1978 STEREO FM TUNER BUYING DIRECTORY

Popular Electronics

WORLD'S LARGEST-SELLING ELECTRONICS MAGAZINE

JANUARY 1978/$1

Build "CHARGE!" — a 12-V DC Electronic Bugler

How a Spectrum Analyzer Works

Plus:

The Direct-Disc Revolution + Exploring Computer
Lines + Read/Write Memory Experiments
udio Loudness Controls + Lou Garner's
ual Electronics Predictions

New 1978 Electronic Games

A roundup of latest microprocessor-based video and nonvideo electronic games sweeping the nation.

TESTED THIS ISSUE:

Yamaha Model 2020 AM/Stereo FM Receiver
Optonica Model RT-3535 Stereo Cassette Deck
dbx Model 128 Dynamic Range Enhancer
E F Johnson Viking 4360 CB AM Mobile Transceiver

0 14024 14278 01
Popular Electronics

The Cobra 50XLR CB has it all. AM/FM Stereo. Cassette. And CB. All in one compact unit. All engineered to bring you the same loud and clear sound Cobra is famous for.

The remote mike houses the channel selector, squelch control, and channel indicator. So all you need for talking CB is right there in your hand. The cassette player features through the dial loading and four-way fader control.

Because they're only five inches deep, there's a Cobra in-dash radio to fit almost any car with little or no modification to the dash. This feature, plus the step-by-step Installation Manual and Universal Installation Kit makes them the easiest in-dash radios to install. And our Nationwide network of Authorized Service Centers makes them the easiest to service.

There are four Cobra in-dash models to choose from including AM/FM/Stereo/8-track/CB. But no matter which you choose you can be sure of getting the best sounding radio going. The ultimate car radio.

The Cobra.

Cobra®

Punches through loud and clear.

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CIRCLE NO. 50 ON FREE INFORMATION CARD

THE ULTIMATE CAR RADIO.

ANALOG DELAY

INTRODUCING... TWO-CHANNEL ANALOG DELAY UNIT FOR AMBIENCE SYNTHESIS AND DELAY EFFECTS

FEATURES

* TWO INDEPENDENT CHANNELS
* 3072 STAGES OF DELAY PER CHANNEL
* ADJUSTABLE INPUT AND OUTPUT LEVELS WITH INPUT OVERLOAD INDICATION
* INTERNAL OR EXTERNAL VOLTAGE CONTROLLED DELAY TIME
* COMPANDOR IN EACH CHANNEL
* 3 MODES/CHANNEL WITH ADJUSTABLE MIX
* CONVENTIONAL REVERB OUTPUT FOR MUSIC EFFECTS

If you haven't heard what analog delay can do for home music reproduction, you're missing something. Let's face it, stereo in your living room is flat and 2 dimensional. Without the mixture of direct and delayed sounds that a large hall provides, almost all music reproduced in the home is lifeless. Quadraphonics has not proved to be the solution to this problem. The recent developement of bucket-brigade semiconductor technology has made it possible to offer a reasonably priced delay unit that can transform your listening room into a concert hall. Using your present stereo system, the 2AS-A, and whatever you have in the way of 2 additional speakers and 2 channels of power amplification— you have all the parts to put together an ambience system that is capable of creating the kind of 'space' you enjoy music in. You don't need state-of-the-art componentry to enjoy an ambience system. The secondary power amplifiers and speakers can be of very modest performance and yet still serve to create strikingly realistic spaciousness in your listening room. If you don't have 2 extra power amp channels on hand, we offer several low cost, low power amps in kit form that would be ideal for this purpose.

Although the 2AS-A has been designed for use in music reproduction systems as an ambience synthesizer, its voltage controlled clock and mixing capabilities allow it to be configured in a number of ways for delay effects such as phasing, flaging, chorous, and vibrato. External voltage control for special effects must be user supplied.

The 2AS-A is sold in kit form only and includes the circuit boards, components, chassis (11½" x 10" x 4"), cover 120VAC power supply, assembly instructions and application notes.

2AS-A Analog Delay Unit
$250.00 ppd. Cont. U.S.

Southwest Technical Products Corp.
219 W. Rhapsody, San Antonio, Texas 78216

London: Southwest Technical Products Co., Ltd.
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CIRCLE NO. 46 ON FREE INFORMATION CARD

JANUARY 1978
VOLUME 13, NUMBER 1

Popular Electronics®

WORLD'S LARGEST-SELLING ELECTRONICS MAGAZINE

Coming Next Month

BUILD A LOW-COST EPROM PROGRAMMER

NO CAMERA / NO CHEMICAL PRINTED-CIRCUIT BOARDS

MODERN TURNTABLE DESIGN

TEST REPORTS
Garrard GT-25 Turntable
Sherwood Micro CPU / 100 Stereo FM Tuner
Ten-Tec Century / 21 CW Transceiver

Electronic games on the cover include: Fairchild's Video Entertainment System (upper left); Mattel Electronics™ Football (upper right); and Parker Bros. Code Name: Sector™.

POPULAR ELECTRONICS, January 1978, Volume 13, Number 1, Published monthly at One Park Avenue, New York, NY 10016. One year subscription rate for U.S. and Possessions, $12.00; Canada, $15.00; all other countries, $17.00 (cash orders only, payable in U.S. currency). Second Class postage paid at New York, NY and at additional mailing offices. Authorized as second class mail by the Post Office Department, Ottawa, Canada, and for payment of postage in cash.
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Editorial correspondence: POPULAR ELECTRONICS, 1 Park Ave., New York, NY 10016. Editorial contributions must be accompanied by return postage and will be handled with reasonable care; however, publisher assumes no responsibility for return or safety of manuscripts, art work, or models.
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Feature Articles

Construction Articles

Columns

Julian Hirsch Audio Reports

Electronic Product Test Reports

Departments

Editorial

ELECTRONICS AND THE HANDICAPPED

I was startled to learn at a recent AT&T press conference that there are about 50-million people in this country who are considered to be handicapped to some extent. (For example, 1 out of 4 elderly people suffer hearing-loss problems.) And I was impressed by the ongoing efforts of a voluntary organization of telephone-industry workers—the Telephone Pioneers of America—who create and make available various electrical and electronic aids for the blind, deaf, retarded, and motion- and speech-handicapped after working hours.

Many of these devices require some handiness with a soldering iron; a few demand kit-building experience. For instance, one "Pioneers" chapter supplies an "Audio Aid" device to enable needy persons who are hard-of-hearing to boost the sound level of a TV receiver, motion-picture, etc., so that it can be heard better. (A converted portable radio's speaker acts as a microphone in this case, and the amplified sound is heard through an earphone.) Complete plans are available for converting a G.E. Model P2790 or Model 7-2705 portable radio for this purpose from Telephone Pioneers of America, Bell Telephone Laboratories, Room 6H-416, Murray Hill, NJ 07974. Any radio with an earphone jack can be similarly modified, though some parts substitutions may be required. A pc foil pattern (1" x 7/16") is included in the plans, as well as a point-to-point wiring diagram.

Putting the "beep" in the baseball.

Another illustration of how Pioneers' ingenuity and dedication have made life more pleasurable for handicapped people is the development of a "beeping" softball. Here, a telephone engineer buried an amplifier and electronic beeper inside a ball so that blind children can play baseball. In 1973, the Audio Ball was placed in the National Baseball Hall of Fame in Cooperstown. Today, local Pioneer chapters have devised other "beeping" sports aids for the blind: an audio basketball laced with bells that's played against a backboard wired for sound; an audible hockey puck; a beeping horseshoe game; a beeping golf putting device; an audio ring-toss game, and so on.

For retarded and autistic children who can't relate to adults, Telephone Pioneers developed, make and donate talking dolls and toy animals. The toys are equipped with two-way radios so that a therapist can remain out of sight and talk through the toy to young patients, who frequently respond to this "person."

There are a host of other ways in which persons with electronics know-how can aid the handicapped. For example, people confined to wheelchairs could be shown how their everyday living can be enhanced through listening to shortwave radio broadcasts, learning Morse code, building electronic kits, etc. There are other areas of assistance, too. For instance, one may record book and magazine articles on tape for distribution to the blind. A vocal interface for a computer would enable some handicapped people to control a variety of electric appliances, even opening and closing a door, by emitting a specific sound. The list of ways in which you can provide help through your knowledge of electronics is virtually endless. So why not set aside some time for this very worthwhile effort?

Any PE readers interested in contributing ideas or assistance to the Pioneers, or wish to receive free plans for any devices that help the handicapped, contact the Telephone Pioneers of America at AT&T, 195 Broadway, New York, NY 10007.

Art Salsberg

CIRCLE NO. 5 ON FREE INFORMATION CARD

Letters

ALGEBRAIC NOTATION TRANSLATION

To your many readers who have requested an "algebraic" translation of my June 1977 article "How to Program Calculators for Fun and Games," all of the game programs have been translated from Hewlett-Packard "Reverse Polish Notation" into Texas Instruments "algebraic" notation for the SR-56. They are available for the nominal fee of $2.00 to cover printing, postage, and handling—*Dale G. Platteter, Suite 201, 1315 Q St., Bedford, IN 47421.*

RADAR DETECTORS

This is in rebuttal to your November Editorial's comments about whether it was morally correct to use radar detectors. My corporation uses them in all our vehicles; not to "outfox" the law, but as a reminder that "radar" is being used on our vehicles. We do this because we *know* that some highway patrolmen running speed traps will lie to make "brownie points."—*Clarence Jones, Saint George, SC.*

GREMLINS AT WORK

About the article in the November issue, "How to Dress up Your Projects." The first page was terrible. I could hardly read it. —*Damon Hill, Atlanta, GA.*

The circuits in Figs. 2 and 3 of "Experimenter's Corner," October 1977, should be interchanged.—*G. Levelius, Mansfield, OH.*

COMPLIMENTS ON QUALITY

Permit me to compliment POPULAR ELECTRONICS' quality and content. Some 25 years ago, I was reading the Amateur Radio magazines and remember PE as a pulp magazine that appeared to be written for the average sixth grader. I guess those sixth graders have grown up, and PE has kept pace with the growth, providing us with sophisticated and fascinating articles and magnificent ads. My only wish is that you would have more ads from some of the computer stores because I am so ignorant about computers that I do not know where or how to start digging out the information, equipment sources, etc.—*Jay M. Burns, Luling, LA.*

WANTS MORE "GUIDES"

I very much enjoyed and benefitted from "Guide to Oscilloscopes" (June 1977). I am a third-year electrical engineering student, and the article on scopes answered many questions my college instructors never bothered to address. I would like to see POPULAR ELECTRONICS publish similar features on power supplies, r-f generators, and VOM's. I am particularly interested in these items.—*Charles B. Howard, Minneapolis, MN.*

INTERFACING

While considering the construction of a giant digital scoreboard ("A Digital Timer-Scoreboard for Athletic Events," August 1975), I found a simple and very effective means of directly interfacing digital IC's to large ac displays. I used a light-activated SCR optoisolator (GE's H11C1). The Ga-As LED in this device can be driven directly by the current that normally drives one segment of a small LED display. I used the Intersil 7205 stopwatch IC, which has a 5-volt, 20-mA multiplexed output. Each segment of my giant display consists of four clear "nite lites" wired in parallel. The display consumes about 150 mA at 117 volts ac per segment, which is well within the 300-mA rating of the LASCR.—*Doug Henry, Corvallis, OR.*

LOG CONVERTER PART NUMBER CHANGE

In the "½-octave Real Time Audio Analyzer, Part 2," in the October 1977 issue, Texas Instruments has changed the number of *IC36* from SN76502 to TL441 —*Gil Gamesh, Babylon, N.Y.*

CIRCLE NO. 14 ON FREE INFORMATION CARD

Learn to service Communications/CB equipment at home...with

NRI'S COMPLETE COMMUNICATIONS COURSE

Learn design, installation and maintenance of commercial, amateur, or CB communications equipment.

The field of communications is bursting out all over. In Citizens Band alone, class D licenses grew from 1 to over 2.6 million in 1975, and the FCC projects about 15 million CB'ers in the U.S. by 1979. That means a lot of service and maintenance jobs . . . and NRI can train you at home to fill one of those openings. NRI's Complete Communications Course covers all types of two-way radio equipment (including CB), AM and FM

Transmission and Reception, Television Broadcasting, Microwave Systems, Radar Principles, Marine Electronics, Mobile Communications, and Aircraft Electronics. The course will also qualify you for a First Class Radio Telephone Commercial FCC License or you get your tuition back.

Learn on your own 400-channel digitally-synthesized VHF transceiver.

You will learn to service all types of communication equipment, with the one unit that is designed mechanically and electronically to train you for CB, Commercial and Amateur communications: a digitally-synthesized 400-channel VHF transceiver and AC power supply. This 2-meter unit gives you "Power-On" training. Then we help you get your FCC Amateur License with

special instruction so you can go on the air.

The complete course includes 48 lessons, 9 special reference texts, and 10 training kits. Included are: your own electronics Discovery Lab, Antenna Applications Lab, CMOS Frequency Counter, and an Optical Transmission System. You'll learn at home, progressing at your own speed, to your FCC license and into the communications field of your choice.

NEW CB SPECIALIST COURSE NOW OFFERED

NRI now offers a special course in CB Servicing. You get 37 lessons, 8 reference texts, your own CB Transceiver, AC power supply and multimeter . . . for hands-on training. Also included are 14 coaching units to make it easy to get your commercial radio telephone FCC license—enabling you to test, install, and service communications equipment.

NRI offers you five TV/Audio Servicing Courses

NRI can train you at home to service TV equipment and audio systems. You can choose from 5 courses, starting with a 48-lesson basic course, up to a Master Color TV/Audio Course, complete with designed-for-learning 25″ diagonal solid state color TV and a 4-speaker SQ™ Quadraphonic Audio System. NRI gives you both TV and Audio servicing for hundreds of dollars less than the two courses as offered by another home study school.

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

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NRI's complete computer electronics course gives you real digital training.

Digital electronics is the career area of the future . . . and the best way to learn is with NRI's Complete Computer Electronics Course. NRI's programmable digital computer goes far beyond any "logic trainer" in preparing you to become a computer or digital technician. With the IC's in its new Memory Kit, you get the only home training in machine language programming . . . experience essential to trouble shooting digital computers. And the NRI programmable computer is just one of ten kits you receive, including a TVOM and NRI's exclusive electronics lab. It's the quickest and best way to learn digital logic and computer operation.

You pay less for NRI training and you get more for your money.

NRI employs no salesmen, pays no commissions. We pass the savings on to you in reduced tuitions and extras in the way of professional equipment, testing instruments, etc. You can pay more, but you can't get better training.

