetime. As you can see by referring to the scope photo in Fig. 4, the approximate risetime is only 3.5 ns (10 and 90% amplitude points).

The one-ohm resistor, *R3*, in Fig. 2 can be made from a piece of nichrome wire. Simply cut the wire a bit at a time until it measures 1 ohm.

Now that you know how to put together a simple high-current, superfast pulser, what can you do with it? Avalanche circuits are ideal for operating power sensitive LED's and semiconductor injection lasers. For example, a typical injection laser marketed by at least one of the parts dealers in the back of this magazine requires up to 10 amperes or more in a fast risetime pulse no wider than 200 nanoseconds. A wider pulse will overheat and melt the laser junction. SCR pulsers can be used, but they aren't nearly as fast or efficient. They also require a higher operating voltage to achieve the same discharge current levels.

Other uses include a miniature r-f tone transmitter, pulse generator, sawtooth generator, and audio oscillator. The ultra-fast risetime of the discharge pulse is rich in harmonics which can be broadcast to a nearby receiver. Figure 5 shows how to modify the basic circuit for use as a waveform generator or audio oscillator. The oscillator version is nice for initial experiments since you can easily hear the frequency of oscillation.

When you assemble an avalanche transistor circuit, keep these tips in mind:

1. Keep *C1* at 0.02 μF or smaller. Larger values may work, but with the increased discharge time, you run the risk of damaging *Q1*.

2. Avoid turning *R1*'s shaft to a very low resistance setting. If this occurs *Q1* may avalanche through *R1* and be destroyed by the resultant high and continuous discharge current. You can use a 50K resistor in series with *R1* to be on the safe side.

3. If you don't have a 0-150-volt dc power supply, use a fresh 67.5-volt battery. Depending on the BV_{CEX} of *Q1*, you might need to use two 67.5-volt batteries in series.

4. Whatever power supply you choose, be sure to use caution when operating the circuit. Even a harmless looking 67.5-volt battery can supply an unpleasant jolt so keep one hand in your pocket when the circuit is operating to avoid accidental electrical shocks. Use well-insulated clip leads to connect the circuit to a power supply.

5. If you use the circuit to power an LED or injection laser, keep the leads in the discharge path as short as possible to avoid such inductance-caused effects as pulse stretching and ringing.

6. If you don't have a scope, a convenient way to measure the BV_{CEX} of various transistors used for *Q1* is to increase *R1* to a megohm or more to slow down the repetition rate to a few pulses per second while monitoring the voltage on *C1* with a high-impedance VOM. The voltage on *C1* will rise to the BV_{CEX} and then collapse as *Q1* avalanches. Since *C1* charges so fast, the meter reading will closely approximate BV_{CEX}. ◈

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50 for $1.98 Cat. No. 7E3137
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8 for $1.98
barrels of blemished 3, 4 and/or 5 digit readouts to USA for "dump". Untested. Cat. No. 7E3138

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100 for $1.98
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25 for $1.98
Type ER-900, same type used to trigger scrs, triacs. Sometimes called "diacs". Untested. No. 7E3160

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40 for $1.98
Wide asst. of values from 1mf to 300mf in mixture of voltages. 100% marked 'n good. Why barreled? U-got-a-buy! Cat. No. 7E 3226

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40 for $1.98
Truthfully the factories (by mixing 'em in barrels) do all of us a favor. WUT A BUY! Asst. capacities and voltages. Cat. No. 7E 3227

BARREL KIT #128 MINI DIP ICS
75 for $1.98
Large mfgr dumped 100's of lbs into barrels. Includes 741s, LM-380-8, 703, 567, 555, 558—but who knows? Factory to you. All mixed, you test. Wt. 1 lb. Cat. No. 7E 3245

BARREL KIT #131 TANTALUM ELECTROS
30 for $1.98
Mixed, marked prime, top grade asst. values, voltages. GE, Centralab, etc. Cat. No. 7E 3255

BARREL KIT #133 C-MOS IC'S
60 for $1.98
Deliberately thrown in barrels, so we can't test 'em! The famous CD4000 series. How good? Who knows?. Who cares? It's only 3¢ ea. Cat. No. 7E 3257

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Precision, mini lamp all-metal, panel, with mtg hardware. Lamp maker's overstock. 7E3297

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Mfr dumps to prepare for new styling, voltages all over the place. Good yield. Cat. No. 7E3298

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40 for $1.98
TO-92, a Motorola dump, unknown numbers, but high yield to good darlingtons. Retesters didn't get 'em! You will. 7E 3285

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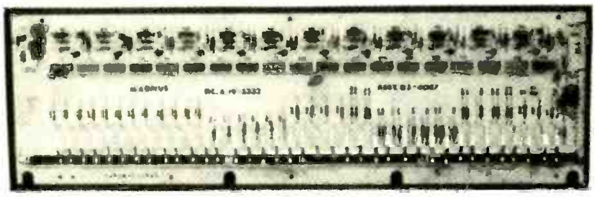
MAGNUS TONE GENERATOR BOARD



This MAGNUS tone generator board has 12 SCR oscillators & IC dividers for 37 notes (3 octaves), plus 3 chord oscillators. The basic component for your organ or synthesizer. Requires only +5v, +15v, and an amplifier. Use with our P5210 keyboard, below. 5¾" x 19¼.

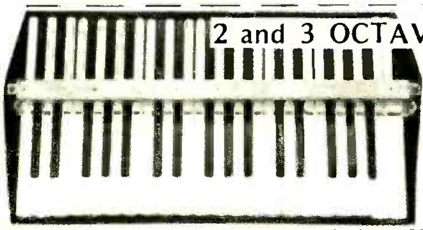
STOCK NO. P5244 **$17.95 each, 2/35.00**

Matching 13 watt amplifier for use with P5244 tone generator. Complete with power supply rectifiers & filters. 4¾" x 6".

STOCK NO. P5245 **$9.95 each, 2/18.00**

STOCK NO. P5348 Power Transformer **$3.75 ea, 2/7.00**

2 and 3 OCTAVE KEYBOARDS



We have a limited number of matching 2 & 3 octave keyboards. Use with tone generator, above, or with a synthesizer of your own. P5210 has 37 keys, is 9¾" x 19". P5280 has 25 keys, is 8½" x 13".

STOCK NO. P5210	4 lbs.	3 octaves	**$17.95 each, 2/35.00**
STOCK NO. P5280	3 lbs.	2 octaves	**$8.95 each, 2/17.00**

Send for latest free catalog. Minimum order $5, phone orders welcome: **(617) 388-4705.** Include sufficient postage; excess will be refunded. BANKAMERICARD & MASTERCHARGE welcome, ALL numbers needed for processing. Minimum charge $15.

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*Data Sheet included on these items

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*2102	1K Static Ram 450 NS	1.60
*5203 Q	Eraseable Prom 2K	11.95
*50310	Slide rule calculator chip	3.95
*50240	Top octave organ chip	5.95
*50250	Alarm clock chip	4.45
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LM340K-15	15 Volt pos. regulator	.89
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LM320K-5	5 Volt neg. regulator	.84
LM320-5.2	5.2 Volt neg. regulator	.84
LM320K-12	12 Volt neg. regulator	.84
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2N6050	Darlington	.75
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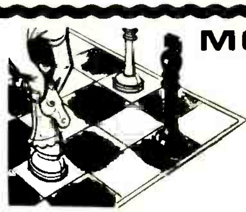

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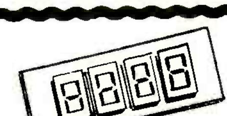
- Frequency Counter................ Kit 012 + Kit 030 + Kit 016 +Time Base
- RPM Counter........................ Kit 012 + Kit 030 + Kit 020 + Kit 018



4-DIGIT DECADE COUNTER KIT

$19.95 KIT 012

One chip 4 digit decade counter kit, with both 7 segment and BCD output.

1. Chip features internal oscillator for scanning speed.
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4. PC Boards can be cascaded to 8-12-16, etc. digits.
5. Kit includes counter chip, drive circuit for 4 cathode type displays and PC Board. (For readout board see (FND70-FND503)

KIT 016 FREQ. COUNTER

Features FET input front end with trigger circuit for measuring complex waveforms. Measures from 0.1Hz to 10MHz when used with Kit 015 or 019. Measures from .01Hz to 35MHz when used with Kit 013 and 014.

$24.50

KIT 017 DVM

1.999V as basic, with polarity indication. 1 M ohm input impedance and accuracy to 1% if properly adjusted

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KIT 020 RPM COUNTER

Counts from 1 to 100,000 RPM. RPM counter kit contains components and PC board.

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KIT 030 POWER SUPPLY

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(Contains all parts except transformer)

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1 Mhz crystal chain time base divider. Outputs; 1Mhz-100Khz-10Khz-1Khz-100Hz-10Hz-1Hz-0.1Hz. Accuracy better than .005% with proper adjustment.

Kit 013 complete CMos with PC board $15.75
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Kit 014 Same as Kit 013, but with TTL......... $13.75

Kit 015 50Hz or 60Hz chain time base using line frequence as reference. Accuracy 0.1-0.05%. Outputs 10Hz-1Hz-0.1Hz. Complete with CMos shaping circuit and PC Board.. $9.75

Kit 019 Same as Kit 015, but with TTL and 60Hz only.. $7.75

Kit 018 60Hz chain time base using line frequence for Kit 020 RPM counter.

*Outputs: .6 sec. = 100th of RPM
6 sec. = 10th of RPM
60 sec. = full revolution

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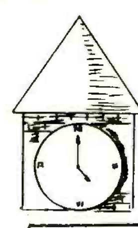

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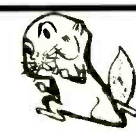

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PC Board for 4 digit display FND70	$1.75

All PC display boards are multiplexed for adding additional digits.