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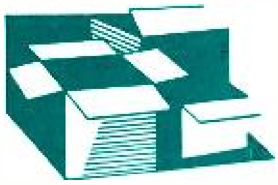
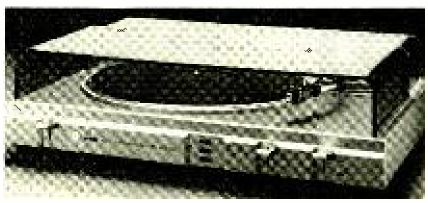


New Products

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.

SETTON TURNTABLE

The TS-11, a turntable with several convenience features, has been announced by Setton International. Controls are arranged on the front panel for easy access, and the dustcover telescopes, rather than lifting, both to prevent jarring of the arm and to allow the



turntable's use on shelves with limited headroom. The two-speed turntable has an automatic return and shutoff. A light illuminates the stylus path as it moves across the disc, for easier manual cueing.

CIRCLE NO. 91 ON FREE INFORMATION CARD

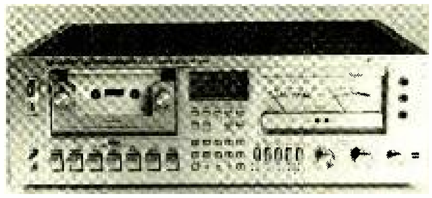
COBRA CB/RADIO COMBINATIONS

Cobra Communications has announced two 40-channel CB/stereo FM-AM combination units for in-dash mobile use. Both are only 5 inches deep, with adjustable tuning shafts for easier adaptation to most cars, and are supplied with 24-page installation manuals. A built-in monitor circuit automatically cuts off sound from the AM/FM radio section when calls are received on any pre-selected CB channel. CB sections feature DynaMike gain control and an r-f/S meter. The Cobra 47XLR, with remote-control digital-readout microphone, pushbutton AM-FM tuning and PA output provision is $299.95. The 46XLR, without those three features, is $259.95. It includes front-panel LED channel readout.

CIRCLE NO. 92 ON FREE INFORMATION CARD

SHARP CASSETTE DECK

Microprocessor control is used to add several unique functions to Sharp's new RT-3388 cassette deck. The Auto Program Locate Device (APLD), which searches ahead to the next blank space between selections on existing Sharp decks, can be programmed on this one to jump ahead to the 2nd, 3rd, or even 19th such blank space, and either stop



or begin playing at that point. The memory rewind will not only rewind to zero (or any other point) and stop or begin playing, but can also be programmed to stop at any given point on the tape thereafter. The tape counter is an LCD digital display which can also be set to show the time a tape has been running. A built-in quartz digital clock allows timer-operated automatic recording or playback. Other features include Dolby noise reduction, dual VU meters with peak indicators, mike and line mixing, and separate bias and equalization selector switches. $300.

CIRCLE NO. 93 ON FREE INFORMATION CARD

RAM STEREO PREAMPLIFIER

The RAM200 stereo preamplifier from RAM Audio Systems, Inc, features FET inputs, class-A output circuits, and some unusual control features. Balance is controlled by an array of 5 pushbuttons, which gives a range up to 30 dB of attenuation, in 2-dB steps, in either channel. Preamplifier output level is indicated in dBm by dual LED arrays. Input and output connections, including two phono circuits, tuner, aux, two tape monitor circuits and one external processor loop, are accessible beneath a removable panel at the top-rear of the cabinet. There is an additional front-panel input and tape output. Other features include direct input for moving-coil cartridges, automatic muting for amplifier and speaker protection, and a tape-output interlock that prevents feedback howl. THD and IM are reportedly each less than 0.02%, and S/N is greater than 80 dB on phono inputs. $1000.

CIRCLE NO. 94 ON FREE INFORMATION CARD

MODULAR ELECTRONIC PROJECTS

A modular system of snap-in components that can be used to assemble a variety of educational electronic projects has been an-

nounced by Takahashi and Associates. Six kits are available, each consisting of a number of interchangeable module blocks carrying the symbols of the components they contain, plus a plastic frame with battery case, tuning capacitor meter and antenna. The number of module blocks supplied ranges from 12 in the smallest kit to 46 in the largest, whose frame also includes a light-sensitive CdS cell, a speaker and several built-in controls. Among the projects that can be assembled from the kits are a radio, a wireless microphone, a light control circuit, touch buzzer, morse code tone circuit, and others. No soldering is required. Address: Takahashi & Associates, 3183-G Airway Ave, Costa Mesa, CA 92626.

COMMANDER CB ANTENNA

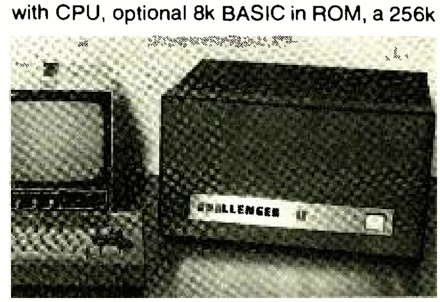
"Magnum Ears", a twin-loaded CB mobile or apartment antenna only 13 inches high, has been announced by Commander. VSWR is adjustable to 1.2:1 or better, according to the

manufacturer. The twin-loaded radiating elements form a centerfed dipole with a claim of high efficiency. The antenna comes with a 6-pole magnetic base mount that measures 4" in diameter. $21.95.

CIRCLE NO. 95 ON FREE INFORMATION CARD

OHIO SCIENTIFIC COMPUTER

Ohio Scientific has added the Challenger II to its Challenger microcomputer series. The new model is a complete computer, equipped with CPU, optional 8k BASIC in ROM, a 256k



Memory Management ROM, a 4k RAM and a serial port. The system can be operated at clock rates of 1 MHz or 2 MHz. It's available in two video-based models, the IIV and IIP.

CIRCLE NO. 96 ON FREE INFORMATION CARD

B.I.C. INDOOR FM ANTENNA

The "Beam Box," an electronically directable FM antenna styled to resemble other stereo components, has been announced by B.I.C.

Where superior technology makes the musical difference: Sansui's new DC integrated amplifier and matching tuner.

Sansui is proud to introduce the new AU-717 DC integrated amplifier and matching TU-717 tuner, designed for your greatest listening pleasure. We are proud of the superlative specifications that our sophisticated research has achieved. The finest available at any price.

But the best specs alone don't always mean the finest music reproduction. And so we are proud that our precision engineering and superior circuitry design create pure and brilliantly clean tonal quality that's distinctly superior.

Listen to what we offer: Frequency response of the AU-717 from main in, 0Hz to 200kHz (+0dB, −3dB), (the widest of any DC integrated amplifier available), gives you sharp, clean transients and greatly reduced phase shift problems. Total harmonic distortion is astoundingly low, less than 0.025%, from 10-20,000Hz. 85 watts/channel min. RMS, both channels driven into 8 ohms.

Dual independent power supplies provide truest stereo separation and a large power reservoir. For uncolored phono reproduction equalization is within ±0.2dB (20-20,000Hz, extended RIAA curve). And the calibrated-attenuator level control guarantees volume precision.

The matching TU-717 tuner features dual IF bandwidth to let you select for lowest distortion (0.07% mono, 0.07% stereo) or maximum selectivity (80dB). S/N is excellent: 80dB mono, 77dB stereo.

In addition, the AU/TU 717's are elegantly styled, offer rack mounting adaptors and are most attractively priced. Less than $450* for the AU-717 and less than $320* for the TU-717.

Listen to these brilliant new components at your franchised Sansui dealer today. When you hear the new Sansui AU/TU-717's you will never again want to settle for less than the best.

Sansui. A whole new world of musical pleasure.

*Approximate nationally advertised value. The actual retail price will be set by the individual dealer at his option.

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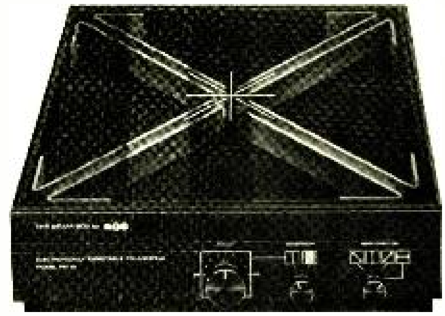


The antenna, which requires no batteries or power, has a bi-directional pickup pattern which can be oriented into any of four pairs of quadrants at 45° intervals, to reduce multipath interference. Switch-selected, broad and narrow bandwidth settings are available and the antenna may be tuned, in the narrowband position, to be less selective to unwanted signals. Bandwidth at the narrow setting is 3 MHz at −3-dB points. At approximately 4 MHz from the tuned frequency, response is claimed down 10 to 12 dB. Gain is said to be −5 dB in narrowband position, −12 dB in wideband, referenced to a standard dipole. $89.95.

CIRCLE NO. 97 ON FREE INFORMATION CARD

AP PRODUCTS BREADBOARDS

The Unicard series of reusable, solderless breadboard module cards from AP products has been revised. Like the previous Unicards, the new models include matrix breadboarding sockets on bus-wired circuit boards designed to plug into standard 5¼" card racks. They also have extractor handles for easy withdrawal and rubber feet for protection during bench work. The new Unicards' matrix sockets now have rows of 5 tie-points (vs. the previous models' 4), giving the new Unicard I a total of 960 tie-points (192 rows of 5) and 1620 (324×5) for the new version of the Unicard II. Prices start at $31.50 for the Unicard I.

CIRCLE NO. 98 ON FREE INFORMATION CARD

BOSE SPEAKER SYSTEM

A new Bose Direct/Reflecting speaker system, Model 601, features four 3" tweeters and two 8" woofers, all radiating in different directions through the top and front of the ported enclosure. System impedance is 8 ohms;

crossover frequency, 2 kHz. Minimum amplifier power required is 15 watts rms per channel or more. A major portion of the sound energy is directed upward, both directly to the listener and indirectly via the wall above and behind the speaker, to position the sound above the level of sound-absorbing furniture and simplify speaker placement. A 2-position "symmetry control," which alters the speaker's directional characteristics by varying the signal level to the various drivers, is also provided as an aid to easier placement. The 601 is supplied in mirror-image pairs. Dimensions are 25.5"H × 15"W × 13"D (66 × 39 × 33 cm).

CIRCLE NO. 99 ON FREE INFORMATION CARD

PANASONIC CAR CASSETTE PLAYER

The Model CX-7100 cassette player is one of a new line of car audio components introduced by Panasonic. The CX-7100 has an auto reverse mechanism for continuous play, a two-stage preamp and dual-channel amplifier. Output power is 4.5 watts per channel at 400 Hz with 10% THD into a 4-ohm load. Other features include one-lever operation for fast forward/rewind/eject, lockable fast forward and rewind, and automatic and manual program selector, and a direction indicator lamp. Dimensions are 7 4/5"W × 2 12/25"H × 5 3/10"D (190 × 64 × 135 mm) and weight is 3.3 lb (1.5 kg). Price $99.95.

CIRCLE NO. 100 ON FREE INFORMATION CARD

New Literature

CB ANTENNA TUNER BROCHURE

"The Ultimate in Antenna Tuning Systems," a new four-page brochure that describes new "isolated circuit" antenna tuners for mobile and base stations for CB operation is available from Norcom Electronics Inc. The brochure illustrates and describes the company's "Iso-Tune," "Back Talk," and "Ultra-Tune" antenna tuners, all of which are said to tune antenna systems to optimum SWR across all 40 channels. Address: Norcom Electronics Inc., 23611 Chagrin Blvd., Beachwood, OH 44122.

NBS HOME SECURITY ALARM PAMPHLET

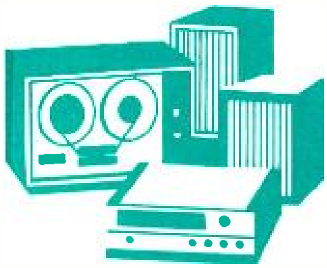
Descriptions of the different home security alarm systems and their operation are highlighted in "Home Security Alarms: What They Are and How They Work" from the National Bureau of Standards. The pamphlet suggests where each type of system should be installed for best protection, explains how the sensors and "panic buttons" are connected to the control unit, tells how the alarm reports intrusions, and offers tips on cost, quality, and performance. Address: Home Security Alarms, Dept. 676E, Consumer Information Center, Pueblo, CO 81009.

ORA REPLACEMENT CATALOG

Eight-page catalog contains original Japanese replacement parts for the service of CB radio, TV, hi-fi equipment, etc. It features integrated circuits, transistors, ceramic filters, tape and cassette heads, plus more. Address: Ora Electronics, Box 7548, Van Nuys, CA 91409.

HEATH INSTRUMENTS CATALOG

A 32-page Heath/Schlumberger catalog lists their complete line of test instruments and new products. These include three new frequency counters with ranges up to 1 GHz, a FET multimeter, a lin/log swept-function generator, and a low-cost voltage-controlled function generator. Other instruments included are oscilloscopes, chart recorders, VOM's and VTM's, power supplies, distortion analyzers, color TV service equipment, learn-at-home electronics courses, and more. Address: Heath/Schlumberger Instruments, Dept. 570-010, Benton Harbor, MI 49022.



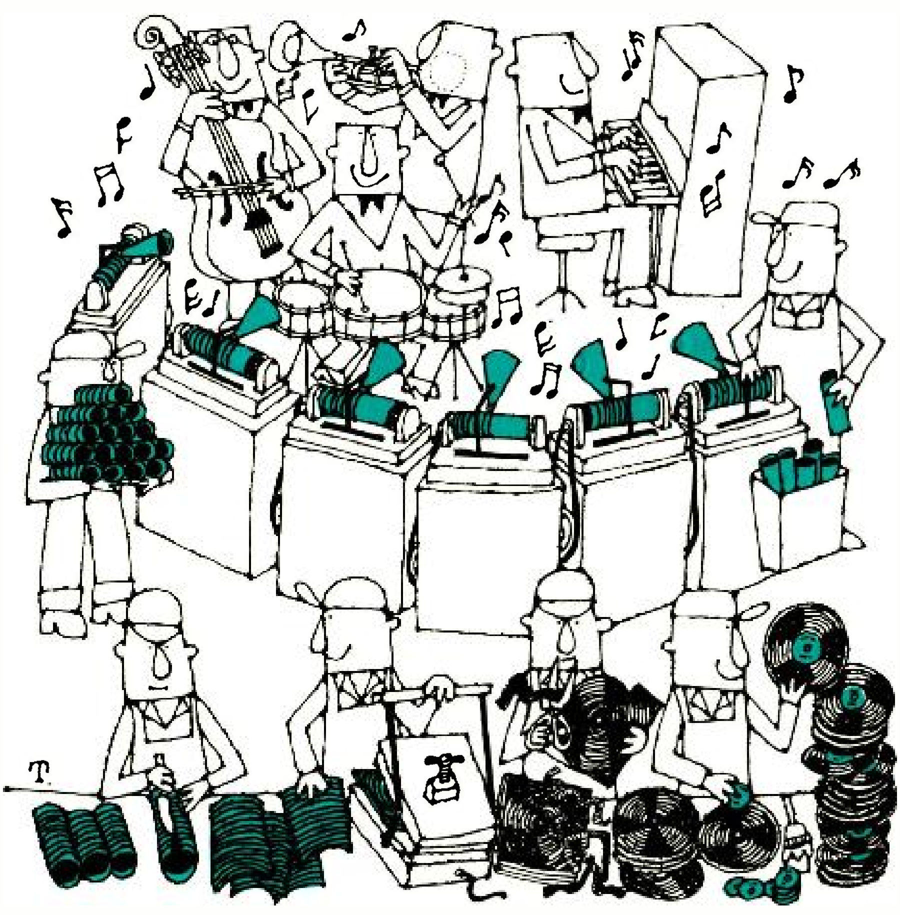
Stereo Scene

By Ralph Hodges

THE DIRECT-TO-DISC REVOLUTION(?)

NOT LONG AGO, I got my first chance to participate in a direct-to-disc recording session. It was not what you'd call a major production. Only one performer, a function generator, was involved, and the object was to put about a minute or so of a 1-kHz square wave on lacquer (i.e., the lacquer-coated aluminum disc on which a master disc recording is cut).

You probably have noticed oscilloscope photos of 1-kHz square waves in phono-cartridge test reports, usually made with a square-wave test record from CBS. If the cartridge is reasonably good, the photos can look pretty decent in terms of waveform and visible resonances; and if a cartridge can make the waveform look good, we can generally assume that the recording itself is good, right? A fair assumption. However, CBS has cut that square wave without RIAA equalization, so that, with a magnetic phono cartridge, the recording must be played back with a "flat" phono preamplifier. Most consumers don't have a suitable high-sensitivity preamplifier that lacks RIAA equalization. Therefore, our intention was to cut a square wave with the full RIAA recording preemphasis, so that it would play back flat on the average audiophile's phono system. This makes a world of difference and of difficulty in the cutting studio.



The Agony of Defeat. The sorry fact is that the best of modern disc-recording equipment cannot cut a clean 1-kHz RIAA square wave. At least it couldn't the way we were going about it, with a modified Wavetek function generator having a rise time almost faster than light. We used in succession the current Ortofon and Neumann cutters, generally considered to represent the state of the art, with about an equal lack of success. Even some of the cutters' electronics were found not up to the task, so that we had to bypass them and run straight into the lathes' power amplifiers. Still not good enough! A cutting-stylus assembly is a comparatively massy, inertia-plagued structure which, when stimulated in this brutal way, is just bound to ring. We could see the ringing under the microscope and we could see it when we played the test cuts, indicating that —in this respect at least—the playback phono cartridge was actually better than the cutting instrument.

Finally we fudged and cut a 500-Hz square wave instead (which, because we were doing half-speed cutting, was actually 250 Hz as far as the cutter head was concerned). This turned out to be much easier.

Direct-Cutting Philosophy. I began this column by saying that this was a direct-to-disc recording session, and it certainly was for a minute or two. However, almost all the rest of the many cuts we were putting onto our test record were derived from a master tape, and you may be justified in wondering why the square-wave test couldn't come from the master tape as well. The reason is that, as bad as a cutter head seems to be at handling a square wave, the typical tape machine is about a hundred times worse. Although tape recording involves no mechanical inertia (according to Barkhausen, there is definitely a sort of *magnetic* "inertia" involved, however), it does involve oodles of phase shift. Sony offers a phase-corrected machine (Model TC-880-2) that can reproduce a nicely recognizable

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square wave for an oscilloscope display. But even so, in comparison with a cutting lathe, most tape machines come off a distinct second best, all possible things being considered.

At present, phase shift is a controversial subject in audio circles. It's easy to demonstrate that you can put a square wave through huge amounts of it and never hear the difference. But on the other hand, process it in another way and you might hear a very distinct difference. And, of course, keeping track of phase phenomena in a modern recording facility handling music signals by means of multiple microphones, several tape machines, numerous signal processors, and finally a cutting lathe is staggeringly complex. In fact, in practice no one really attempts to do it; everyone down the line just tries to trust his ears.

This is one of the cases frequently made for direct-to-disc recordings, the recent proliferation of which has come as a great surprise to many both within and outside the music/recording industry. To take the points made by the direct-cut recordists and their disciples in some sort of order:

(1) Simplify. Eliminate all those generations of tape, which can only degrade rather than exalt the final result, and take the music right to its final recorded form as directly as possible.

(2) Again, simplify. A direct-cut recording must take place in real time, and it is absolutely final. The mixing engineer will therefore have to decide on his basic balances right at the start, and forget about any possibility of "fixing" them somehow in a later mixdown session. He will also realize that any wrong move he makes at the mixing console will ruin an entire LP side, every single note of which will have to be rerecorded. On the assumption that an engineer/producer's second and third guesses are frequently worse than his first (made when the performers were actually present and playing), the direct-to-disc approach imposes a harsh discipline that will (theoretically) make for a better final recording. It will also serve to make the engineer/producer much more conservative, which is the way audio purists generally think he ought to be.

(3) And yet again, simplify. Many audiophiles and many audio professionals suspect that the Dolby system and other noise-reduction processors, which have largely contributed to making the whole multitrack recording technique possible, are responsible for considerable audible degradation of the final result. (This is not by any means proven, I hasten to point out.) Properly executed direct-disc recording is inherently quiet, so you can get rid of all the black boxes.

(4) Improve. The tape medium in its present form is seriously limited by noise on the one hand and magnetic-saturation effects on the other. The disc medium is temperature, excursion, and velocity limited. Temperature is always a consideration; it is readily possible to burn out the coils of a cutter head. But temperature considerations are largely irrelevant to noise and distortion. As for excursion and velocity, a modern cutter can create a groove that undulates widely and rapidly enough to throw any available playback stylus into fits of mistracking. Hence a tape recordist constantly flirts with distortion to maintain dynamic range. A disc recordist need worry only about seeing smoke—and about the possibility of cutting a groove that no consumer record player will be able to follow. Thus, disc recording is superior (theoretically) in performance potential and overall flexibility.

(5) Rationalize. The disc medium does of course have some serious ultimate limitations, most of them concerned with the fact that an LP record is only 12 inches wide. Grooves take up space, and the more vigorous their excursions the more space they take up. It occasionally happens that a recording studio sends a 60-minute tape, full of electric bass and kick drum, to a disc-mastering house with instructions to turn it into a single LP that is louder and bassier than anything in the "Top Ten." Well, it simply can't be done. So the disc engineer curses the tape engineer, and finally some compromise is worked out whereby the tape is either "conditioned" to suit the disc's limitations and/or some material is dropped. Now had the disc engineer been involved from the moment the first microphone was set up, making available his intimate knowledge of the potential and limitations of his equipment (with which the tape engineer often has only a passing familiarity), the final recording would be (theoretically) much more rationally and carefully produced. I need hardly point out that, in a direct-to-disc situation, the disc engineer *is* present right from the beginning.

The Consumer View. Everyone I know who has heard any of the better direct-to-disc productions has recognized their sonic merits to at least some degree (the musical merits of some of them are debatable, though). I will never

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forget the expression on the face of a widely known and respected tape authority when he heard the concluding finger-cymbal "ping" on the "Peace Train" cut (Sheffield release number 2) come through his speakers. And that points up one of direct-to-disc's distinct advantages: the disc medium is capable of considerably more dynamic range at high frequencies than is the current tape medium. As Craig Stark clearly pointed out in an article in the November issue of this magazine, tape will actually lose high-frequency energy the further it is driven into saturation. The disc medium, particularly if a CD-4 cutting stylus is used, will not lose "recoverable" energy in this way; it may actually gain energy from distortion products (which may come from overload of the cutter-head amplifiers, the cutter head itself, or your playback stylus or electronics).

Otherwise, reaction to the direct-to-disc phenomenon seems to be mixed. In what I think is the majority view, serious listeners believe that a disc recording originating from a tape source can be just as technically satisfying, although it may not be capable of quite so many sonic pyrotechnics. I won't comment except to say that most recordings I hear are far from equalling the better direct-to-disc productions. Of course, this is readily attributable to the typical record's being a mass-produced product—a carefully mass-produced product, yes, but one that does not generally receive more care than what is considered necessary for mass-marketability. When someone goes to the trouble of producing a direct-to-disc recording, he is not likely to neglect the subsequent metalwork, pressing, and packaging that will bring it to the consumer in the most attractive form possible. Some, like the Umbrella albums distributed by Audio Technica, bear a prominent individual serial number, and are treated in every way like a limited-edition fine arts print. (Incidentally, direct-to-disc recordings are true limited editions. When all the parts involved in pressing the record, from lacquer to metal master to mother to stamper are worn out, the recording ceases to be available unless the performers go back into the recording studio and do it all over again. Some direct-to-disc producers even skip the mother-stamper stages and press from the metal masters, which makes the edition even more limited, although of potentially higher quality.)

Aesthetics may also deserve a part in the direct-to-disc picture. My reaction on first hearing the Lincoln Mayorga Brahms-Handel piano coupling (Sheffield Lab 4) was that the performance, although not likely to devastate the musical world, had a very satisfying vitality, flow and continuity. Continuity is forced upon a performer by the direct-cut process; a cutting lathe cannot be stopped at mid-LP side and then restarted. Many music appreciators seem to feel that the patched-together performance made possible by tape editing has become a wretched excess—another instance in which direct-to-disc imposes a possibly beneficial discipline on all the parties that are involved.

Most people believe that economics will determine the final fate of direct-to-disc recording. As far as I know, you cannot buy a direct-cut disc for less than about $12, which may be a bargain because these recordings are not cheap to produce. The one truly large-scale production to emerge so far is Telarc's recording, distributed by Discwasher, of the Cleveland Orchestra playing selections of Berlioz and others. (However, look for at least one big orchestral release from Sheffield at any moment.) I have nothing but admiration for the dedicated people who embarked on this project, but it must have been frighteningly expensive to finance. And it is, alas, flawed (flawed in my opinion by an improper application of multi-miking techniques—a practice that the "simplicity" philosophy of direct-to-disc seemed destined to resist). As has been pointed out, the recording does not offer an overwhelming amount of music per side, both because the sides were intended to be of the highest quality and because the recording engineer had to space the grooves by intuition. (When you cut a record from a tape, a "preview" head some distance in front of the actual playback head scans the tape and directs a computer to allow as much groove spacing—but no more—as is necessary to accommodate the musical violence that is to follow).

Still, the Telarc/Cleveland production has some exciting things to be heard, if your sound system and your aural expectations are as demanding as my own. As listeners to recorded music, we may never encounter its like again. And there is one thing everyone is hopeful about: that the conspicuous success of the direct-to-disc revolution will force the standards of all recorded music to become that much higher. At present, the great body of recorded music has a long way to go. ◇

Julian Hirsch Audio Reports

HIRSCH/HOUCK LABORATORIES

LOUDNESS CONTROL—BOON OR BANE?

MOST PEOPLE, when they first see a knob labelled "loudness" on a high-fidelity amplifier or receiver, probably assume that it is just a volume control under a different name. To be sure, it does control volume, but the distinction between a *volume* control and a *loudness* control is much more than a matter of semantics or word choice.

In the earliest days of hi-fi, people became aware that, when the volume of a musical or vocal program was reduced, the balance between the low, middle, and high frequencies was altered. The apparent bass volume decreased much more than the mid-range, or overall volume level, and to a lesser extent there was an exaggerated loss of highs as well. The effect was to give a program a thin, constricted sound at low listening levels, even when the system was capable of delivering a full-frequency-range response at normal listening levels.

The explanation of this effect lies not in the equipment, but in a property of the human ear. We do not hear all frequencies with equal loudness, even though they may impinge on the ear with equal intensity. The ear is most sensitive at about 3500 Hz and slightly less so at lower and higher frequencies, even at high volume levels. In addition, the change in hearing sensitivity (the human frequency response, if you will) is also level dependent. At sound levels of 90 dB or more (a rather loud level for home music reproduction) there is relatively little difference in hearing sensitivity over much of the audio range, except for the broad peak in response at about 3500 Hz. As the absolute sound level is decreased, low frequencies must be emphasized proportionally in order to sound as loud as a 1000-Hz reference tone. The same sort of emphasis is required at high frequencies for equal apparent loudness, except that the shape of the curve at high frequencies changes very little with changes in loudness.

A number of acousticians have made experimental studies of this effect. Perhaps best-known were Fletcher and Munson, of Bell Telephone Laboratories, whose findings were published in the early 1930's. Subsequently, other investigators derived somewhat different families of curves that relate subjective loudness to frequency and level. The Fletcher-Munson Equal Loudness Contours are reproduced in Fig. 1. As we shall see, their validity, or lack of it, as compared to the results obtained in later experiments, has little bearing on the subject at hand. The contours represent the sound pressure level (SPL) required at various frequencies to sound as loud as a 1000-Hz tone does at the indicated level.

Early hi-fi enthusiasts were quick to relate the phenomenon of apparent loss of bass at low volumes to the Fletcher-Munson effect. If their findings were correct, it would be reasonable to assume that, if a truly high-fidelity recording of a musical performance which would be heard at levels of 90 dB or more in the concert hall were to be played in the home at a 60-dB average level, there would be a considerable loss of apparent bass response. In fact, the Fletcher-Munson contours show that a 30-Hz tone would have to be boosted in level by about 25 dB to sound as loud as a 1000-Hz tone at 60 dB but would require a correction of only about 3 dB at 90-dB levels.

An apparently simple and logical solution to this dilemma would be to build a frequency compensating circuit into the volume control of the amplifier so that reducing the midrange level boosts the bass (and possibly the treble, although there are differing views on this) in the correct amounts to conform to the shape of the equal-loudness contour for each listening level. This is essentially what has been done (or at least attempted) in the vast majority of amplifiers and receivers manufactured for the high-fidelity market in the past 25 years or more.

Unfortunately, although all of these *loudness compensators* do pretty much what they were designed to do (electrically), most of them fail dismally to make a recording or broadcast sound as natural at low levels as it does at higher listening levels. Worse, most of them make the sound so tubby and heavy that few serious music lovers would even consider using the compensation. Fortunately, in almost every amplifier, it can be switched off, leaving the "loudness control" to act as a normal volume control.