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Direct drive display outputs, * Current control regulation on chip, * Low power brightness control on chip. * RFI eliminating slowup circuitry, * Sleep Radio feature, * 24 hr. snooze alarm, * Independent digit setting, * Non multiplexed output circuitry. 12VAC CT 1/2 amp transformer for Kit No. 1 **$2.00**

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Complete kit with components, PC Board, Transformer, wood grain case, and filter for display window. Includes .5 inch read outs. **$22.50**

* Components for Kit No. 2 or Kit No. 3 sleep radio feature, add $.95

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7005	4 digit counter/latch decoder; 7 segment output only. 24 pin dip w/spec	$ 9.50
7007	4 digit counter/latch decoder with BCD output only. 16 pin dip w/spec	$ 7.00
70250	4-6 digit alarm clock 28 pin dip w/spec	$ 5.50
PC Board for 70250		$ 4.25
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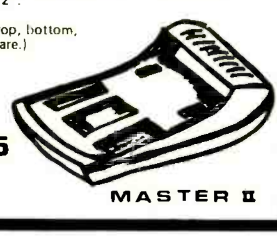

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7402	.21	7448	.94	74153	.94
7404	.21	7453	.21	74154	1.00
7406	.29	7473	.42	74161	1.04
7408	.21	7474	.42	74163	1.24
7410	.21	7475	.70	74164	1.94
7413	.54	7476	.44	74165	1.54
7420	.21	7483	.90	74174	1.34
7427	.29	7490	.74	74175	1.44
7430	.21	7492	.80	74181	2.80
7437	.44	7493	.80	74192	1.30
7438	.39	7495	.80	74193	1.30
7440	.21	7496	.80	74195	.84
7442	.74	74121	.43	74197	.84
		74123	.80		

CMOS

4000	.24	4018	1.49	4035	1.39
4001	.24	4019	.59	4037	4.50
4002	.24	4020	1.59	4040	1.59
4006	1.49	4021	1.49	4041	.89
4007	.24	4022	1.19	4042	.79
4008	1.15	4023	.24	4043	.80
4009	.59	4024	.99	4044	.59
4010	.55	4025	.24	4047	.59
4011	.24	4026	1.49	4049	.59
4012	.24	4027	.59	4050	.59
4013	.59	4028	.99	4066	.99
4014	1.49	4029	1.39	4077	.39
4015	1.19	4030	.49	74C92	.29
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4017	1.29	4033	1.49	74C107	1.29
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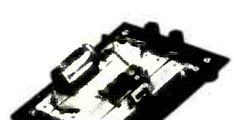

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7404	.16	74151	.60	74S85	2.00	74LS164	1.50	4006	.90	4042	.60
7410	.14	74157	.60	74S140	.50	74LS174	1.50	4007	.16	4044	.70
7420	.14	74160	.75	74S172	3.50	74LS175	1.50	4011	.16	4049	.38
7427	.25	74161	.75	74S175	1.50	74LS193	1.50	4012	.16	4050	.38
7438	.25	74163	.75	74S181	3.50	74LS251	1.50	4013	.35	4066	.65
7440	.14	74165	.80	74S197	1.50	74LS253	1.50	4021	.95	4068	.35
7445	.45	74174	.75	74S257	1.50	74LS257	1.50	4023	.16	4071	.16
7450	.14	74175	.75			74LS258	1.50	4024	.75	4073	.16
7451	.14	74177	.70	Low Power				4025	.20	4075	.16
7473	.22	74180	.80	Schottky				4027	.40	4516	.95
7474	.23	74181	1.50	74LS00	.25						
7493	.50	74191	1.00	74LS02	.25						
7495	.49	74192	.70	74LS10	.25						
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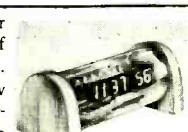

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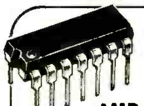

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7401	.21	7474	.30	74175	.93	4002	.23	4075	.23
7402	.21	7475	.49	74176	.79	4006	1.23	4081	.23
7403	.21	7476	.32	74177	.79	4007	.23	4082	.23
7404	.21	7480	.70	74180	.70	4008	.79	4502	.79
7405	.21	7482	.70	74181	2.15	4009	.44	4510	1.14
7406	.25	7483	.70	74182	.79	4010	.44	4511	1.05
7407	.25	7485	.89	74184	2.19	4011	.23	4514	2.80
7408	.21	7486	.28	74185	2.19	4012	.23	4515	2.80
7409	.21	7489	2.19	74188	3.50	4013	.40	4516	1.23
7410	.21	7490	.44	74189	3.50	4014	.96	4518	1.14
7411	.21	7491	.70	74190	1.23	4015	.96	4520	1.14
7412	.21	7492	.44	74191	1.23	4016	.40	4527	1.68
7413	.25	7493	.44	74192	.88	4017	1.05	4528	.88
7414	.89	7494	.70	74193	.88	4018	1.05	4585	1.23
7416	.25	7495	.70	74194	.88	4019	.23	LM309K	1.80
7417	.25	7496	.70	74195	.88	4020	1.14	LM324N	1.28
7420	.21	74100	1.28	74196	.88	4021	1.14	LM340T-5	1.25
7421	.25	74107	.30	74197	.88	4022	.96	LM340T-6	1.25
7423	.35	74109	.33	74198	1.49	4023	.23	LM340T-8	1.25
7425	.35	74121	.35	74199	1.49	4024	.84	LM340T-12	1.25
7426	.25	74122	.44	74251	1.09	4025	.23	LM340T-15	1.25
7427	.33	74123	.61	74279	.58	4026	1.68	LM340T-18	1.25
7428	.28	74125	.40	74365	.67	4027	.40	LM340T-24	1.25
7430	.21	74126	.40	74366	.67	4028	.89	LM3900N	.88
7432	.25	74132	.70	74367	.67	4029	1.14	NE536T	3.24
7433	.30	74141	.88	74368	.67	4030	.23	NE540L	2.04
7437	.25	74145	.70	75150	1.31	4033	1.51	NE555V	.48
7438	.25	74147	1.63	75450	.88	4034	3.50	NE556A	.88
7440	.21	74148	1.30	75451	.61	4035	1.14	NE560B	3.83
7441	.88	74150	1.16	75452	.61	4040	1.14	NE561B	3.83
7442	.53	74151	.70	75453	.61	4041	.79	NE562B	3.83
7443	.63	74153	.65	75454	.61	4042	.79	NE565A	1.25
7444	.63	74154	1.03	75491	.81	4043	.70	NE566V	1.28
7445	.70	74155	.70	75492	.84	4044	.70	NE567V	1.36
7446	.70	74156	.70	75493	1.09			uA709CV	.44
7447	.70	74157	.70	75494	1.19	4049	.40	uA710CA	.44
7448	.70	74160	.88	8093	.40	4050	.40	uA711CA	.53
7450	.21	74161	.88	8094	.40	4051	1.26	uA723CA	.60
7453	.21	74162	.88	8095	.67	4052	1.26	uA741CV	.44
7454	.21	74163	.88	8096	.67	4053	.72	uA747CA	.70
7460	.21	74164	.96	8097	.67	4060	1.58	uA748CV	.49
7470	.30	74166	1.26	8098	.67	4066	.79	MC1458V	.53
7472	.30	74170	2.64	82S25	2.19	4071	.23	2102	2.65
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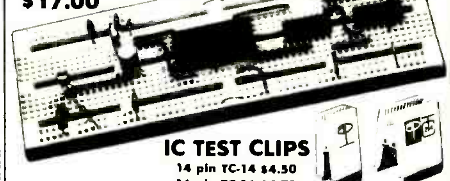

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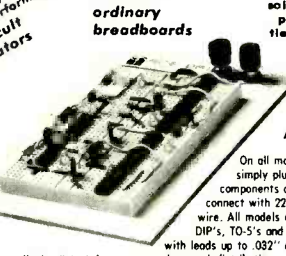

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2.2uf/50v	.08	.65/10	2.2uf/50v	.12	.90/10	100uf/16v	.17	1.30/10
3.3uf/50v	.08	.65/10	3.3uf/35v	.12	.95/10	100uf/25v	.20	1.55/10
4.7uf/25v	.08	.65/10	3.3uf/50v	.12	1.00/10	100uf/50v	.29	2.30/10
4.7uf/50v	.08	.70/10	4.7uf/25v	.11	.90/10	220uf/16v	.20	1.55/10
10uf/25v	.08	.65/10	4.7uf/35v	.12	.95/10	220uf/25v	.29	2.35/10
10uf/50v	.10	.75/10	10uf/16v	.11	.90/10	330uf/16v	.29	2.35/10
22uf/25v	.09	.70/10	10uf/25v	.12	1.00/10	330uf/25v	.32	2.55/10
22uf/50v	.12	1.00/10	10uf/50v	.14	1.15.10	470uf/16v	.32	2.55/10
100uf/6.3v	.09	.75/10	22uf/16v	.12	1.00/10	470uf/25v	.37	3.00/10
100uf/16v	.11	.85/10	22uf/25v	.13	1.05/10	1000uf/16v	.39	3.15/10
100uf/25v	.13	1.10/10	33uf/16v	.12	1.00.10	1000uf/25v	.56	4.50/10
			33uf/25v	.14	1.15/10	2200uf/16v	.62	4.95/10
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220pf/500v	.04	.36/10
470pf/500v	.04	.36/10
1000pf/500v	.04	.37/10
2200pf/500v	.04	.37/10
4700pf/500v	.04	.32/10
.01ufd/500v	.06	.50/10
.01ufd/50v	.03	.24/10
.022ufd/25v	.03	.28/10
.047ufd/25v	.05	.42/10
.1ufd/25v	.08	.62/10