To see why these schemes fail, take another look at the Fletcher-Munson curves. Each is related to a specific sound pressure level at the listener's ear. Now look at the family of loudness compensation frequency-response curves in Fig. 2, which are typical of the performance of most modern amplifiers and re-

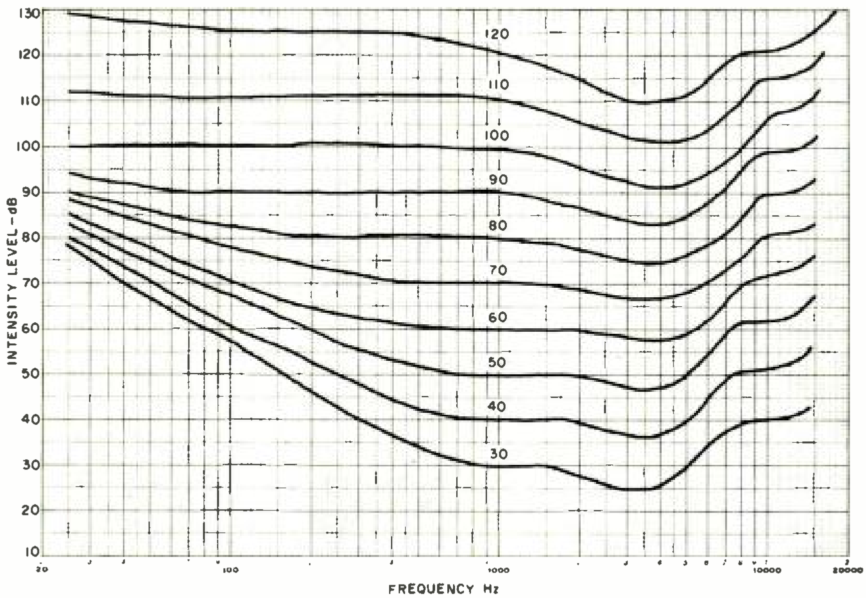


Fig. 1. Fletcher-Munson curves show how perceived loudness varies with frequency even though test signal amplitude remains constant over range.

ceivers. Each is related to a specific amplifier volume control setting, with 0 dB corresponding to a maximum volume setting. Unfortunately, there is no relationship between the two sets of curves. Even their shapes are different, but if they were alike, the situation would be no better. Depending on the gain of the amplifier, efficiency and frequency response of the speaker systems, size of the listening room and its furnishings, listening level preferences, particular recording, sensitivity of the phono cartridge, acoustic conditions under which the recording was made, and other factors equally beyond the listener's control or knowledge, the amount of boost provided by the loudness control may be nearly correct. However, it is more likely to give too much or too little compensation at any given frequency. There is literally almost no chance for such a system to perform properly.

It would appear to be self-evident that *any* type of loudness compensation must have a means for independently setting the absolute listening level and the amount of compensation applied. In effect, this means two volume controls are required. Inexplicably, this point seems to have escaped the attention of the vast majority of receiver and amplifier designers. (They know better, of course, but marketing considerations tend to dominate the situation.) The end result is the almost universal use of a simple tapped volume control with a capacitor or a simple RC network that comes into play at a certain control setting, regardless of program level.

All of the equal-loudness contour curves were derived from measurements made on numbers of human subjects and statistically processed so that the result is a sort of composite or "average" hearing response. Statistics being what they are, there is always a good chance that you or I will hear things differently from the predictions of the curves. Even if the compensation worked perfectly, it would not be correct for us. In this author's opinion, the exact compensation curve used at any given control setting is relatively unimportant, since the whole process is at best a crude approximation. Any of the proposed compensation curves, when applied correctly, is probably better than nothing. However, when they are applied

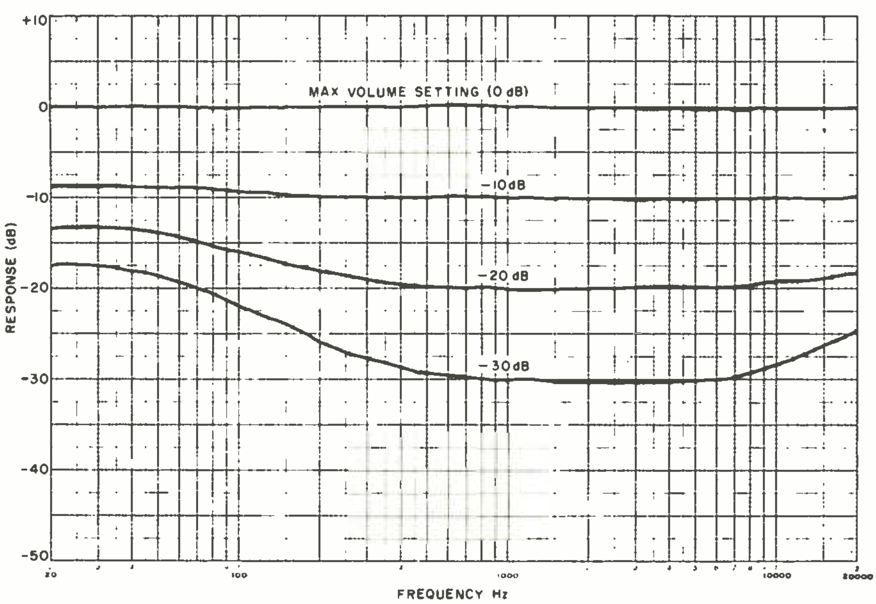


Fig. 2. Loudness compensation curves typical of performance of most modern amplifiers and receivers. Each is related to a specific volume setting.

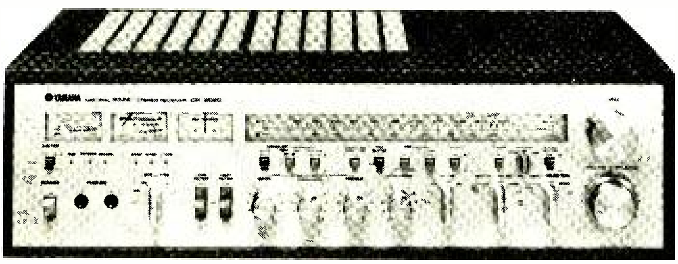
incorrectly, it is certain that any of them is worse than nothing at all.

The situation is not completely hopeless, however. The handful of receivers and amplifiers that do have separate volume and loudness controls can usually be made to sound at least acceptable when loudness compensation is used for low-level listening. Some are better than others, and individual preferences certainly play a part in such quality judgments. One of the best indications of a good loudness compensation system is that the loudness of the program hardly seems to change as the control setting is changed. This may seem paradoxical (after all, we *do* want to change the volume), but the key word is "seems."

A case in point is the Yamaha Model CR-2020 receiver reviewed in this issue. It is astonishing how little the quality of the program changes as the loudness control is operated through its full range, yet the midrange level has changed by 20 dB, or a power ratio of 100 times. The program becomes less loud, but almost imperceptibly so because the frequency balance is maintained at a subjectively constant value. This is the entire justification for the loudness control in the first place.

YAMAHA MODEL CR-2020 AM/STEREO FM RECEIVER

Medium-high-power receiver has exceptionally versatile operating flexibility.



HIRSCH-HOUCK LABS REPORT

All Yamaha hi-fi recievers share a basic family resemblance. The Model CR-2020 AM/stereo FM receiver represents no exception. It is rated to give 100 watts/channel into 8 ohms from 20 to 20,000 Hz with less than 0.05% total harmonic distortion (THD). The receiver's front panel has a simple rectangular dial cutout with no bezel or decorative trim across the top of its silver-colored panel.

The receiver is supplied in an attractively finished walnut-grain wooden cabinet. It measures 21¼"W × 16¼"D × 6½"H (54 × 41.5 × 16.7 cm) and weighs 42.5 lb (19.3 kg). National advertised value is $700.

General Description. The FM scale has linearly spaced calibrations at 0.5-MHz intervals and red LED's that indicate which tuner section (FM or AM) is in use. The dial "pointer" is a piece of plastic that resembles the cursor on a slide rule, with a fine red line that facilitates precise frequency readings. The smooth flywheel mechanism that drives the tuning system is operated by a large aluminum knob to the right of the dial window.

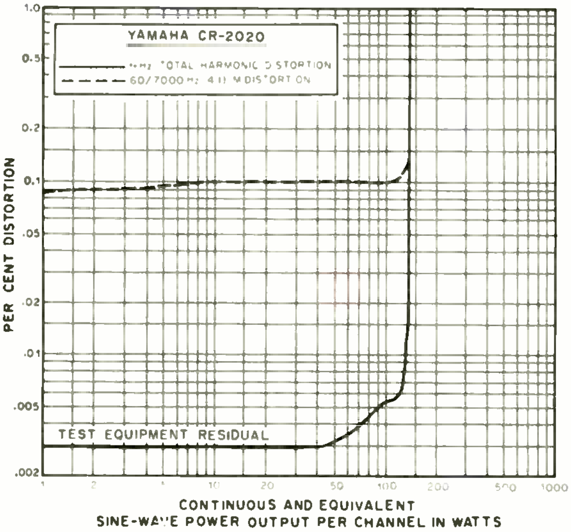
To the left of the dial are three meters. The FM TUNING meter is a conventional center-of-channel indicator. The other two meters are labelled SP OUT; they indicate the voltages across the speaker terminals and are calibrated logarithmically in watts delivered to 8-ohm loads over a range of from less than 0.01 watt to 200 watts. The center meter, moreover, serves a dual function. In addition to being an SP OUT meter, it also serves as a SIGNAL Q meter to indicate the signal quality and is, hence, a combination signal-strength and multipath-distortion meter. When a signal has been tuned for a maximum pointer deflection and the antenna is oriented for minimum fluctuation of the meter's pointer, the signal is heard with the least amount of noise and distortion.

A button under one of the meters converts the center meter to a full-time SIGNAL Q meter when it is depressed, simultaneously disengaging the other SP OUT meter. In normal use, with the button in its out position, the function change occurs automatically. As soon as the tuning knob is touched, the center meter indicates signal quality. Releasing the knob automatically switches the meter back to indicating output power. The switch is provided for situations where one cannot hold the tuning knob, as when changing antenna orientation.

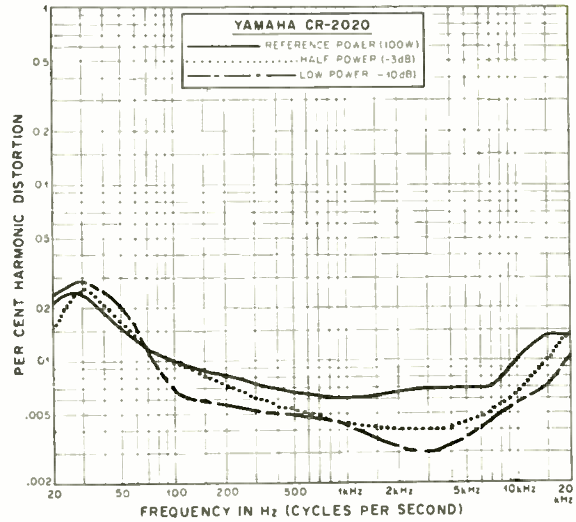
At the lower right of the front panel is a large VOLUME control knob, behind which is a center-detented BALANCE ring. The other controls are arranged in functional groups, with the tone controls at the lower center of the panel. The BASS, TREBLE, and PRESENCE controls each have 11 detented positions. Buttons above them can be used to change the bass and treble turnover frequencies, with a choice of 125 or 500 Hz for the bass and 2.5 or 8 kHz for the treble. The action of the PRESENCE control is centered at 3000 Hz, unlike the usual midrange tone control that operates at 1000 or 1500 Hz. A button located between the turnover selectors is used to switch in and out the tone controls.

The LOUDNESS compensation control, located to the right of the tone controls, is a Yamaha exclusive. This 11-position detented control allows a user to vary the midrange gain over a 20-dB range while simultaneously boosting the low and high frequencies relative to the midrange. With the LOUDNESS control fully clockwise, the response is flat and the VOLUME control is set to give the loudest listening level one expects to use. Then when the volume is adjusted with the LOUDNESS control, a proper balance is maintained between the different frequencies without the unnatural heaviness that mars the sound of most loudness-compensation systems.

The MODE selector can be used to connect either channel or their sum to both audio channels as well as to provide normal and reversed channel stereo operation. The INPUT SELECTOR



1000-Hz total harmonic distortion and 60/7000-Hz IM distortion.



Total harmonic distortion at rated (100 W), half, and low power.

and REC OUT SELECTOR, unique to the entire Yamaha receiver line, are entirely independent. This setup allows one to tape from any source while listening to any other source.

The INPUT SELECTOR has positions for TAPE 1, TAPE 2, TUNER, PHONO, and AUX. The REC OUT SELECTOR can supply either one or two tape decks with signals from TUNER, AUX, or PHONO sources or from the preamplifier output (PRE OUT). The last permits the full tone-control and filter capability of the receiver to be used ahead of the tape recording process. There are two cross-connected dubbing positions for copying tapes from either machine to the other and providing the capability of monitoring the playback from either deck with the appropriate setting of the INPUT SELECTOR.

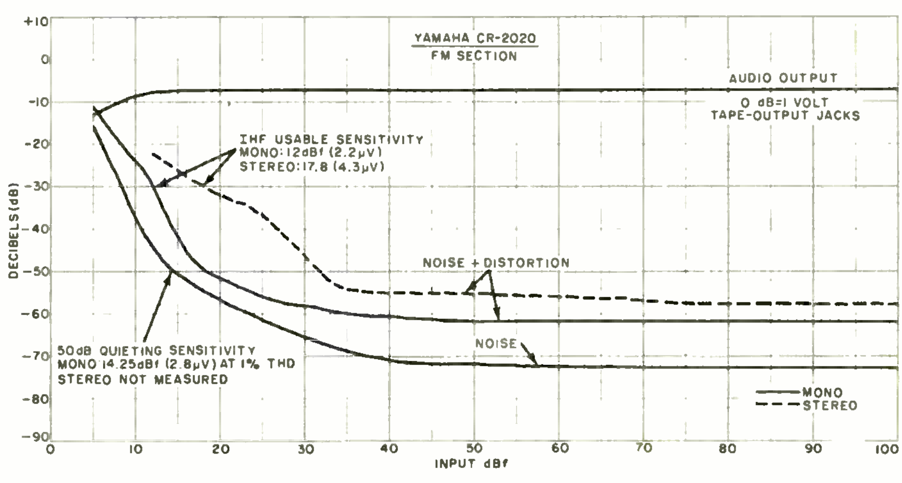
Above the tape switches are a TUNER button that allows selection of either AM or FM reception and a small PHONO selection switch with positions for a magnetic and a moving-coil cartridge input. (The receiver has a built-in "prepreamplifier" for the very low output of moving-coil cartridges.) The AUDIO MUTE button, located near these controls, permits the audio level to be reduced by 20 dB for temporary interruptions.

Other buttons under the dial scales include switching for an external DOLBY FM ADAPTER, which simultaneously changes the deemphasis from 75 to 25 μs; FM BLEND for noise reduction on weak stereo signals; FM MUTING, which in its OFF position switches the tuner to mono operation; and MUTING LEVEL for selection of either a 3- or a 30-μV muting threshold. The final button, labelled OTS (Optimum Tuning System), actually controls an afc system that is automatically deactivated when the tuning knob is touched. When a station is tuned in and the tuning knob is released, the afc system comes on slowly. With the OTS button engaged, the OTS is disabled at all times.

Completing the front-panel control lineup are lever switches for POWER and LOW and HIGH FILTERS and a rotary switch that connects any or none of three pairs of speaker systems or two combinations of two pairs at a time to the amplifier's outputs. The FILTER switches each have three positions with center OFF. The LOW turnover frequencies are nominally at 15 and 70 Hz, the HIGH at 8000 and 12,000 Hz. All filter slopes are at a rate of 12 dB/octave. Above these switches is a row of LED's that indicate the status of the POWER, TONE CONTROL, AUDIO MUTING, FM BLEND, and OTS switches and when a stereo FM station is being received. There are also two PHONES jacks on the panel.

On the rear apron of the receiver are a full complement of phono-jack connectors for the signal sources, three sets of insulated spring clips for the amplifier outputs, and antenna terminals for 75- and 300-ohm FM antennas and a wire-type AM antenna. The ferrite-rod AM antenna is hinged. Separate PRE OUT and MAIN IN amplifier connectors that are normally joined together by a slide switch make it possible to insert signal-processing devices between the two parts of the circuit. There are also three accessory ac outlets on the rear apron, one of which is switched.

Laboratory Measurements. Yamaha does not use the "standard" method for rating the distortion and noise performance of its receivers. The company's Noise-Distortion Clearance Range method is an expression of the



Noise and sensitivity curves for FM section of receiver.

total noise and distortion in the output of the amplifier as a function of output power when measured with a conventional null-type distortion meter. This part is quite standard; where the departure from the standard arises is in making the measurement through the preamplifier at 1000 Hz with the VOLUME control set 20 db below its maximum.

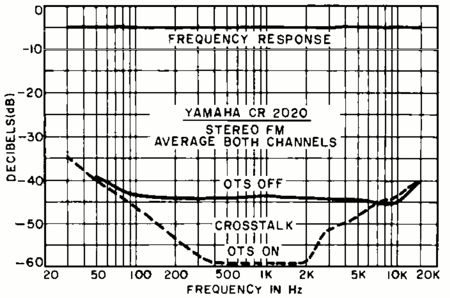
In the case of the Model CR-2020, Yamaha's NDCR rating is less than 0.1% noise and distortion between 100 mW and 100 watts output into 8 ohms. This represents very good performance, especially at the low-power end where the distortion of most amplifiers is masked by noise. To a great extent, this is due to the use of a dual volume control, with one section before the tone control amplifier and the other following it. This causes the noise to drop steadily as the volume setting is reduced, yet minimizes the possibility of overload from a high-level input signal.

We did not measure the NDCR as such, but much of the same information can be inferred from our normal measurements. The one-hour pre-conditioning period at one-third power made the receiver quite hot, especially on the grille above the output transistors, but with no ill effects. The outputs clipped at 130 watts/channel, with both channels driving 8-ohm loads at 1000 Hz. The 4- and 16-ohm clipping levels were 172 and 82 watts, respectively.

The 1000-Hz THD was below the 0.003% residual of our test equipment from 0.1 watt to more than 50 watts output and was only 0.007% at 120 watts, just short of the clipping point. The IM distortion was 0.057% at 0.1 watt and about 0.1% in the 10-to-130-watt output range. Even at a very low output of 10 mW, the IM was under 0.1%, which was an indication of the relative absence of crossover distortion.

At rated power and below, the THD was 0.02% to 0.03% at 20 to 50 Hz (approximately the residual of the test equipment at those frequencies). It reduced to 0.003% to 0.006% at middle frequencies and increased to 0.01% to 0.015% at 20,000 Hz. The risetime, through the AUX inputs, was 5 μs, and the slew rate of the amplifier was 21 volts per microsecond.

As might be expected, the tone controls could provide almost any desired response characteristic. With the 125- and 8,000-Hz turnover frequencies, a considerable variation was possible in the output at the frequency extremes, with no effect between 300 and 3000



Frequency response and crosstalk with optimum tuning in and out.

Hz. The action of the PRESENCE control peaked at 3500 Hz and had no effect below 1000 Hz or beyond 10,000 Hz. Since the maximum range of this control was ±6 dB, extreme effects were not possible. It was much more subtle in its action than some earlier so-called "presence" controls we had seen.

The filters are among the best to be found on a contemporary receiver. The measured cutoff frequencies of the HIGH filter (where the response was down 3 dB) were 7 and 10 kHz, and with its 12-dB/octave slope, it was possible to reduce hiss significantly without a serious effect on program quality. The LOW filter had its −3-dB frequency at 75 Hz (in its 70-Hz position) and was an effective rumble filter. In the 15-Hz position, the response was down 2 dB at our lower measurement limit of 20 Hz.

Yamaha's loudness compensation is, in our opinion, one of the best (if not *the* best) currently available. It is probably the only one we are able to use without unacceptable deterioration of listening quality. As the control is turned counterclockwise, the loudness drops almost imperceptibly, because the apparent frequency balance remains constant over the full 20-dB range of the control. (That range is somewhat limited and might require the main VOLUME control to be reset from time to time, but this is a small price to pay for the listening benefits of the system.)

The RIAA equalization error of the phono preamplifier was too small to measure, being less than the inherent ±0.25 dB resolution of the General Radio frequency-response plotter. The equalization changed by less than 0.5 dB at any frequency when measured through the inductance of a typical phono cartridge.

The receiver has an unusually high audio gain. It required only 35 mV at the AUX inputs, 0.58 mV at the PHONO input, for a reference output of 10 watts. The respective unweighted noise levels were −82 and −72 dB, which in addition to the very low distortion readings tend to confirm Yamaha's NDCR rating. In spite of its high sensitivity, the phono input overloaded at a very high 280-mV input. No measurements were made on the moving coil "prepreamplifier."

The FM tuner section was in many ways as impressive as the receiver's audio amplifier. In mono, the IHF sensitivity was 12 dBf (2.2 μV) with 1% distortion. In stereo, the IHF sensitivity was 17.8 dBf (4.3 μV), but the 50-dB quieting sensitivity could not be measured accurately because of a considerable level of 19-kHz pilot carrier signal that masked the noise level in the audio outputs. The pilot carrier level was −48 dB, making this one of the very few specifications in which the receiver fell short of its published ratings. (The rated suppression is 60 dB, which is not a particularly low figure, either.)

The distortion at a 65-dBf (1000 μV) input was 0.085% in mono and 0.16% in stereo, and the mono S/N at that input was 72.5 dB. These measurements were made, as the IHF standard specifies, with the AFC (OTS) turned off. Turning it on resulted in a substantial increase in distortion, to 0.58%. Carefully centering the tuning meter actually made the distortion greater, yielding a 0.75% reading. The stereo distortion, with L − R modulation and OTS off, was 0.4% at 100 Hz, 0.089% at 1000 Hz, and 0.12% at 6000 Hz.

The FM frequency response was ruler-flat, varying no more than about ±0.1 dB from 30 to 15,000 Hz with the OTS on. With the OTS off, the response was much the same, except that the tuner section switched into mono below 50 Hz for some inexplicable reason. This was one of several strange effects we observed, mostly relating to the automatic functions of the receiver, such as the OTS and the meter function switching. For example, the stereo channel separation was virtually uniform at 44 to 45 dB from 100 to 12,000 Hz and still a superb 40 dB at 30 and 15,000 Hz with the OTS off. Turning on the OTS improved the separation dramatically to an almost unbelievable 59 to 60 dB between 500 and 2000 Hz.

The other tuner performance characteristics ranged from good to excellent. The capture ratio was 1 dB at a 45-dBf (100 μV) input and 0.8 dB at 65 dBf. The AM rejection was a very good 70 dB. Image rejection was about 88 dB. Alternate channel selectivity was 74 dB, and adjacent channel selectivity was 4 dB. The stereo threshold was 12 and 33 dBf (2.2 and 25 μV) in the alternate positions of the MUTE switch. The corresponding muting thresholds were 14 and 35 dBf (2.7 and 30 μV). The muting had no hysteresis allowing it to drop in and out with almost no change in signal level. This is undesirable, since a fading signal can rapidly jump in and out of stereo, with more audible side effects than if the mute and unmute levels were slightly different. However, the muting action was very smooth and noise-free.

The AM tuner section had a frequency response (and overall listening quality) far above the average. It had a notable lack of background noise and a frequency response that was down 6 dB at 35 and 7200 Hz.

User Comment. The Yamaha Model CR-2020 receiver was so outstanding in its performance that the few instances where it fell short of expectations are obvious only because of the contrast. Even so, the "plusses" so far outweighed the "minuses" that we were left with a strongly positive net impression of the receiver.

In actual use, the receiver was a pleasure to hear and to operate. Not only does it have just about the best loudness compensator in the business, but its operating flexibility is extraordinary. The receiver competes with a host of very fine receivers, but it can match any of them in sound quality and has few, if any, peers with respect to versatility.

Yamaha does not use a low-pass filter in its FM audio outputs to remove the 19-kHz pilot carrier. Instead, a proprietary carrier cancellation circuit is used. This gives a truly flat frequency response, but in our test unit, it allowed an undesirable amount of the 19-kHz carrier to leak into the program outputs. It is probable that the adjustment of the cancellation circuit had shifted on our test sample. There were, of course, no audible effects from the −48-dB level of the carrier, although it did make some of our measurements difficult to perform. It could easily cause problems with an inadequately filtered tape recorder and almost certainly with an external Dolby unit. There would be no problem if the rated −60-dB suppression were obtained.

In addition to the strange behavior of the OTS system and its effect on distortion and channel separation, the accuracy of the SP OUT meter could not be checked because at power levels exceeding about 10 watts, the meters cut off and returned to zero. On program material, the meters could be driven to about 50 watts before the same thing occurred. Obviously, this is not normal behavior, and we would not be surprised to find that a single fault was responsible for all of these mysterious effects. These are likely unique to our test sample, not the typical production run.

The SIGNAL Q meter was an outstandingly effective tuning aid. It accurately indicated relative signal strength and multipath distortion over a wide range of receiving conditions. Only an oscilloscope might tell the user more, but it would be much more expensive and certainly not as easy to interpret as the meter. Those listeners who depend on AM for any significant part of their listening will find the AM tuner in this receiver to be one of the handful that have acceptably good AM quality—in this case, much more than acceptably good.

In sum, the Yamaha Model CR-2020 is an elegant receiver, tastefully styled and distinctively different from any of its competitors in appearance, operating features, and performance. It is powerful enough for the majority of home installations; yet it is not burdened by excessive size, weight, or price.

CIRCLE NO. 101 ON FREE INFORMATION CARD

OPTONICA MODEL RT-3535 STEREO CASSETTE DECK

Features automatic program locating feature for cueing tape selections.

HIRSCH-HOUCK

Optonica's Model RT-3535 tape deck features a novel Auto Program Locator Device (APLD) that can be used to cue rapidly to any of several selections recorded on a single cassette. To some extent, the APLD system overcomes a fundamental limitation of the tape medium, which usually cannot be readily accessed in a random manner as can be done with disc recordings.

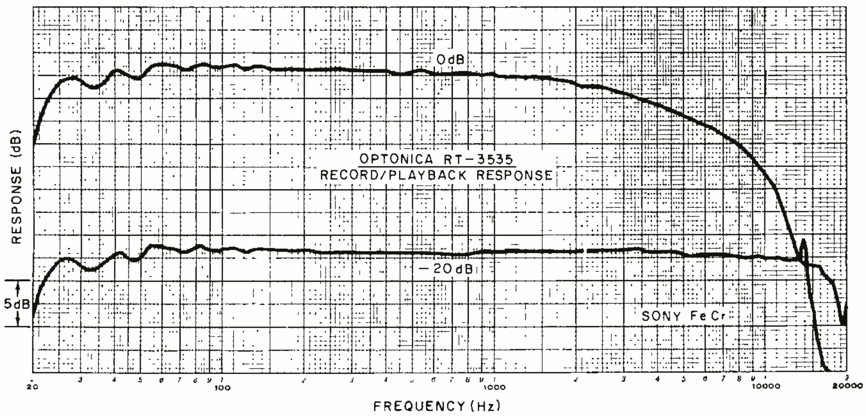
The front-loading deck, which is the company's top-of-line model, features two tape heads and two motors. The capstan is driven by a dc servomotor/ voltage-generator setup, while a high-torque dc motor drives the tape hubs.

The deck measures 18⅜"W × 14"D × 5¾"H (466 × 356 × 146 mm) and weighs 22.4 lb (10.2 kg). Its nationally advertised value is $429.95.

General Description. At the left of the front panel is the tape compartment, below which is the usual row of control levers. Pressing the EJECT lever causes the cassette compartment door to swing upward into the machine. To load a cassette, it must be pushed into the loading ramp at a slight upward angle for a distance of about 2" (5.1 cm), which allows the cassette to drop easily into playing position.

The cassette compartment door must be closed manually. (It can also be left open during play.) If a cassette is already in the compartment, a firm pressure on the EJECT lever pops it out of the compartment for easy removal. Although the cassette compartment door has a window, the angle of the cassette and the lack of internal illumination make it difficult to determine visually the playing status of the tape.

The other levers in the grouping are for controlling tape motion stop/start, turning on and off the record circuits, switching to fast forward or reverse wind, and activating the pause function. It is possible to go from any operating mode to any other operating mode without stopping the tape. The one exception to this is that the tape must come to a stop before the EJECT lever is operated. There is an automatic mechanical disengagement of the capstan at the end of the tape.



Record/playback response of Optonica RT-3535 with Sony FeCr tape.