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1N5227B	3.6v	.15	$11/C	1N5237B	8.2v	.15	$11/C
1N5228B	3.9v	.15	$11/C	1N5238B	8.7v	.15	$11/C
1N5229B	4.3v	.15	$11/C	1N5239B	9.1v	.15	$11/C
1N5230B	4.7v	.15	$11/C	1N5240B	10v	.15	$11/C
1N5231B	5.1v	.15	$11/C	1N5241B	11v	.15	$11/C
1N5232B	5.6v	.15	$11/C	1N5242B	12v	.15	$11/C
1N5233B	6.0v	.15	$11/C	1N5243B	13v	.15	$11/C
1N5234B	6.2v	.15	$11/C	1N5244B	14v	.15	$11/C
1N5235V	6.8v	.15	$11/C	1N5245B	15v	.15	$11/C

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1N4002	.66/10	5.60/C	1N4006	.90/10	7.75/C
1N4003	.68/10	5.80/C	1N4007	.99/10	8.60/C

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4-40 ½ Screw	.60/C	4.05/M
6-32 ¼ Screw	.65/C	4.40/M
6-32 ½ Screw	.75/C	4.85/M
8-32 3/8 Screw	.90/C	5.85/M
2-56 Hex Nut	.55/C	3.60/M
4-40 Hext Nut	.55/C	3.75/M
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556A	DIP	1.71
710	DIP	.69
711	DIP	.30
723	DIP	.71
733	TO-5	1.02
739	DIP	1.23
741	mDIP	.37
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4011A	.33	4028A	1.13	4082A	.40
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5005	" "	10/$13.90	100/$122
5738	" "	10/$20.00	100/$176
309K	5V Regulator	10/$10.00	100/$89
741	Operational Ampl.	10/$2.50	100/$22
3900	Quad amplifier DIP	10/$3.20	100/$29
74123	Dual Monostable Multivibrator	10/$5.60	100/$50
MAN 1	Display	10/$11.90	100/$104

RESISTOR KIT
CARBON FILM ± 5%
¼ OR ½ WATT
455 RESISTORS 44 VALUES
SUPPLIED IN A 15 DRAWER, 60 COMPARTMENT STORAGE CABINET — TABLE OR WALL MOUNT, READY TO USE

$24.95 ea.

¼ WATT — 01255
½ WATT — 01505

RESISTOR ASSORTMENT
R (OHMS)

R	QTY	R	QTY	R	QTY	R	QTY	R	QTY	R	QTY
1.5	5	68	5	1.0K	20	10K	20	100K	20	1.5M	5
3.3	5	100	10	1.5K	10	15K	10	150K	10	2.2M	5
6.8	5	150	10	2.2K	20	22K	10	220K	10	3.3M	5
10	10	220	10	2.7K	10	27K	10	270K	5	4.7M	5
15	5	270	5	3.3K	10	33K	20	330K	10		
22	5	330	10	3.9K	10	39K	10	470K	10		
33	5	470	20	4.7K	20	47K	10	680K	10		
47	10	680	10	6.8K	10	68K	10	1.0M	20		

PACKAGE OF 10 — DEDUCT 15%
PACKAGE OF 100 — DEDUCT 25%

6 DIGIT LED CLOCK KIT
INCLUDES:
- MM314 clock circuit
- 6 FND70 LED displays (.250" red 7 segment)
- All necessary transistors, resistors & capacitors
- 1 double sided PC board accommodates LED's & clock circuitry
- Schematic & instructions

Does not include 12V-300 ma transformer, switches & case **$12.95**

QUANTITY DISCOUNT NOT APPLICABLE ON THIS ITEM

METAL FILM RESISTORS
±1% ¼ WATT

QTY	PRICE EACH	PRICE MINIMUM 10 PER VALUE	PRICE MINIMUM 100 PER VALUE
0 - 10	$.20		
10 - 100	.20	$.15	
100 - 1000		.10	$.09
1000 -		.10	.08

RESISTANCE (OHMS)

22.6	71.5	182	887	11.8K	40.2K
23.7	78.7	187	1.15K	13.0K	45.3K
25.5	84.5	191	1.5 K	15.0K	48.7K
30.9	105	205	2.49K	18.2K	54.9K
34.8	110	232	3.57K	19.1K	60.4K
40.2	115	243	4.75K	19.6K	64.9K
45.3	137	499	5.49K	22.6K	69.8K
51.1	147	604	6.04K	24.9K	84.5K
61.9	158	715	7.15K	28.0K	
64.9	178	806	8.25K	37.4K	

Zener Diodes, Diodes & Rectifiers

IN 486B	Diode	250V	$ .25 ea.
IN 715A	Zener	11V	.25
IN 747A	Zener	3.6V	.25
IN 754A	Zener	6.8V	.25
IN 756A	Zener	8.2V	.25
IN 904	Sw. Diode	30V	.10
IN 914	Sw. Diode	100V	.10
IN 4858	Zener	120V	.25
IN 5230A	Zener	4.7V	.25
IN 5242B	Zener	12V	.25

DISPLAYS

MAN1	$1.95
MAN2	3.95
MAN3A	.19
MAN5	2.95
MAN6	3.95
MAN7	1.49
MAN8	2.95
MAN66	2.95
DL10A	2.19

DISCRETE LED'S

ME4	$.29
MV50	.15
NSL100	.15
NSL101	.15
NSL102	.15
XC209-R	.18
MV5020 RED	.18
GREEN	.18
AMBER	.18
CLEAR	.18

MISC DEVICES

ULN 2208	FM gain block 34dB mDIP	1.39
ULN2209	FM gain block 48dB mDIP	1.59
2513	64 x 8 x 5 character generator	11.00
CA 3046	Transistor array 14 pin DIP	.86

5% OFF ON ORDERS OVER $50.00
10% OFF ON ORDERS OVER $100.00
15% OFF ON ORDERS OVER $500.00

TTL

7400	.16	7451	.20	74153	1.14
7401	.18	7453	.20	74154	1.29
7402	.17	7454	.20	74155	1.23
7403	.18	7460	.20	74156	1.23
7404	.22	7464	.40	74157	1.14
7405	.22	7465	.40	74158	2.06
7406	.40	7470	.35	74160	1.60
7407	.40	7472	.35	74161	1.44
7408	.21	7473	.40	74162	1.71
7409	.22	7474	.40	74163	1.60
7410	.18	7475	.66	74164	1.83
7411	.29	7476	.45	74165	1.83
7413	.63	7483	.91	74166	1.71
7414	.81	7485	1.27	74170	2.65
7416	.40	7486	.46	74173	1.71
7417	.40	7489	2.48	74174	1.86
7420	.18	7490	.59	74175	1.60
7422	.30	7491	1.12	74176	1.02
7423	.33	7492	.82	74171	.97
7425	.31	7493	.69	74180	1.04
7426	.30	7494	1.68	74181	3.43
7427	.33	7495	.91	74182	.91
7430	.23	7496	.91	74184	2.29
7432	.26	74100	1.50	74185	2.29
7437	.40	74105	.51	74187	4.50
7438	.40	74107	.46	74190	1.35
7440	.20	74121	.48	74191	1.35
7441	1.13	74122	.52	74192	1.25
7442	.89	74123	.69	74193	1.19
7443	1.00	74125	.62	74194	1.25
7444	1.00	74126	.72	74195	1.02
7445	1.02	74132	1.02	74916	1.44
7446	1.07	74141	1.20	74197	1.02
7447	1.02	74145	1.20	74198	2.06
7448	1.20	74150	1.12	74199	2.06
7450	.20	74151	.91	74200	5.90
				74279	1.08

LOW POWER

74L00	.29	74L51	.33	74L90	1.71
74L02	.29	74L55	.38	74L91	1.67
74L03	.29	74L71	.29	74L93	1.94
74L04	.29	74L72	.45	74L95	1.94
74L06	.29	74L73	.56	74L98	3.21
74L10	.29	74L74	.56	74L164	3.21
74L20	.38	74L78	.91	74L165	3.21
74L30	.38	74L85	1.44		
74L42	1.71	74L86	.79		

LOW POWER SCHOTTKY

74LS00	.36	74LS32	.38	74LS95	2.09
74LS02	.36	74LS40	.45	74LS107	.59
74LS04	.36	74LS42	1.40	74LS164	2.20
74LS08	.38	74LS74	.59	74LS193	2.20
74LS10	.36	74LS90	1.30	74LS197	2.20
74LS20	.36	74LS93	1.30		

HIGH SPEED

74H00	.25	74H22	.25	74H61	.25
74H01	.25	74H30	.25	74H62	.25
74H04	.25	74H40	.25	74H74	.39
74H08	.25	74H50	.25	74H101	.39
74H10	.25	74H52	.25	74H102	.49
74H11	.25	74H53	.25	74H103	.58
74H20	.25	74H55	.25	74H106	.58
74H21	.25	74H60	.25	74H108	.60

SCHOTTKY

74S00	.38	74S08	.52	74S22	.38
74S02	.45	74S10	.38	74S32	.52
74S03	.38	74S20	.38	74S74	.38
74S04	.45				

8000 (SIGNETICS)

8263	5.79	8267	2.59

Date sheets on request. Add 30¢ each if item is priced below $1.00 each.

Satisfaction guaranteed. Shipment will be made postage prepaid within 5 days from receipt of order. Payment may be made with personal check, charge card (include number and exp. date), or money order. Phone Orders — BofA and M/C card or C.O.D.

Add $1.00 to cover shipping and handling if order is less than $50. Add $2.00 if order is less than $10.00. California residents add sales tax. Include shipping expense for orders shipped out of U.S. and Canada approx. 15% of order.