To the left of the control levers are two microphone jacks, a stereo headphone jack and a pushbutton POWER switch. To the right of the cassette compartment are three pushbuttons labelled SPACE, INPUT and LIMITER, respectively. The SPACE button is used in connection with the APLD system to insert non-signal segments on the tape; the INPUT switch connects the recording preamplifier to either the LINE or the MICROPHONE sources (the two cannot be mixed); and pressing the LIMITER switch automatically prevents distortion from excessive signal levels when the recording level exceeds 0 dB. The index counter and its reset button are located immediately below these pushbuttons.

Three lever switches at the lower center of the panel permit adjustment of the deck's operating parameters for different tape formulations. The BIAS switch has positions labelled LOW, MED, and HIGH. The EQ (equalization) switch has two positions labelled 70 μs and a third labelled 120 μs. Between the BIAS and EQ switches are legends for NORM, FeCr, and CrO_2 that indicate the recommended settings for the three basic tape formulations. (A fourth formulation, low noise/high output, can also be obtained by changing switch positions.) The third switch controls the Dolby noise-reduction system that is built into the deck. It has an OFF and two ON positions, the uppermost connecting the MPX FILTER to remove any 19-kHz pilot carrier from FM signals in addition to providing noise reduction.

At the upper right of the panel are two large illuminated dB meters, between which are a red RECORDING indicator and a green DOLBY indicator. At the bottom of the panel are the OUTPUT control (for adjusting the level of the playback signal simultaneously for both channels) and separate RECORD level controls for the two channels. Between the controls and meters is a row of 10 small black buttons numbered 1 through 9 and C, plus a button with no identification. These are the APLD system controls.

The APLD system functions in both the fast-forward and the rewind modes. It senses the absence of a recorded program between the selections recorded on the tape. As an example of how it works, assume you wish to hear the fifth selection on the tape, omitting the first four selections. A light touch on button number 4 will cause the deck to skip the first four selections and stop at the beginning of the fifth selection. Then, all you need do is operate the PLAY lever to hear the desired selection.

When the number 4 button is touched, the unidentified button proves to be a seven-segment numeric LED indicator that displays the number of the button activated (in this case, a numeral 4). Each time the fast-moving tape passes an interval between selections, the displayed number decrements by one digit.

The C button clears the APLD system's memory. This permits the user to resume normal operation of the deck. If C is pressed during a fast-speed search, the tape stops at that point.

The proper operation of the APLD system depends on the absence of program material for a duration of at least 4 seconds between selections. When the user makes his own recordings, the deck is equipped to insert the necessary silent interval automatically. To accomplish this, the SPACE button is first depressed and at the end of each selection the PAUSE lever is operated. This immediately cuts off the recording signal but allows the tape to run for a few seconds to provide the silent interval.

The level meters are fast-responding, peak-indicating types to minimize the chances of overloading the tape on high-level transients. The tape heads are not accessible from the front. However, a small door on top of the deck can be removed to permit cleaning.

Laboratory Measurements. We checked the playback equalization of the deck with TDK and Nortronics tapes for the "normal" (120-μs) EQ setting and Teac tape for the 70-μs settings. In both cases, the response was within ±1 dB from 40 to 10,000 Hz. The overall record/playback response was then measured with Maxell UD-XL (normal), TDK SA (CrO_2), and Sony Ferrichrome (FeCr), as recommended by Optonica. The "normal" response had a slightly depressed upper midrange output, but was within ±2 dB from 21 to 15,000 Hz. The CrO_2 response was flatter, with a ±2.5-dB variation from 22 to just beyond 15,000 Hz. The best overall frequency response was with FeCr tape, which varied only ±2 dB from 23 to 17,000 Hz, bettering the company's own specification of 30 to 17,000 Hz.

The Dolby circuits changed the high-frequency response by no more than 2 dB at a −20-dB level, and caused no measurable change at a −40-dB level. The MPX FILTER had less than a 1-dB effect on the response at 14,000 Hz, but it attenuated the incoming signals by more than 20 dB at 16,500 Hz and higher frequencies.

For a 0-dB recording level, the input was 72 mV through the LINE inputs and 0.185 mV through the MIC inputs. The playback output from a 0-dB recording depended on the tape used. It ranged from a maximum of 0.77 volt with TDK SA to a minimum of 0.53 volt with Sony FeCr tape. The limiter had no effect until the input level reached +1 dB, but an input of as much as +20 dB was held to an effective 2.7-dB increase in recording level, with only 3% playback distortion. The meters had a 10% to 15% overshoot on 0.3-second tone bursts and indicated +0.5 dB on a standard Dolby level tape of 200 nWb/m. (The calibrated Dolby level is at 0 dB.)

At a 0-dB recording level, the playback distortion was 0.71% with Maxell UD-XL, 2.5% with TDK SA, and 1.8% with Sony FeCr tapes. The reference 3% distortion level was reached at recording inputs of +6 dB, +1 dB, and +3 dB, respectively.

The IEC "A" weighted S/N reading (without Dolby) for the tapes, referred to the 3% distortion signal level, was 60.7 dB with UD-XL, 57.4 dB with SA, and 58.3 dB with FeCr tapes. With the Dolby system switched in and using CCIR weighting, these figures improved to 68.5, 66.4, and 67 dB. At maximum gain, the noise through the microphone inputs increased by 10 dB. But at usable gain settings, the noise increase was both inaudible and unmeasurable.

Although the headphone output was designed for 8-ohm phones, the volume level was adequate with 200-ohm phones as well.

The flutter was 0.13% on playback only in an unweighted rms measurement and 0.14% in a combined record/playback measurement. The transport operated smoothly and quietly. In its fast speeds, it moved a C60 cassette from end to end in about 82 seconds.

User Comment. As our lab measurements reveal, this is a very good recorder, whose performance is generally of the caliber one would expect from a machine in its price class.

One difficult test for many cassette recorders to pass is to record FM tuner interstation hiss at a −10-dB level and to compare the playback with the incoming signal. Most machines reveal varying degrees of dulling of the highs and sometimes low-frequency colorations. The Model RT-3535, however, passed this test with a virtually perfect reproduction of the hiss, using TDK SA tape.

We found that the APLD system performed well on most commercially recorded tapes, but it could be "fooled" by an insufficiently long silent interval between selections or by unexpected silences within a selection. With our own recordings, made with the aid of the SPACE button on the deck, the APLD worked perfectly every time.

This deck marks an auspicious entry for Optonica into the American audio scene. There are a host of cassette decks with generally similar features and performance, but this one offers something different. Perhaps not everyone will find the APLD equally useful, but if random rapid access to one of a series of recordings on the same cassette is of any importance to you, this machine offers an ideal answer to the problem. Best of all, none of the fundamental performance qualities of a first-rate cassette deck seem to have been sacrificed in any way as a result of the inclusion of the APLD system.

dbx MODEL 128 DYNAMIC RANGE ENHANCER

Remarkably effective, versatile unit's operation is formidable to master.

The expanders and compressors from dbx have been a part of professional and home audio scenes for several years. During this time, they have undergone considerable modification and improvement to make them better, more unobtrusive performers. The latest, and perhaps most effective, of the dbx devices is the Model 128 dynamic range enhancer. It is a remarkably versatile accessory that can provide noise reduction and dynamic range enhancement either separately or simultaneously.

The Model 128 is normally connected into the tape recording and monitoring path of an amplifier or receiver. The tape recorder then connects to the system via jacks located on the rear apron of the Model 128. In operation, the Model 128 consumes only 10 watts of power from the ac line.

The Model 128 is compact, measuring only 11"W × 10¾"D × 3¾"H (28 × 27.3 × 9.5 cm) and weighing 8 lb (3.6 kg). Its nationally advertised value is $450.

General Description. As a tape recording noise-reduction system, the Model 128 compresses the signal going into the recorder by a factor of 2:1. (A 20-dB input change emerges as a 10-dB change in output.) The dynamic range of the system is approximately 110 dB, making it theoretically possible to compress a "live" program with a 100-dB dynamic range into 50 dB, which can be accommodated by any good open-reel tape recorder and some of the better cassette decks.

During playback, the Model 128 acts as an expander whose slope complements the recording compression slope. Hence a 10-dB playback level change coming out of the recorder is converted to the original 20-dB change by the dbx circuits. The program dynamics are not modified in the recording and playback process through the Model 128, but any noise added in the recorder is reduced by the amount of the playback expansion (values up to 30 dB are possible in practice). Unlike the Dolby and ANRS systems, whose operation depend on precisely controlled levels within the system, the dbx system is virtually independent of level. (A 60-dB program range can be located anywhere within the unit's 110-dB range without affecting the final results).

The successful operation of a compander requires close matching of the recording and playback slopes and operating time constants. Since the same circuits are used for both functions, dbx manages to achieve this quite successfully. The detailed operation of the dbx Model 128 (employing what dbx calls the "dbx II" system) is quite complex. It is explained in considerable detail in the instruction manual for the Model 128. It is worth noting that "encode" and "decode" frequency response characteristics of the Model 128, in its noise reduction mode, are far from "flat." About 10 dB of high-frequency preemphasis is used during recording and a corresponding deemphasis during playback to further reduce the modulation noise that accompanies the action of the dbx processor.

The second function of the dbx 128 is as a dynamic range enhancer, or volume expander. This is done with a separate expansion channel, usable simultaneously with the noise reducer or by itself when playing ordinary disc or FM radio programs. Actually, the enhancer channel can be continuously varied from full ("infinite") compression to an expansion slope of 2.0, although compression is not likely to be used except for such purposes as background music or accommodating the wide range of signal levels that usually exist during a conference or meeting. As the control knob is advanced through a slope of 1.0 (linear), the most prominent effect is usually the change in background noise, which drops markedly during expansion. With an expansion slope of 1.2 or 1.3, it is possible to realize a worthwhile noise reduction on most programs, without objectionable side effects, and with a corresponding enhancement of the program dynamics.

The basic operation of the dbx 128 is controlled by six pushbutton switches, three of which are for the noise-reduction functions during tape recording. The BYP (bypass) button routes the tape recorder signals around the dbx circuits; REC switches in the compressor (with a 2.0 slope) between the program and the recorder's input, with the high-frequency preemphasis added; and PLAY places the dbx circuits in the recorder's playback path with high-frequency deemphasis and in a 2.0 expander mode.

The two enhancement buttons are labelled PRE and POST and refer to the position of the variable compander circuit relative to the tape noise reduction circuit. PRE allows the program to be expanded or compressed before it is recorded, while POST makes these operations possible on the playback signal (in both cases, independent of the action of the noise reducer). With proper use of this feature, the Model 128 actually makes it possible to improve the quality of a tape recording, relative to the original signal, instead of merely not adding any more noise to it.

A control knob to the left of the enhancement buttons permits the compander slope to be varied. A LEVEL control near it operates in conjunction with amber and red LED's on the panel to set the level at which the device goes from expansion to compression. The enhancement circuit can also be set to go into operation above a certain signal level (as set by the LEVEL control) instead of operating over the full dynamic range of the instrument. Pressing the button changes the mode from linear to "above threshold" so that the dbx system becomes a peak unlimiter or a peak compressor, according to one's needs. Program levels are unaffected when the amber LED is on.

The remaining controls include a power switch, a tape playback level matching control, and an input selector button labelled TAPE and DISC. The latter position bypasses all the tape recorder circuits to permit the enhancement circuits to operate on the program coming from the associated amplifier or receiver. The DISC nomenclature applies to the playing of dbx-encoded phonograph records, of which there are a few, through the decoding circuits of the Model 128.

Laboratory Measurements. The dynamic nature of the dbx Model 128 range enhancer makes it impractical to make quantitative performance measurements. Except for verifying the deemphasis and preemphasis curves and the complementary nature of the recording and playback slopes, we evaluated the system's performance entirely by actual use.

User Comment. In spite of its small size and accessory nature, the Model 128 is a formidable unit to master. The user's manual is very complete (almost too complete, in some respects), but it is not easy reading. Our recommendation is that it be studied like a textbook on dynamic signal processing, which it very nearly is, and that the Model 128 be set up in a system and the controls experimented with until one has a fairly clear idea of what is happening when any particular control configuration is used.

The SLOPE control must be set to 1.0 when noise reduction is in use. Otherwise, the input and output signal relationships will be altered. The control has no detent or definite center position but appears to be accurately calibrated.

With a slope of about 1.2, the expander was very effective in reducing background hiss from phonograph records and FM tuners, with a light enhancement of dynamic range and almost never any signs of noise "pumping" (a common weakness of expanders). The entire operation was so noncritical that, in most cases, one would not be concerned unduly about the actual signal levels, or when the threshold lights were flashing. (Although out of habit, we tried to keep them flashing on normal program variations.)

As a noise reducer, the Model 128 was at its best. The magnitude of the compression during recording can be appreciated by listening to the program off the tape while recording. It is incredibly noisy and shrill. When the same program is played back through the PLAY mode, however, one would never guess that it ever had been in compressed form. It sounded exactly like the original program, in every respect, without an audible hint of processing.

With a cassette recorder, the Model 128 makes it possible to record at a low level (as low as −20 dB, hardly moving the recorder meter pointers), thus avoiding the usual problems with high-frequency tape saturation. Yet, during playback, the S/N ratio is at least as good as with normal operation of the machine. Although Dolby noise reduction can be used with the Model 128, dbx points out that it offers no advantage, and should be switched off when one is making a dbx recording.

A drawback of the dbx system is its incompatibility with other noise-reduction systems, such as the omnipresent Dolby and ANRS, or with no system at all. A dbx recording *must* be played back through a dbx decoder since it is unlistenable in its encoded form. The same applies to dbx phonograph discs; they have an unbelievable dynamic range when properly played, but cannot be listened to without a dbx decoder. Moreover, the Model 128 does not provide the ability to monitor a program off the tape while recording. (It has only one set of circuits. The reasons for making the Model 128 in this way are obvious when one considers its price, even without the duplication of facilities required.)

Aside from the foregoing, and likely more important to serious recordists, the Model 128 is perhaps the most effective and versatile tape recording noise reducer and dynamic range enhancer available to the amateur recordist or hi-fi enthusiast. Aside from the considerable practice needed to become familiar with its operating modes, it is a virtually foolproof product and is outstandingly free of the undesirable side effects that often accompany such signal processing.

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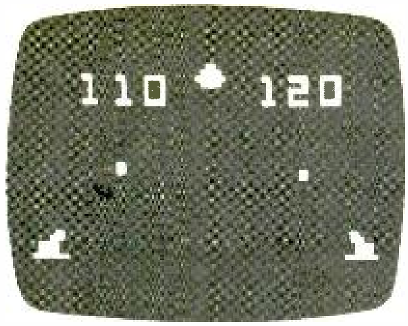
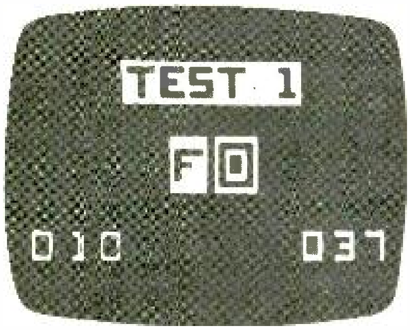
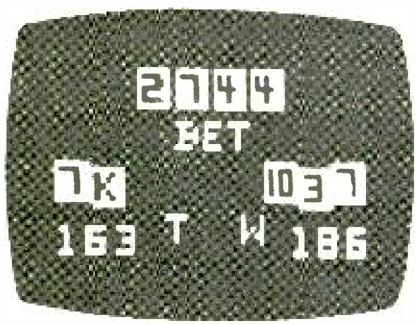


SPACE WAR

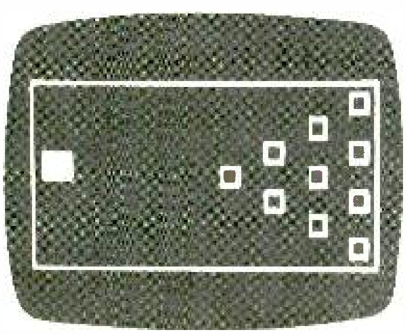


T.V. SCHOOL HOUSE I



T.V. CASINO I
BLACKJACK

"Only after you've experienced the sheer joy of slaughtering your best friend will you know the true meaning of fun."



BOWLING

Courtesy RCA

New 1978 Electronic Games

A host of video and nonvideo electronic games, many using microprocessors, promises the public more stimulating fun for leisure time.

BY KRIS JENSEN

A COUPLE of years ago, an electronic video game consisted of a simple "black box" that, when connected to a TV receiver, produced little more than some version of video table tennis. In some cases today, that black box is virtually a personal computer. Now there are games whose color images try your gambling instincts at blackjack, your "destroy" capability against an enemy tank, your patience and fortitude through a maze while a "cat" attempts to devour you, your artistic talent with computer-drawn pictures, or your knowledge of math and history. And that is just the beginning in video games!

Furthermore, there are nonvideo games—a new breed of electronic battlegrounds emerging from game manufacturers who were never in the electronics business. Traditional game manufacturers like Parker Brothers (of Monopoly™ fame), Milton Bradley, Mattel Toys, and others now offer nonvideo hand-held or table-top electronic games. Consequently, these manufacturers blithely sidestepped the FCC and the production delays caused by Class I interference tests.

The Electronic Industries Association estimates that some 3.5-million video games were sold last year. The figure for this year is expected to reach 10 million—and that is for video games alone; non-TV games are coming on strong, too. With figures like these, integrated-circuit chip suppliers such as General Instruments, Texas Instruments, National Semiconductor, and Rockwell are hard pressed just to keep up with anticipated demands.

Then and Now. Atari got the video-game ball rolling across TV screens in a big way in 1975 with its "Pong" game, a hit-the-ball with a paddle game that featured automatic on-screen digital scoring. "Super Pong" followed, offering four resident games—two forms of tennis, Catch, and Robot, all in full color with automatic scoring and sound effects. A host of other companies shared the success in this market, including Coleco and Magnavox, among leaders of "dedicated" games.

Now these games are commonplace. Prices have dropped considerably—to as low as $19.95. Moreover, there are many more game variations available in a number of 1977–1978 models. Atari, as an example, has dropped its former line and introduced "Ultra Pong," with 16 color-game variations selling for 40% less than last year's more limited "Super Pong." National Semiconductor's "Adversary 370"—introduced last year as a tennis-hockey-handball game—has been joined by the company's new "Adversary 600," which has 12 action fields and 23 games that include "Pinball" and "Wipeout" (with 240 stationary targets) games as well as some of the traditional paddle-ball games. It uses NS's MM57106 game chip, combined with an LM1889 Modulator IC to produce full color, audio and r-f signals. Magnavox's "Odyssey 4000" has eight full-color games with remote, hand-held joysticks. Unlike most other paddle-ball games, users can move on-screen players in horizontal as well as vertical directions. In addition, an "Odyssey 5000," with many more built-in games, is expected to be marketed.

There are also video games that do not feature paddle-ball formats. For example, Atari has debuted a $79.95 "Video Pinball" game, a tank battle game, and a "Stunt Cycle" game.

Most games provide a host of devices to make them more interesting, such as different paddle sizes, choice of ball speeds, etc. An interesting innovation this year on a few games is indenting the hockey-goal areas so that the puck can rebound behind the goal, as in the real-life sport. The major consideration here is to minimize eventual boredom. But a new generation of video games will surely overcome this possibility: programmable video games.

Programmable Video Games. Fairchild Camera and Instrument broke the ice on programmable video games at the end of 1976 with its "Video Entertainment System." Based on a reprogrammable microcomputer chip set, it spearheaded the format used by other manufacturers of programmable games. Here, one inserts what appears to be a tape cartridge (actually it's a solid-state circuit that contains game programs on ROM) into a slot on the game machine to select a particular game or games in full color if played on a color TV receiver. Hockey and tennis are resident games stored in the machine's F8 microprocessor. These games are disabled when a Videocart™ is inserted. There are 15 different cartridges available at this writing, including "Baseball," "Desert Fox" (a tank battle game), "Shooting Gallery," "Math Quiz," and an introduction to "Backgammon." The machine is priced at $169.95, while each game cartridge is listed at $19.95.

The baseball game may be cited as an example of the degree of sophistication that microprocessor games can achieve. Here, a "green" team plays nine innings against a "blue" team. The player whose team is in the field can control the positioning of outfielders in order to "catch" the ball hit by the batter. Furthermore, he can pitch a fast ball, letup ball, slow ball, and curve ball in any direction. Balls, strikes, outs and runs register on screen. Hit the batter and a figure on the screen goes to first base. The score is automatically maintained on screen, of course. Clearly, the challenge of outfoxing one's opponent makes the enjoyment of a game last that much longer.

Following on the heels of Fairchild's programmable video game was RCA with its "Studio II Home TV Programmer." Whereas Fairchild's game has remote controls, RCA's features two calculator-type keyboards on the console, which measures 15″ long × 7″ wide × 2″ deep. There are five resident games: Bowling, Freeway, Addition, Doodle, and Patterns. Plug-in cartridges, of which there are currently six, also consist of ROM's that plug into a socket. Built-in games are then disabled; players continue to control new games via the front-panel keyboards. Among the plug-in cartridge games available are baseball, space war, and "TV School House" (social studies and mathematics quizzes). The latter has a Yellow Series for elementary students and an Orange Series for advanced students. Both are accompanied by manuals to answer questions randomly selected by the Studio II computer. The faster the correct answer is selected and entered on the keyboard, the higher the score registered on the TV screen. The console is priced at $149.95, and cartridge prices range from $14.95 to $19.95 each, depending on contents.

The RCA Studio II game is based on the CDP1802, the same 8-bit chip used in the POPULAR ELECTRONICS "Elf" microcomputer, as well as the black-and-white graphics chip. In addition, inside the machine are two 512 × 8-bit ROM's. They act as an "interpreter" to provide common game-display patterns such as scorekeeping, alphanumerics and subroutines. A second ROM contains programming to execute any of five resident games. TV refresh (direct-memory access or DMA is used), and stack and variable storage are provided by 512 bytes of RAM.

Atari's new $189.95 "Video Computer System" comes with one plug-in cartridge that provides 27 game variations with full-color capability, including a combat package of "Tank" and "Jet Fighter." The latter game provides steerable and nonsteerable missiles, cloud formations and multiple fighter versus bomber combinations. The system includes two joystick controls, four detachable paddle controls and a player difficulty option switch. Five additional cartridges are currently available, offering 10 to 50 game variations each. They include "Space Mission," "Air-Sea Battle," "Street Racer," "Indy 500" and "Video Olympics."

Bally, well known for its arcade games, has entered the consumer electronics market with a programmable video game called, "Professional Arcade." The model has two on-board games called "Gunfight" and "Checkmate," with controls for up to four players. In addition, it incorporates a 4-func-

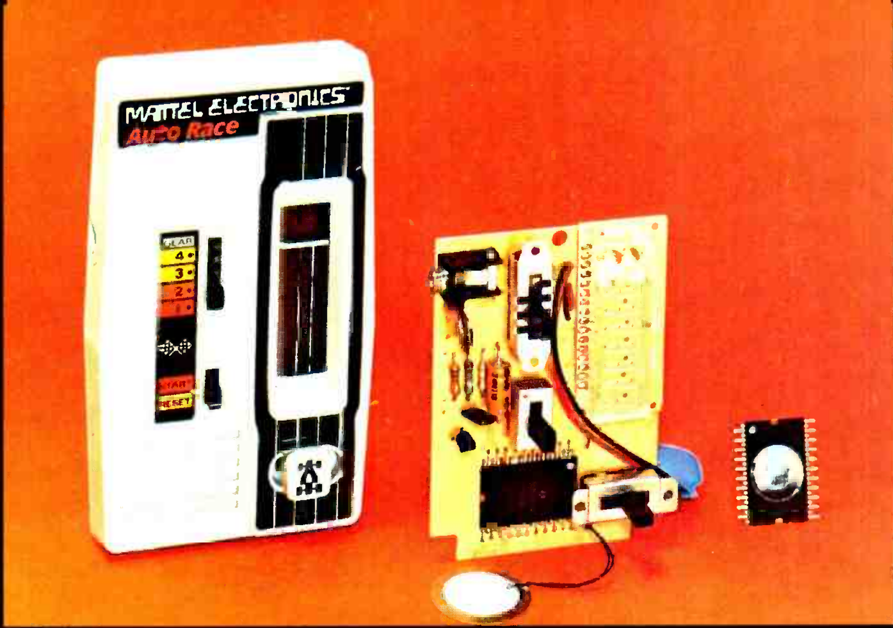
a Electronics (assembled by Rockwell International) for Mattel, Inc.'s "Auto Race" include PPS-4/1 microcomputer and segmented LED matrix.

b Milton Bradley's nonvideo "Comp IV" selects one of 32,000 random-number combinations when turned on. The players then try to guess number.

c In Fidelity Electronics' "Chess Challenger," moves are entered via keyboard. Display indicates player/machine moves and game outcome.

d Microphotograph of Texas Instruments' TMS-1000 microprocessor. It can be tailored to fit any number of games and has direct drive for displays.

e Studio II, RCA's TV programmer, has five built-in games and also uses optional plug-in cartridges for other types of programs.

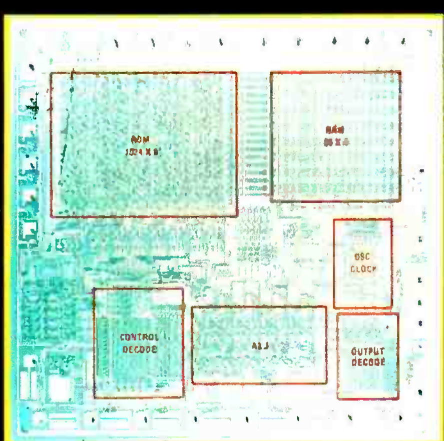

MATTEL ELECTRONICS
Auto Race

a

b


CHESS
CHALLENGER
FIDELITY ELECTRONICS

c


ROM
RAM
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CLOCK
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OUTPUT
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d

e

My father always told me that there were certain advantages to putting all your eggs in one basket. "John," he said, "learn to do one important thing better than anyone else, and you'll always be in demand."

I believe he was right. Today is the age of specialization. And I think that's a very good thing.

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tion, 10-memory printing calculator with a screen display, entry correction and scroll button. A cassette mode permits plugging in "Videocade" electronic programs, which consist of an Action/Skill series, a Sports series, an Educational series, and a Strategy series. This programmable machine also features music. For example, in "Gunfight," the user operates the movable arm of a computer-generated "cowboy" to aim and fire at an opponent—assuming he is not hiding behind a movable cactus. If the player "Kills" the opponent, the latter dies on the screen to the sounds of "Taps" and "The Funeral March." The Arcade is priced at about $290, while cassettes are $20 each. At this writing, the model is awaiting FCC type approval.

Coleco Industries, Inc. also has an "Arcade" programmable game on the market. It's called, "Telstar Arcade," and features a three-sided console. One side has a built-in car steering wheel that acts as an input controller for auto racing games, another a pistol and holster for target and shooting games, and the third a set of knobs for paddle games such as tennis, hockey, etc. Games are determined by the programmed Telstar cartridge used, which is triangular in shape. The unit comes with a cartridge that contains programming for three games: "Road Race," "Quick Draw" and "Tennis." The console with one cartridge is priced between $100 and $125 at this writing, while other cartridges (unannounced) will be priced at $20.

No TV Needed. Games that do not require a TV receiver have begun to enter the electronic-game market in force. Milton Bradley, for example, has introduced a hand-held game incorporating a microprocessor, called "Comp IV." When the $30 game is first switched on, it selects one of 32,000 random-number combinations. By using the keyboard, a player enters his number guesses. LEDs display how close the player's guesses are to the game-selected number. The idea is to logically deduce the numbers and their order in as few tries as possible.

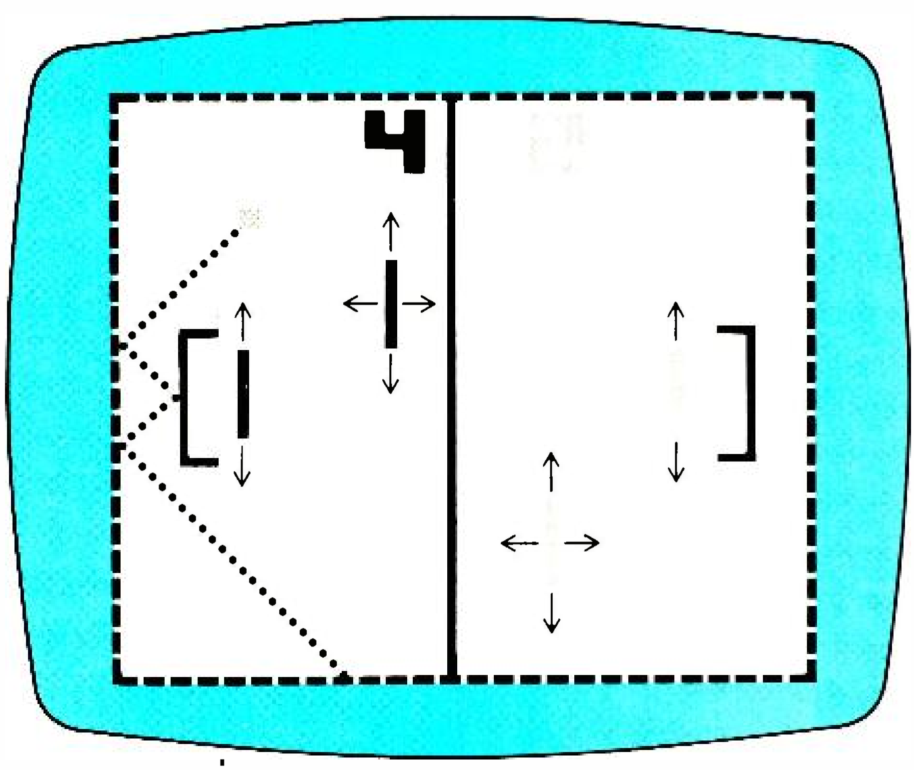
Comp IV can be programmed to operate with three, four, or five number strings to make the game as easy or as simple as one likes.