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P.O. BOX 3036-R MONTEREY, CA. 93940 USA
PHONE (408) 659-3171

CIRCLE NO. 30 ON FREE INFORMATION CARD

CRYSTALS

THESE FREQUENCIES ONLY

Part #	Frequency	Case/Style	Price
CY1A	1.000 MHz	HC33/U	$4.95
CY2A	2.000 MHz	HC33/U	$4.95
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

CLOCK CHIPS — CALCULATOR CHIPS

MM5309	6 Digit, BCD Outputs, Reset PIN	$5.95
MM5311	6 Digit, BCD Outputs, 12 or 24 Hour	4.95
MM5312	4 Digit, BCD Outputs, 1 PPS Output	4.95
MM5313	6 Digit, BCD Outputs, 1PPS Output	4.95
MM5314	6 Digit, 12 or 24 Hour, 50 or 60 Hz	4.95
MM5316	4 Digit, Alarm, 1PPS Output	6.95
MM5318	Video Clock Chip For Use With MM5841	9.95
CT7001	6 Digit Calander, Alarm, 12 or 24 Hour	6.95

CALCULATOR CHIPS

MM5725	6 Digit, Four Function, Less Decimal	$2.95
MM5738	8 Digit, 5 Function + − × ÷ %	2.95
MM5739	8 Digit, 4 Function, Floating Decimal	2.95
CT5001	12 Digit, 4 Function	3.95
CT5005	12 Digit, 4 Function with Memory	5.95
CT5030	12 Digit, 4 Function and %	7.95

MISC. MOS

MM5320	TV Camera Sync. Generator	$19.95
MM5330	4½ Digit DVM Chip	9.95
MM5369	60 Hz Timebase Circuit From 3.58 MHz	5.00
MM5841	Video Generator For MM5318	18.00
MC1408-L7	7 Bit Digital to Analog Converter	9.95
MK5007	4 Decade Counter with Latches	10.95
LD110/LD111	3½ Digit DVM Chip Set	25.00
95H90	100 MHz ÷ 10 Counter For Prescalers	13.95

Filament Transformers

Type No.	Price
F-7X	5.10
F-13X	3.80
F-14X	4.15
F-16X	5.35
F-25X	5.25
F-40X	7.00
F-45X	7.50
F-54X	8.50

Add 50¢ Postage

VECTOR WIRING PENCIL

Vector Wiring Pencil P173 consists of a hand held featherweight (under one ounce) tool which is used to guide and wrap insulated wire, fed off a self-contained replaceable bobbin onto component leads or terminals installed on pre-punched "P" Pattern Vectorbord®. Connections between the wrapped wire and component leads, pads or terminals are made by soldering. Complete with 250 FT of red wire **$9.50**

REPLACEMENT WIRE — BOBBINS FOR WIRING PENCIL

W36-3-A-Pkg. 3	250 ft. 36 AWG GREEN		$2.40
W36-3-B-Pkg. 3	250 ft. 36 AWG RED		$2.40
W36-3-C-Pkg. 3	250 ft. 36 AWG CLEAR		$2.40
W36-3-D-Pkg. 3	250 ft. 36 AWG BLUE		$2.40

1/16 VECTOR BOARD

0.1" Hole Spacing — P-Pattern

	Part No.	L	W	Price 1-9	20-49
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

VECTOR TERMINALS

Series	Part No. Gold	Finish Tinned	Post Size	25 pcs Gold	25 pcs Tin	50 pcs Gold	50 pcs Tin
T44	T44-1	T44	.025 sq.	1.50 lot	1.00 lot	2.75 lot	1.75 lot
T46	T46-1	T46	.028 sq.	1.75 lot	1.25 lot	3.00 lot	2.25 lot
T49	T49A	T49	.025 sq.	1.75 lot	1.25 lot	3.10 lot	2.25 lot
T42-1	PKG. 100		Terminals	$3.50 C	$13.00M		

DIP SWITCH

These switches feature seven SPST slide switches in a molded dip. They are ideally suited for microprocessor applications. $1.95

100 PER STRIP — MOLEX PINS

Intended for use as an inexpensive substitute for IC sockets. Also perfect for use as board connectors and in subassemblies.

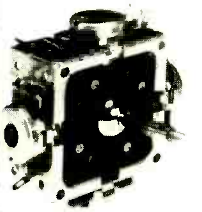
SPECIAL — 100/1.49 — 1000/12.00

64 KEY KEYBOARD

The ideal item for the real homebrew computer hobbyist. This keyboard features 64 unencoded SPST keys, unattached to any kind of P.C.B. A very solid molded plastic 13" x 4" base suits most applications.

$24.95 ea.

JOYSTICK



These joysticks feature four 100K potentiometers, that vary resistance proportional to the angle of the stick. Sturdy metal construction with plastics components only at the movable joint. Perfect for electronic games and instrumentation.

$9.95 ea.

MICROPROCESSOR COMPONENTS

8080 SUPPORT DEVICES

8080A $37.95	8212	8 BIT INPUT/OUTPUT PORT FOR 8080	$5.95	8080 $24.95
	8224	CLOCK GENERATOR AND DRIVER FOR 8080	12.95	
	8228	SYSTEM CONTROLLER AND BUS DRIVER FOR 8080	12.95	

CPU'S			RAM'S			
8008	8 BIT CPU	$19.95	2601	256 x 1	FAST	5.00
8080	Super 8008	24.95	1101	256 x 1	Static	$2.25
8080A	Super 8008	37.95	1103	102 x 1	Dynamic	2.95
SR'S			2101	256 x 1	Static	6.95
2504	1024 Dynamic	$9.00	2102	1024 x 1	Static	1.95
2518	Hex 32 BIT	7.00	2107	4096 x 1	Dynamic	19.95
2519	Hex 40 BIT	4.00	2111	256 x 4	Static	7.95
2524	512 Dynamic	2.95	7010	1024 x 1	MNOS	29.95
2525	1024 Dynamic	6.00	7489	16 x 4	Static	2.49
2527	Dual 256 BIT	3.95	8101	256 x 4	Static	7.95
2529	Dual 512 BIT	4.00	8111	256 x 4	Static	7.95
2532	Quad 80 BIT	3.95	8599	16 x 4	Static	3.49
2533	1024 Static	7.95	91L02	1024 x 1	Static	2.49
3341	Fifo	6.95	74200	256 x 1	Static	6.95
74LS670	16 x 4 Reg	3.95	93410	256 x 1	Static	1.75
UART'S			PROMS			
AY-5-1013	30K Baud	$6.95	1702A	2048	Famos	$15.95
ROM'S			5203	2048	Famos	14.95
2513	Char. Gen.	$11.00	82S23	32 x 8	Open C	5.00
7488	Random Bits	3.50	82S123	32 x 8	Tristate	5.00
2516	Char. Gen.	13.00	74S287	1024	Static	7.95

2K RAM SPECIAL

MM5262 Fully decoded 2Kx1 dynamic RAM. All inputs except clocks are TTL compatible. Provides a 635 ns minimum access time, and requires a +5, +8.5 and −15V power supply. Low power provides non volatile memory using battery back up.

$0.99 ea. (0.05 cents per bit)

Special Requested Items

RC4194	Dual Track V Reg	$5.95	N8T97	$2.00	MK5007	$10.95	MC4044	$4.50
RC4195	±15V Track Reg	3.25	4024P	2.25	8263	5.95	LM3909	1.25
F9368	Decoder	3.95	DM8130	3.25	8267	2.75	MM5320	19.95
LD110/111	DVM Chip Set	25.00	9322	1.30	8288	1.15	4072AE	.45
CA3130	Super CMOS Op Amp	1.49	MC14016	.56	8826	3.00	7422	1.50
MC1408L7	D/A	9.95	2525	6.00	8880	.80	7497	4.00
F3341	FIFO	6.95	2527	3.95	4511AE	2.50	74186	5.00
MM5841	Character Gen	18.00	CD4518	2.50	XR4136	2.00	74279	.90
AY5-9100	Push Button Dialer	17.50	MM5309	5.95	4566AE	3.00		

— WE'LL BE HAPPY TO QUOTE ON YOUR SPECIAL PARTS —

Continental Specialties

PROTO POWER!

POWER FOR THE PROFESSIONAL

Made in USA — Patents Pending

$75 Proto Board 203

Breadboard Prototesting with 5 Volt, 1 AMP Regulated Power Supply Included!

A total ready to use power breadboard prototest device with a built in regulated short proof power supply. Just plug in and start building! 2 extra floating 5 way binding posts for external signals. Self-contained with power switch indicator lamp and power fuse. 24-14 pin DIP capacity. Attractive two-tone quality case. All metal construction. 9¾" L × 5¾" W × 2¾" H. 5 lbs. Order today!

For the economy-minded experimenter . . .

NEW

Proto Board 100 — 19.95

Here's a low cost, big 10 IC capacity breadboard kit with all the quality of QT Sockets and the best of the Proto Board series ... complete down to the last nut, bolt and screw. Includes 2 QT 35S Sockets, 1 QT 35B Bus Strip, 2 5-way binding posts, 4 rubber feet, screws, nuts, bolts and easy assembly instructions.

THE MINI-BREADBOARD BUDGET KIT

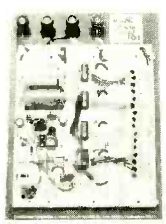
Proto Board 101 — Compact, inexpensive. 10 14-pin DIP capacity. 5.8" long × 4.5" wide. **29.95**

Proto Board 102 — Compact. 12 14-pin DIP capacity. 7" × 4½". **39.95**

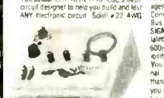
Proto Board 103 — 2,250 solderless tie points, (4) 5-way binding posts, 24 14-pin DIP capacity. 9" × 6". **59.95**

Proto Board 104 — Huge 3,060 solderless tie points, (4) 5-way binding posts, 32-14 pin DIP capacity, 9½" long × 8" wide. **79.95**

COMPLETE KIT

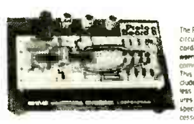


DESIGN MATE 1



CIRCUIT DESIGNER — You asked for it. HERE IT IS! CSC's basic circuit designer to help you build and test ANY electronic circuit. Solid #22 AWG wire interconnects any discreet component without solder. Resistors, transistors, Linear/Digital ICs in TO-5/DIP packages (from 8-40 pins). And more. Components fit directly into Sockets and Bus strips instantly and easily. Plus DESIGN MATE ONE's (DM-1) variable regulated power supply gives 5-15VDC up to 600ma (9 watts). Now that's design flexibility for you!

You can even monitor the DM-1's internal power supply or external circuits thanks to the built in 0-15V voltmeter. If you're into electronics, DM-1 is a must for your laboratory. It comes to you completely wired, tested and ready to use for only $49.95



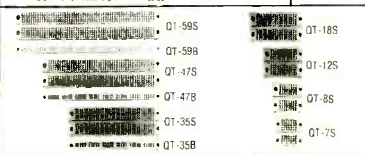
PROTO BOARD 6 — The PB-6 lets the user test and build circuits without soldering or patch cords ... all interconnections between components are made with common #22 AWG hook up wire. This quality breadboarding kit includes 630 component tie points at less than 2.5 cents each. It measures 6" long by 4" wide. Designed specially to Breadboard Microprocessor Circuits. $15.95

Now trace signals or troubleshoot fast. Inject signals or wire unused circuits into existing boards. Scope probes, test leads lock onto Dynagrip inset. Plastic construction — no springs or pivots. Thousands of operations. Narrow throat for high density PC boards.

PC-14	14-pin Proto-Clip	$4.50 ea.
PC-16	16-pin Proto-Clip	$4.75
PC-24	24-pin Proto-Clip	$8.50

LOGIC MONITOR

Simultaneously displays static and dynamic logic states of DTL, TTL, HTL or CMOS DIP ICs.
Pocket size $84.95.



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

DIGITAL CLOCK KIT — 3½ INCH DIGITS

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 Hr. When Ordering

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

Satisfaction Guaranteed. $5.00 Min. Order. U.S. Funds.
California Residents — Add 6% Sales Tax — Data Sheets 25c each
Send a 13c Stamp (postage) for a FREE 1976 Catalog

JAMES

1021 HOWARD ST., SAN CARLOS, CA. 94070
PHONE ORDERS — (415) 592-8097

AUTOTEL™

WARNING LIGHTS ARE NOT ENOUGH

AN AUDIBLE ALARM INDICATING POTENTIAL ENGINE DAMAGE

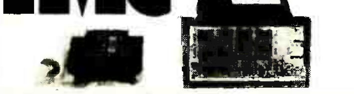
AUTOTEL is an effecient (15 ma current standby) device by which every owner of an automobile, truck or vehicle equipped with indicator lights for temperature and oil pressure can be assured of a reliable warning **before** an impending failure.

AUTOTEL, by means of an audible signal 70 db pulsing) immediately forewarns the vehicle operator of a malfunction or failure, allowing time to correct and prevent major engine failures. It is programmed so there is no sound during normal operating conditions.

AUTOTEL features CMOS circuitry, packaged in a 2½" sq. x ⅞" case. The kit comes complete with all components, hardware and case to hook directly into your car's warning light system.

$14.95 Assembled $9.95 Per Kit

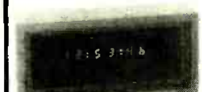
IMC 3½ DIGIT DVM KIT



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

JE700 CLOCK



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.

12 or 24 Hour — 115 VAC — **$19.95**

Liquid Crystal Temperature Display — Six Digit Light Emitting Diode Display — DL 33 Display

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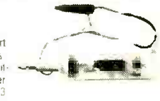
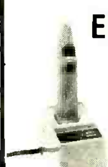
JE803 PROBE



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) - o (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

ELECTRONIC TOOLS



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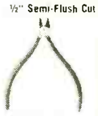

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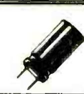

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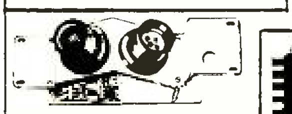
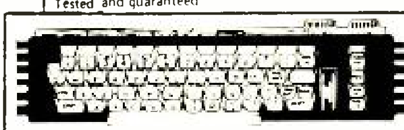


ACOUSTIC COUPLER

This coupler was manufactured by Novation, Inc. Tarzana, California for use in Texas Instrument's model 725 Electronic Data Terminal. It is compatible with Bell 103 and 113 data sets or equivalent. The coupler operates asynchronously to a maximum speed of 450 baud in the full or half duplex mode coupled to a standard telephone handset. Transmit freq. is 1270hz for mark and 1070hz for space. Receive frequency is 2225hz for mark and 2025hz for space. Unit required ± 12 VOLTS and + 5 VOLTS for operation. Complete with schematic & all pertinent information, fully reconditioned, calibrated, and guaranteed. $47.50

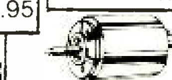


ASCII COMPUTER KEYBOARDS

These keyboards were manufactured for use on Texas Instrument's line of Silent 700 series data terminals. They are fully encoded with TTL large scale integrated circuits (T.I. TMS 5000 in 28 pin socket). Additional IC's provide a parallel 7 bit, without parity, code plus a strobe signal indicating "valid" data and six other independent outputs for these special keys which are not encoded. The keys are reed type with a format similar to typewriter. Internal circuitry provides for two key rollover and de bounce. Output is on standard 10 pin double readout connector for data and power input. And 8 pin double readout connector for six special switch functions.

KB 6 Clare/Pendar 720627-1 — New tested $39.95; T.I. Part number 959327-1 — Used tested $29.95. A 56 key ASCII encoded Alphanumeric keyboard with six extra switch closures to ground marked HERE IS, PAPER ADV., BREAK, REPEAT, TAPE→ TAPE←

KB-7 Clare/Pendar 720731-1 — New tested $49.95; T.I. Part number 959326-1 — Used tested $39.95. This is a 64 key full ASCII encoded keyboard



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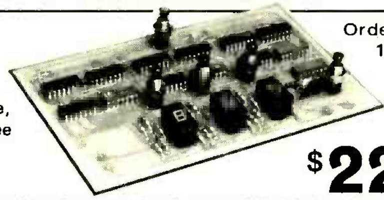

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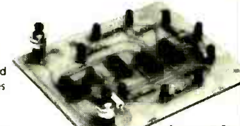

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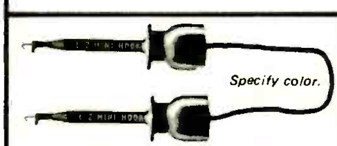

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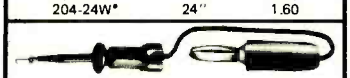

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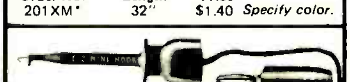

Jumper X-100W Mini Hook to Stacking Banana Plug**

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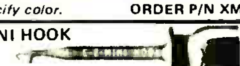

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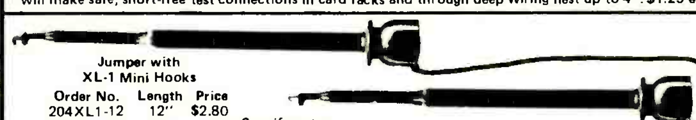

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7404N	.21	.19	7475N	.55	.50	74156N	1.02	.92
7405N	.20	.19	7476N	.44	.40	74157N	.90	.80
7406N	.36	.28	7480N	.80	.72	74158N	1.50	1.30
7407N	.36	.28	7481N	1.30	1.25	74160N	1.02	.92
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7409N	.28	.21	7483N	.82	.76	74162N	1.40	1.30
7410N	.22	.19	7484N	1.80	1.70	74163N	1.00	.90
7411N	.26	.20	7485N	1.20	1.08	74164N	1.16	1.05
7412N	.34	.32	7486N	.44	.40	74165N	1.20	1.10
7413N	.45	.42	7489N	2.20	2.10	74166N	1.20	1.10
7414N	.98	.95	7490N	.56	.51	74167N	5.00	4.50
7416N	.35	.32	7491N	.84	.76	74170N	2.00	1.80
7417N	.35	.32	7492N	.56	.50	74173N	1.66	1.50
7418N	.30	.27	7493N	.62	.56	74174N	1.00	.90
7420N	.15	.14	7494N	.88	.80	74175N	.96	.90
7421N	.30	.26	7495N	.80	.72	74176N	1.08	1.00
7422N	.50	.45	7496N	.75	.68	74177N	1.08	1.00
7423N	.37	.36	7497N	5.00	4.50	74178N	1.42	1.30
7425N	.30	.23	74100N	1.10	1.00	74179N	1.80	1.70
7426N	.28	.26	74104N	1.00	.90	74180N	1.12	1.02
7427N	.28	.25	74105N	1.00	.90	74181N	3.00	2.70
7428N	.40	.33	74107N	.40	.36	74182N	1.00	.90
7430N	.26	.20	74109N	.40	.36	74184N	2.80	2.50
7432N	.32	.30	74110N	1.00	.90	74185N	3.00	2.70
7433N	.44	.40	74111N	1.00	.90	74188N	5.00	4.80
7437N	.29	.20	74116N	2.00	1.80	74190N	1.20	1.10
7438N	.29	.27	74118N	2.20	2.00	74191N	1.20	1.10
7439N	.44	.40	74119N	4.00	3.60	74192N	.98	.90
7440N	.17	.16	74121N	.60	.54	74193N	.92	.88
7441N	.85	.83	74122N	.48	.43	74194N	1.36	1.23
7442N	.40	.39	74123N	.68	.62	74195N	.75	.70
7443N	.72	.65	74125N	.50	.45	74196N	1.40	1.30
7444N	.72	.65	74126N	.50	.45	74197N	1.40	1.30
7445N	.90	.81	74128N	.50	.45	74198N	1.40	1.30
7446N	.90	.81	74132N	.92	.85	74199N	1.40	1.30
7447N	.98	.90	74136N	.80	.72	74200N	9.00	8.00
7448N	.98	.90	74141N	1.70	1.50	74221N	1.36	1.25
7450N	.14	.13	74145N	1.10	1.00	74247N	2.40	2.20
7451N	.14	.13	74147N	1.90	1.70	74251N	1.90	1.80
7453N	.14	.13	74148N	1.50	1.35	74278N	2.90	2.50
7454N	.14	.13	74150N	1.52	1.40	74279N	.66	.60
7459N	.20	.18	74151N	1.02	.92	74298N	2.00	1.80
7460N	.14	.13						

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74H01N	.25	74H21N	.33	74H53N	.36	74H74N	.80
74H04N	.33	74H22N	.33	74H54N	.36	74H76N	.75
74H05N	.33	74H30N	.33	74H55N	.36	74H102N	.75
74H08N	.40	74H40N	.36	74H60N	.36	74H103N	.90
74H10N	.33	74H50N	.36	74H71N	.75	74H106N	.95
74H11N	.33	74H51N	.36	74H72N	.75		

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74L00N	.24	74L10N	.24	74L51N	.34	74L90N	1.62
74L02N	.24	74L20N	.33	74L73N	.43	74L93N	1.51
74L03N	.39	74L42N	1.33	74L74N	.90	74L95N	1.62
74L04N	.33						

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74LS01N	.44	.40	74LS73N	.58	.55	74LS162N	3.06	2.80
74LS02N	.36	.35	74LS74N	.56	.54	74LS163N	3.00	2.70
74LS03N	.45	.43	74LS76N	.65	.64	74LS170N	5.80	5.30
74LS04N	.44	.40	74LS78N	.92	.90	74LS174N	2.20	2.00
74LS05N	.45	.44	74LS95N	2.08	2.00	74LS175N	2.40	2.20
74LS08N	.38	.37	74LS107N	.59	.58	74LS181N	3.69	3.68
74LS09N	.44	.40	74LS109N	.92	.86	74LS190N	2.85	2.70
74LS10N	.36	.35	74LS112N	.58	.55	74LS191N	2.85	2.70
74LS11N	.46	.42	74LS113N	.92	.85	74LS193N	2.50	2.40
74LS15N	.58	.54	74LS114N	.92	.85	74LS194N	2.25	2.20
74LS20N	.44	.20	74LS123N	1.60	1.50	74LS195AJ	2.40	2.20
74LS21N	.58	.54	74LS138N	1.89	1.80	74LS196AJ	2.76	2.50
74LS22N	.58	.54	74LS139N	2.00	1.80	74LS197AJ	2.20	2.10
74LS27N	.44	.40	74LS151N	1.68	1.50	74LS251AJ	2.08	1.90
74LS30N	.39	.38	74LS153N	1.80	1.79	74LS253AJ	2.42	2.20
74LS32N	.45	.44	74LS157N	1.55	1.54	74LS257AJ	1.89	1.80
74LS40N	.58	.53	74LS158N	1.68	1.60	74LS258AJ	2.06	1.90
74LS51N	.39	.38	74LS160N	3.00	2.70	74LS260AJ	.44	.40
74LS54N	.58	.54						

SCHOTTKY TTL

74S00	.44	74S32	.80	74S113	1.50	74S174	3.30
74S01	.76	74S40	.65	74S114	1.20	74S175	2.90
74S02	.60	74S50	.76	74S133	.80	74S181	6.00
74S03	.75	74S51	.80	74S138	2.20	74S189	4.40
74S04	.55	74S60	.80	74S139	2.20	74S194	3.30
74S05	.76	74S64	.80	74S140	.80	74S195	3.30
74S08	.80	74S65	.80	74S151	2.20	74S251	2.20
74S09	.76	74S74	.90	74S153	3.40	74S253	2.40
74S10	.55	74S76	1.15	74S157	2.40	74S257	2.40
74S11	.65	74S78	1.16	74S158	2.00	74S258	2.40
74S15	.76	74S86	6.10	74S160	3.90	74S260	1.20
74S20	.65	74S86	2.50	74S161	4.70	74S280	5.70
74S21	.76	74S112	1.00	74S172	6.00	74S289	4.00
74S30	.80						

9300 SERIES

9300PC	$1.00	9318PC	2.30	9366PC	1.75	93L18	3.50
9301PC	1.20	9321PC	1.20	93L00	1.50	93L21	1.50
9304PC	1.50	9322PC	1.30	93L01	1.60	93L22	1.80
9306PC	6.90	9324PC	2.00	93L08	3.20	93L24	2.80
9308PC	2.50	9328PC	2.50	93L09	1.80	93L28	3.70
9309PC	1.60	9334PC	2.95	93L10	2.80	93L34	4.00
9310PC	1.50	9338PC	3.30	93L11	4.20	93L38	4.20
9311PC	2.30	9340PC	5.00	93L12	1.80	93L40	6.50
9312PC	1.20	9341PC	4.10	93L14	1.70	93L41	6.50
9314PC	1.30	9342PC	1.15	93L16	3.20	93L60	3.00
9316PC	1.50	9360PC	1.75	93L18	3.50	93L66	2.70

LINEAR IC's

H=TO-5 N=DIP M=MINI-DIP D=CER-DIP K=TO-3

LM105H	3.90	LM311D	.90	LM709CN	.75
LM108H	4.90	LM311M	1.75	LM710CH	.90
LM114H	3.00	LM312H	1.75	LM710CN	.90
LM300H	1.20	LM318H	1.50	LM711CH	.90
LM300N	1.20	LM318M	2.40	LM711CN	.90
LM301AH	.50	LM319N	3.40	LM715CH	3.50
LM301AM	.80	LM324N	1.90	LM715CD	4.60
LM301AN	1.10	LM331N	1.25	LM723CH	.60
LM302N	1.30	LM335K	2.40	LM723CN	.65
LM302H	1.40	LM336K	2.40	LM725CH	1.50
LM304H	1.20	LM337K	2.40	LM725CD	5.00
LM305H	.85	LM339N	2.20	LM733CH	1.40
LM305AH	1.05	LM320-5K	2.90	LM733CD	3.50
LM305N	1.00	LM320-5T	2.50	LM733CN	1.30
LM306N	.95	LM320-12K	2.90	LM741CH	.40
LM307H	.60	LM320-12T	2.50	LM741CD	1.25
LM307M	1.50	LM340-5K	2.60	LM741CM	.39
LM307N	1.60	LM340-6K	2.60	LM747CH	.75
LM308H	.85	LM340-8K	2.60	LM747CN	.90
LM308AH	5.00	LM340-12K	2.60	LM748CN	.55
LM308D	2.25	LM340-15K	2.60	LM777CH	2.15
LM308M	1.00	LM340-18K	2.60	LM777CM	2.10
LM309H	1.75	LM340-24K	2.60	LM3046CN	.95
LM309K	1.50	LM555CM	.70	LM3054CN	1.50
LM310H	1.50	LM556CM	1.30	SG4501T	2.40
LM310M	1.80	LM567CM	1.70	SG4501N	2.40
LM311H	1.20	LM709CH	.75	LM5000K	7.50

CMOS

	1-9	10up		1-9	10up		1-9	10up
4000AE	.15	.14	4021BE	1.35	1.25	4056AE	1.99	1.98
4000AF	.28	.24	4022AE	1.05	1.00	4056BE	2.04	2.03
4000BE	.19	.18	4022BE	1.10	1.05	4060AE	1.70	1.68
4001AE	.24	.20	4023AE	.24	.22	4066AE	2.50	2.49
4001BE	.27	.24	4023BE	.30	.28	4066AE	.90	.89
4002AE	.24	.15	4024AE	.80	.70	4068AE	.44	.43
4002AF	.34	.25	4024AF	.95	.85	4068BE	.53	.48
4002BE	.30	.18	4024BE	.85	.75	4069AE	.44	.43
4004AE	4.00	3.80	4025AE	.24	.20	4069BE	.53	.48
4006AE	1.30	1.20	4025AF	.40	.35	4070BE	.60	.59
4006AF	1.50	1.30	4025BE	.30	.28	4071AE	.45	.44
4006BE	1.35	1.25	4026AE	1.50	1.49	4072AE	.34	.33
4007AE	.24	.23	4027AE	.55	.50	4073AE	.40	.39
4007AF	.40	.35	4027BE	.60	.55	4075AE	.40	.39
4007BE	.27	.28	4028AE	.95	.90	4076AE	1.24	1.22
4008AE	1.15	1.14	4028BE	1.00	.95	4077AE	.40	.39
4008AF	1.30	1.25	4029AE	1.20	1.10	4077BE	.44	.43
4009AE	.50	.45	4029BE	1.25	1.15	4078AE	.40	.39
4009BE	.55	.50	4030AE	.48	.40	4078BE	.44	.43
4010AE	.50	.45	4030AF	.65	.60	4081BE	.40	.39
4010BE	.55	.50	4030BE	.55	.50	4082AE	.39	.38
4011AE	.24	.23	4033AE	2.00	1.90	4082BE	.43	.42
4012AE	.24	.22	4035AE	1.20	1.10	4093AE	1.65	1.64
4012AF	.34	.32	4035BE	1.25	1.15	4095BE	1.95	1.94
4012BE	.29	.27	4040AE	1.20	1.10	4098AE	1.30	1.29
4013AE	.30	.28	4040AF	1.50	1.40	4099AE	2.90	2.89
4013AF	.45	.43	4040BE	1.30	1.20	4502AE	1.50	1.49
4014AE	1.05	1.00	4041AE	1.25	1.00	4507BE	.60	.55
4014AF	1.30	1.15	4042AE	1.00	.85	4508BE	2.20	2.19
4014BE	1.10	1.05	4043AE	.95	.90	4510AE	1.40	1.39
4015AE	1.15	1.10	4044AE	.95	.90	4510BE	1.45	1.44
4015BE	1.20	1.15	4046AE	3.10	3.05	4511BE	2.00	1.99
4016AE	.55	.49	4047AE	2.00	1.90	4512BE	1.30	1.29
4016BE	.60	.54	4048AE	1.43	1.40	4514AE	5.00	4.99
4017AE	1.05	1.00	4049AE	.58	.53	4515AE	5.00	4.99
4017BE	1.10	1.05	4049BE	.63	.58	4516AE	1.75	1.74
4018AE	1.24	1.23	4050AE	.58	.53	4518AE	1.28	.98
4018BE	1.30	1.28	4051AE	1.49	1.48	4520AE	1.28	.98
4019AE	.54	.49	4052AE	1.40	1.39	4528AE	2.20	2.19
4019AF	.74	.68	4052BE	1.45	1.44	4528BE	2.25	2.24
4019BE	.60	.55	4053AE	1.40	1.39	4585AE	2.05	1.95
4020AE	1.45	1.35	4053BE	1.45	1.44	4901AE	.32	.31
4021AE	1.30	1.20	4055AE	1.95	1.94	4911AE	.32	.31

INDUSTRIAL QUALITY COMPONENTS

What is more important? QUALITY or PRICE?
We have decided to offer only the highest quality components. When quality counts, you can count on Ancrona

FIRST QUALITY ONLY

IC SOCKETS

WIRE-WRAP GOLD DIP

PIN	1-24	25	100
14	.45	.41	.37
16	.54	.49	.44

SOLDER – GOLD DIP

PIN	1-24	25	100
14	.34	.31	.28
16	.37	.34	.31

SOLDER-TIN DIP

PIN	1-24	25	100
8	.21	.19	.17
14	.25	.22	.20
16	.28	.25	.23
18	.34	.31	.28
22	.37	.36	.35
24	.47	.43	.40
28	.88	.80	.70
36	1.09	.98	.89
40	1.24	1.12	.90

TO-5 SOCKETS TEFLON

3 PIN	.55 EA
4 PIN	.65 EA
6 PIN	.90 EA
8 PIN	1.10 EA
10 PIN	1.40 EA

PLASTIC TO-5

8 PIN .40 EA

INTERSIL 8038 PRECISION WAVEFORM GENERATOR & VCO

For simultaneous sine, square and triangular waveforms <.001 Hz to 1MHz.

Part No.	1-9	10up
8038CCPD	$3.90	$3.70

1-AMP RECTIFIERS

	10	100	1000
1N4001	1.00	7.00	60.00
1N4002	1.10	8.00	70.00
1N4003	1.20	9.00	80.00
1N4004	1.30	10.00	90.00
1N4005	1.40	11.00	100.00
1N4006	1.50	12.00	110.00
1N4007	1.60	13.00	120.00

HYBRID POWER AMPLIFIERS

SI-1010G	10W	$6.40
SI-1020G	20W	9.90
SI-1030G	30W	18.70
SI-1050E	50W	24.90
SI-1050G	50W	24.90

HIGH VOLTAGE TRANSISTORS

BU204	3A	1300V	$4.14
BU205	3A	1500V	4.95
BU206	3A	1700V	5.94
BU207	6A	1300V	5.85
BU208	6A	1500V	6.93
BU209	6A	1700V	8.64

MATSUO DIPPED TANTALUM CAPACITORS

MFD	WVDC	1-9	10up	50up	MFD	WVDC	1-9	10up	50up
.1	35	$.30	$.25	$.20					
.15	35	.30	.25	.20	4.7	35	$.40	$.32	$.26
.22	35	.30	.25	.20	6.8	35	.40	.32	.26
.33	35	.30	.25	.20	10.0	16	.38	.30	.24
.47	35	.30	.25	.20	10.0	25	.39	.31	.25
.68	35	.30	.25	.20	10.0	35	.40	.32	.26
1.0	35	.30	.25	.20	15.0	35	.95	.64	.56
1.5	35	.35	.28	.23	22.0	16	.40	.32	.26
2.2	20	.30	.25	.20	33.0	20	.95	.64	.56
2.2	35	.35	.28	.23	47.0	20	1.40	1.05	.90
3.3	35	.38	.30	.24	68.0	16	1.40	1.05	.90

CARBON FILM RESISTORS . . . ¼ WATT 5%

150 STANDARD VALUES . . . . $1.69 per 100
10 ohm to 10 megohms . . . .Only in multiples of 100 per value

MICROPROCESSOR SPECIAL

8080A	$34.90
8080	27.50
AM2901	31.50

RAM'S

	1-9	10up
P1101A	2.20	2.10
P1101A1	3.50	3.30
P1103	2.90	2.70
P2101	5.00	4.80
P2101-1	5.10	4.85
p2101-2	5.20	4.90
P2102	2.48	2.30
P2102-1	2.80	2.65
P2102-2	2.70	2.60
P2102A	2.90	2.70
P2102A-2	3.00	2.80
P2102A-4	2.95	2.75
P2111	5.70	5.50
P2111-1	5.80	5.60
P2111-2	5.90	5.70
P2112	5.90	4.70
P2112-2	6.00	4.80
P2401	9.90	9.80
P2405	8.80	8.00
2602B	2.48	2.30
2602-1B	2.68	2.65
2602-2B	2.70	2.60
IM7552CPE	2.48	2.30
IM7552-1CPE	2.80	2.65
IM7552-2CPE	2.70	2.60
TMS4035NL	2.48	2.30
TMS4034NL	2.70	2.60
P8101	5.00	4.80
P8101-2	5.20	4.90
P8102	2.48	2.30
P8102-2	2.70	2.60
P8111	5.70	5.50
P8111-2	5.90	5.70
AM9101APC	3.50	3.30
AM9101BPC	3.90	3.80
AM9101CPC	5.50	5.30
AM9101DPC	7.80	7.00
AM9102PC	2.70	2.60
AM9102APC	3.00	2.80
AM9102BPC	4.90	4.50
AM9102CPC	6.20	6.00
AM9102DPC	7.80	7.00

LOW POWER RAM'S

AM91L02PC	2.75	2.70
AM91L02APC	3.90	3.70
AM91L02BPC	5.00	4.40
AM91L02CPC	7.00	6.00

PROMS

	1-9	10up
1702A	15.95	14.50

SHIFT REGISTER

	1-9	10up
P2401	23.00	19.00
P2405	10.85	9.90
P2505K	3.70	3.30
2512K	4.30	4.05
2521V	2.50	2.20
2524V	2.40	2.20
2525V	3.60	3.50
2533V	10.50	8.50
AM2802PC	4.40	3.50
AM2803PC	4.40	3.50
AM2804PC	4.40	3.50
AM2805HC	3.70	3.30
AM2806HC	7.00	5.60
AM2807PC	2.40	2.20
AM2808PC	3.60	3.50
AM2809PC	2.50	2.20
AM2810DC	10.00	8.00
AM2812ADC	24.00	19.20
AM2812DC	21.00	16.80
AM2813ADC	24.00	19.20
AM2813DC	21.00	16.80
AM2814DC	12.45	9.15
AM2825PC	18.75	15.00
AM2826DC	22.50	18.00
AM2827PC	18.75	15.00
AM2833PC	10.85	8.70
AM2841APC	10.50	8.40

SHIFT REGISTER

	1-9	10up
AM2841PC	8.25	6.55
AM2847PC	5.00	4.50
AM2855PC	7.15	5.75
AM2856PC	7.15	5.75
AM2857PC	7.15	5.75
AM2896PC	5.00	4.50
AM3341PC	8.25	6.50
AM3347PC	6.40	5.10
AM4025D	73.00	58.40

AMD MSI

AM2501DC	9.00
AM2502PC	9.50
AM2503PC	9.50
AM2504PC	16.05
AM2505PC	15.00
AM2506PC	8.80
AM25L02PC	10.70
AM25I03PC	10.70
AM25L04PC	16.05
AM25L05PC	15.00
AM25L06PC	8.80
AM25S05PC	19.00
AM25S07PC	3.78
AM25S08PC	3.51
AM25S09PC	5.40
AM25S10PC	4.50
AM25S18PC	5.40
AM25LS07PC	2.79
AM25LS08PC	2.76
AM25LS09PC	3.49
AM25LS14PC	31.00
AM25LS15PC	2.14
AM25LS138PC	2.12
AM25LS139PC	2.12
AM25LS151PC	2.14
AM25LS153PC	2.14
AM25LS157PC	1.54
AM25LS158PC	1.54
AM25LS160PC	2.94
AM25LS161PC	2.94
AM25LS162PC	2.94
AM25LS163PC	2.94
AM25LS174PC	3.10
AM25LS175PC	2.76
AM25LS181PC	8.00
AM25LS190PC	3.87
AM25LS191PC	3.87
AM25LS194APC	2.62
AM25LS195APC	1.77
AM25LS251PC	2.66
AM25LS253PC	2.66
AM25LS257PC	2.00

COMPUTER INTERFACE

DM8820N	2.40
DM8820AN	6.90
DM8830N	2.40
DM8831N	5.20
DM8832N	6.00
NBT26B	4.40
9600PC	1.30
9601PC	1.20
9602PC	1.95
9614PC	2.30
9615PC	2.40
9616PC	5.00
9617PC	3.50
9620PC	4.00
9621PC	4.00

75107

75107BN	2.60
75108BN	2.30
75109N	2.20
75110N	2.20
75115N	2.25
75138N	2.95
75150N	3.10
75154N	4.10

75107

75208N	2.70
75234N	2.50
75450N	1.25
75451N	1.00
75452N	1.00
75453N	1.00

7520 SERIES SENSE AMPS

7520N	4.00
7521N	2.00
7522N	4.25
7523N	1.75
7524N	2.00
7525N	4.50

TWO-PHASE MOS CLOCK DRIVER

MH0026CN 5.50

MM

MM404H	12.00
MM405H	23.00
MM406H	6.50
MM407H	6.50
MM451H	11.40
MM454F	18.00
MM500H	2.00
MM506H	3.20
MM507H	3.20
MM550H	5.90
MM551H	5.60
MM555H	5.60

MOS-LSI

1402AN	3.80
1403AH	4.00
1403AN	3.80
1404AH	4.50
1404AN	2.90
1405A	4.00
1406	8.40
1407	8.40
1506	3.00
1507	3.00
1602	33.00
TMS3114J	9.40
TMS3120JC	7.00
TMS3120NC	6.00
TMS3133NC	7.50
3341ADC	8.00
3341APC	7.00
3347DC	5.80
3347PC	4.60
4102	4.95
7552	4.95
7562-1	5.40
7552 2	5.50
MM4055D	12.00
MM4056H	9.70
MM4057D	13.00
MM5025N	20.00
MM5026N	20.00
MM5027N	20.00
MM5055N	5.50
MM5056N	5.50
MM5057N	5.50
MM5058N	5.50

BIPOLAR MEMORY

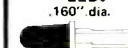
C3101	6.50
P3101	4.90
C3101A	7.30
P3101A	5.80
IM5501CDE	7.30
IM5501CPE	5.80
MM5560D	7.30
MM5560N	5.80
DM8599N	5.80
93403PC	5.80

LEDs

.125" dia.

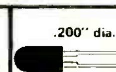
209 RED	$.25
209 YELLOW	.35
209 GREEN	.35

.160" dia.



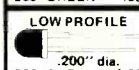
216 RED	$.25
216 YELLOW	.30
216 GREEN	.30

.200" dia.



220 RED	$.25
220 YELLOW	.30
220 GREEN	.30

LOW PROFILE .200" dia.



226 RED	$.25
226 YELLOW	.30
226 GREEN	.30
226 ORANGE	.30

.200" dia.

5053 RED	$.35
5053 YELLOW	.40
5053 GREEN	.40
5053 ORANGE	.40

MV50 RED $.30

216 = MV5024
5053 = MV5053

DISPLAYS

0.6" IN.

EP62R	RED	3.00
EP62G	GREEN	3.60
EP62Y	YELLOW	3.60

Data sheet for EP62 $.25

LARGE 1"

EP1000 RED 5.50
3 pcs EP1000 15.00
5 Pcs EP1000 22.50
Data sheet for EP1000 $.25

XCITON

XAN72 RED 2.00 — XAN52 GREEN 2.00
XAN82 YELLOW 2.00

LITRONIX

DL80	RED	6.00	DL44	RED	6.00
DL81	RED	6.00	DL402	RED	4.00
DL10	RED	6.00	DL701	RED	3.40
DL10A	RED	4.00	DL704	RED	2.25
DL101	RED	4.90	DL707	RED	2.35
DL57	RED	9.90	DL747	RED	2.50
DL61	RED	12.00	DL33	RED	4.00

OPTOISOLATORS

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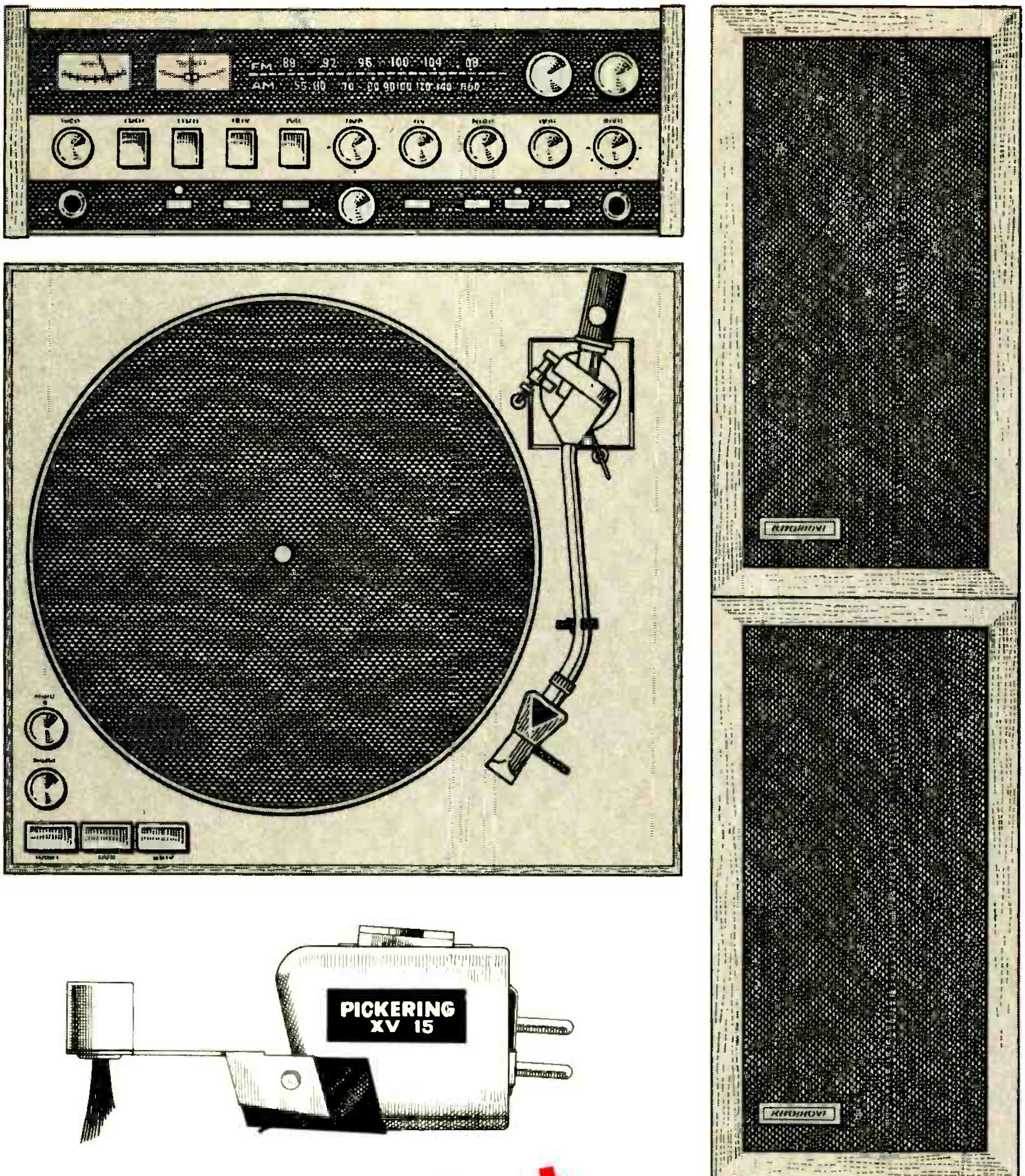

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Your stereo cartridge is the *First* part of your music system. It is too important to overlook, and so is a Pickering.

For further information, see reader service card or write to Pickering & Co., Inc. Dept.PE, 101 Sunnyside Blvd., Plainview, N.Y. 11803

PICKERING

"for those who can hear the difference"

CIRCLE NO. 43 ON FREE INFORMATION CARD

Some reasonably unbiased suggestions on how to select your next record player.

Since you read this magazine, chances are you already own a record player. If you're considering replacing it, it probably no longer meets your requirements. One way or another.

For example, if your turntable operates only manually, you may now prefer the convenience and safety of automatic operation. If it already provides automatic start and stop, but only in single play, you may now want the ability to play a series of records in sequence and without interruption.

You may also be taking an expensive risk with your records every time you play them. Remember: your record collection probably costs more than the rest of your equipment combined. This alone should prompt you to give thought to a new turntable.

For years, Dual's approach has been to build every turntable with more precision than your records are likely to need. Since we traditionally lead the state of the art, every Dual tonearm produces optimum performance from today's finest cartridges and maximum longevity from every record.

This is as true of the least expensive Dual, the 1225, as it is of the CS701. All Dual tonearms, for example, follow the same basic design principles: straight line between pivot and cartridge for maximum rigidity and lowest mass; dynamic balance maintained throughout play; stylus pressure applied around the vertical pivot; anti-skating that automatically compensates for the inherent changes in skating during play.

As for rumble, wow, flutter and deviation from speed accuracy, all are far below audibility in every Dual. (With the direct-drive CS701, they are virtually unmeasurable.)

We don't suggest that Dual is the *only* quality brand turntable available. But where Dual does indeed stand alone is in the many years of proven reliability and durability. For example, many Duals that come in for servicing (usually only for lubrication and cleaning) are more than ten years old. And many Dual owners tell us (via letters and warranty cards) that they now own their second Dual... usually for their second system.

Dual quality comes in a variety of models: semi-automatic, single-play; fully automatic, single-play; single-play/multi-play. Seven models in all as described. We think it only reasonably biased to suggest that you will find your next turntable among them.

Dual 1225.

Dual 1225. Fully automatic, single-play/multi-play. Viscous damped cue-control, pitch-control. 10⅞" platter. Less than $140, less base. Dual 1226, with cast platter, rotating single-play spindle, less than $170. Dual 1228, with gimballed tonearm, synchronous motor, illuminated strobe, variable tracking angle. Less than $200.

Dual 1249. Fully automatic, single-play/multi-play. Belt drive. 12" dynamically-balanced platter. Less than $280, less base. Full size belt-drive models include Dual 510, semi-automatic, less than $200; Dual 601, fully automatic, less than $250. (Dual CS601, with base and cover, less than $270.)

Dual CS701. Fully automatic, single-play. D.C. brushless, electronic direct-drive motor; tuned anti-resonance filters. Less than $400, including base and cover.

Dual 1249.

Dual CS701.

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