This MB game is built on a single board that utilizes a multikey keyboard and a TI 970 game chip. (The 970 is actually part of the new Texas Instruments TMS1000 series of p-channel MOS four-bit microprocessors. During its manufacture, however, a masking technique is used to program an on-board 1-k ROM that tailors the TMS-1000 to fit a customer's requirements in software and allows direct-drive for displays. The chip also supports 256 bits of RAM and an arithmetic unit.)

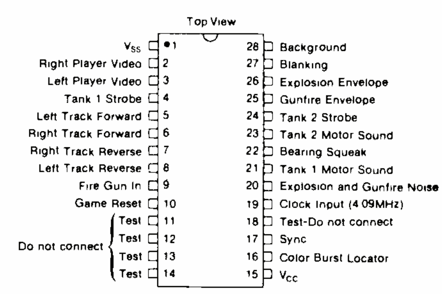
Milton Bradley was not alone in seeing the value of a microprocessor for nonvideo games. A TI system is also the integral component in "Code Name: Sector," a submarine pursuit game from Parker Brothers. This game is truly challenging. Two opponents compete against each other, each commanding a destroyer in an effort to sink a computer-controlled sub as it moves through 4800 possible sections of a nautical-chart board. Seven-segment and discrete-LED displays indicate speed, depth, range, and headings (directions) as opponents try to blow the sub out of the water. Collisions can occur to throw a player off course, and if a player misses the sub, the underwater craft not only moves on a secret course, it will fire back to put the attacker in a random position out of firing range.

Though "Code Name: Sector's" instructions are stored in ROM, a RAM, system is used to temporarily store information on ship positions, compass headings, and speeds. Decoding for the displays is accomplished with a programmable logic array for conversions from BCD (binary coded decimal) to seven-segment format. A Klixon keyboard from TI is used to input information such as speed, steering, sonar control, etc. The entire system operates on a single 9-volt battery. It's priced at $40.

Mattel Electronics has also come up with some innovative ideas on three pocket-size electronic games called



PIN CONFIGURATION
28 LEAD DUAL IN LINE



Above is pin configuration for General Instrument's AY-3-8700 single-chip tank game. It provides 32 rotational angles of tank control and also has noise outputs.

Video screen (left) using GI's AY-3-8600 hockey game chip has two new provisions: lateral as well as vertical movement of forwards and space behind goal for puck to bounce off the wall instead of disappearing.

"Football," "Auto Race" and "Missile Attack." A LED array marks a player's position on the football field as he attempts to avoid other LED "tacklers" that are controlled by the game's electronics package. Seven-segment displays keep track of downs, time, and yardage to go. If a player scores a touchdown, the game plays the tune "Charge!"

In playing "Auto Race," you are racing around a four-lap LED-lighted course. Steering and speed/shift controls allow you to maneuver around opponent cars under the game's control. While playing, motor sounds are produced. You hear a beep to indicate a collision; a victory sound when and if you beat the seven-segment clock through the course.

In "Missile," a LED array indicates that enemy missiles are launched toward your "city." The object of the game is to use your anti-missile missiles to destroy the enemy missiles before they reach home turf. A seven-segment display keeps track of your "kills," but make one mistake, letting an enemy missile through, and the game plays "Taps" just after your city is destroyed.

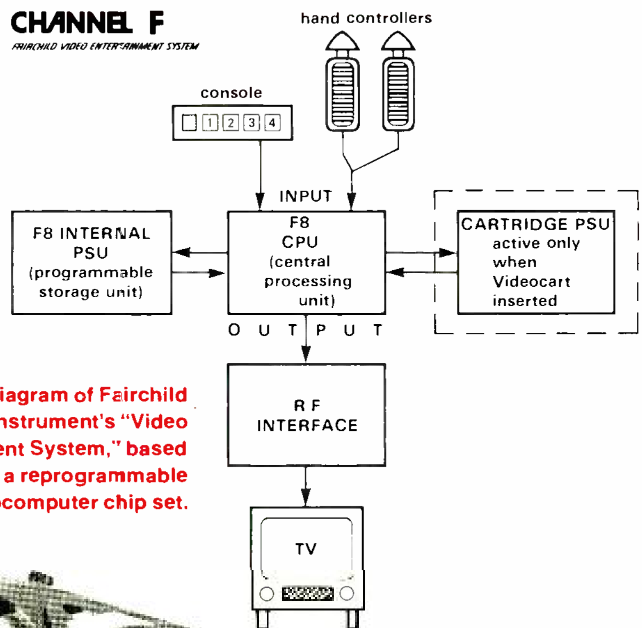
The display is what makes the Mattel games unique. It is a cross between a hand-held calculator number display and a true video display, minus the video. Designed by Rockwell International, it consists of a matrix of 40 × 10 mil GaAs LED's. Three columns of seven vertical line segments make up the Auto Race and Missile Attack displays, while three rows of nine horizontal segments make up the display for the Football field runners. All multiplexing and buffering is accomplished with Rockwell's PPS-4/1 microprocessor. This dedicated chip contains all the software for all three Mattel games. Cost of these is $29.95 for Football, $24.95 each for Auto Race and Missile Attack.

Rockwell is also responsible for the design of another system, sold by Unisonic. Called the "Unisonic 21," it is a Blackjack card game that comes in both shirt-pocket and desk-top models. If you would like to calculate your odds before picking up the next electronic "card," you can flip a switch that converts the game into an eight-digit, four-function calculator.

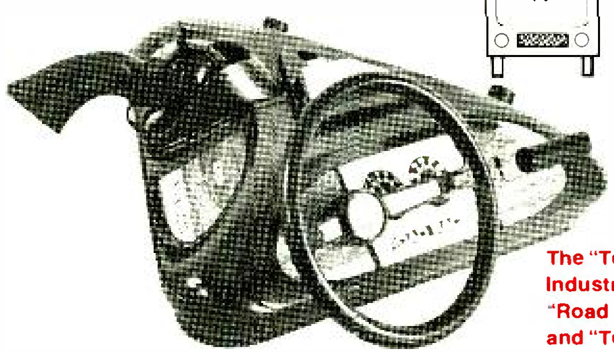
Taking its game more seriously, Fidelity Electronics has developed the "Chess Challenger." It uses four alphanumeric displays and a keyboard. Moves are entered via the keyboard and shown on the displays. Two seconds later, the display indicates the machine's move. An average player will win 25% to

MORE VIDEO GAMES

The Atari Video Computer System uses plug-in game cartridges, has two joy-stick controls, and includes a difficulty option switch.

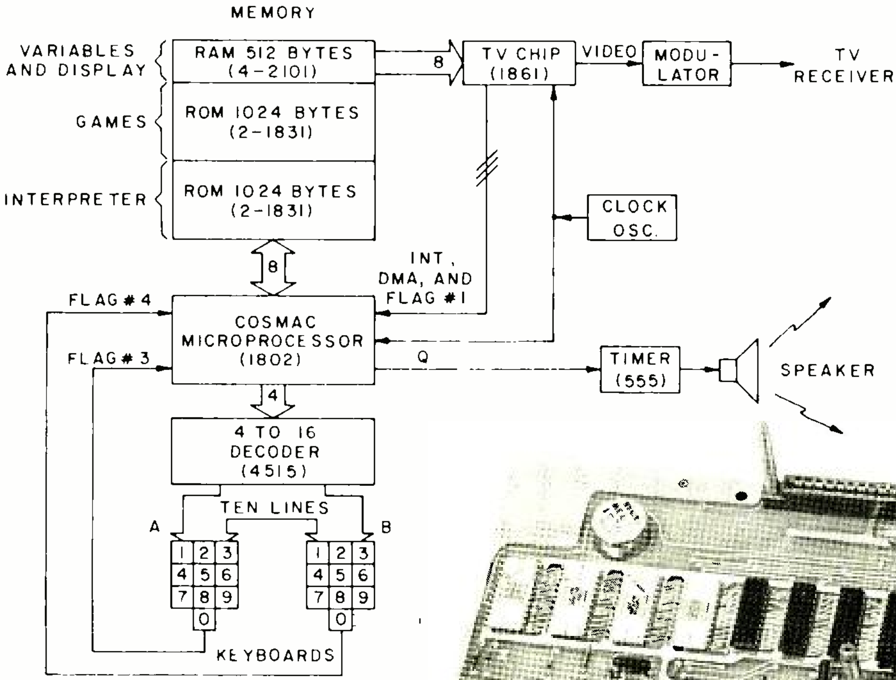


Block diagram of Fairchild Camera and Instrument's "Video Entertainment System," based on a reprogrammable microcomputer chip set.

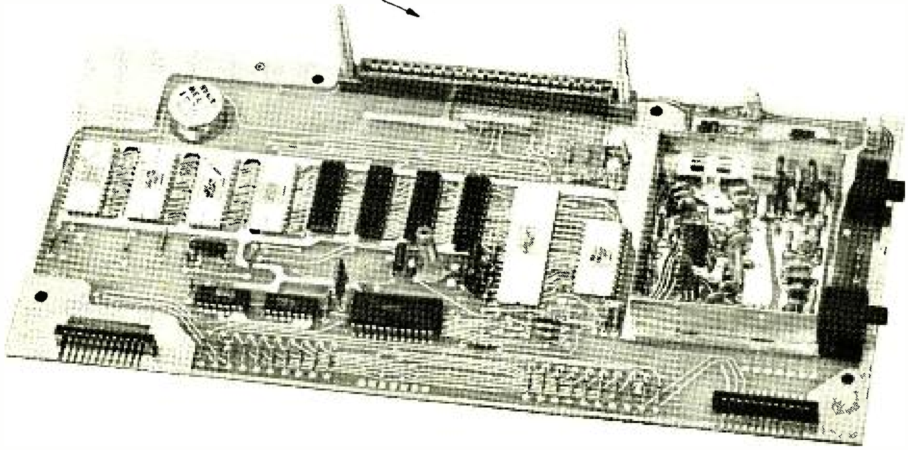


The "Telstar Arcade" from Coleco Industries, Inc., includes "Road Race," "Quick Draw," and "Tennis" on one console.

Bally's "Professional Arcade" with two on-board games has 4-function, 10-memory printing calculator with screen display.



Block diagram of RCA's Studio II programmer is shown at left. Photo of the game's pc board is below. It uses the COSMAC CD-1802 MPU, as in the Elf microcomputer. Two keyboards are provided for players to enter instructions, answers or strategies.



70% of the time in which case, a LED labelled "I LOSE" indicates the machine's defeat. With the "Chess Challenger," you move real chess pieces around a real chess board. (The chess board does not use the standard chess-square identifier terminology. Instead, the terminology is unique to the computer logic system around which the game is built.)

"Chess Challenger" employs a standard 8080 microprocessor chip, a ROM system for strategy storage, and a RAM system for game moves. The game sells for $200 (Heath sells it for $179.95, assembled), and for an extra $75, it can be reprogrammed (another ROM installed) for tournament strength. The upgraded version begins a game by asking at which level you would like to play. You can begin at level 1 and, as you become more proficient, work up to level 3.

The game level approach is also used by Staid's "Compuchess," another chess game recently introduced. The $159.95 hand-held game requires you to supply the chess board. It can be programmed for up to six different skill levels. Levels 1 and 2 are for teaching purposes; levels 3 to 5 are for players already familiar with the game. Because of all the algorithms performed at level 5, it takes the game nearly seven hours to respond to your move. Hence, levels 5 and 6, which require a couple of days to respond, are for the chess-by-mail addict only.

Yet another computerized chess game—"Boris" from Applied Concepts—is a $299.95 machine designed with both beginner and advanced chess players in mind. It features a programmable starting position, handicapping, en passant, castling, automatic queening, editing capabilities, timer, and an 8-digit alphanumeric readout. The computer concedes defeat by flashing "Congratulations" on the display.

The increasingly popular game of Backgammon has not been neglected, either. "Gammonmaster II" by Trycom Inc. and "Computer Backgammon" by Texas Micro Games, Inc. have both been announced and exhibited at shows. In both cases, the computer is a real thinking machine, being required to analyze the entire board before making its move against its human opponent.

National Semiconductor has not confined itself to the pure video game market. Based on its calculator-oriented processor system (COPS), NS has three versions of a learning game called QuizKid. The hand-held games present math problems of varying complexity and require answers within preset time limits. The latest QuizKid Racer game can operate as a single unit, or it can be linked by a cable to another Racer game to allow two opponents to challenge each other while competing against the machine. The COPS series includes two single-chip microprocessors, the MM5799 and MM57140, 8 or 16 k of ROM, 1 k of RAM, and other IC's, including a printer interface chip.

The hand-held game, as a teaching aid for children, could prove an important tool in child education. Other manufacturers, such as Texas Instruments and APF, are also beginning to produce such games.

Still Many More. The number of manufacturers who produce electronic games seems endless, thanks to a steady stream of totally new chips being offered as off-the-shelf items to them. TI, for instance, has Space War, from its new line of game chips. GI has its "Gemini TV Games" IC's, which include cassette-programmable IC's designed around a CP1600 microprocessor and a system instruction ROM (2048 × 10 bit). With appropriate RAM's and graphics processor chips, games such as "Roadrace," "Submarine," "Dogfight," and "Blackjack" can be generated.

The most widely used GI chips employed by game makers are the 8500 and second-generation 8550 n-channel MOS devices. With just a few outboard components, these chips can provide tennis, hockey, handball, practice, and two target games, the last with remote guns. On-screen scoring with sound effects are generated by the chips, as are color outputs for use with a color-generator circuit. It is this flexibility that has made the GI chips so attractive with such manufacturers as Magnavox, Lloyd's, Monteverdi, Venturi, Hanimex, etc. Simply jumpering or switching certain pins of the 28-pin IC adds as much complexity (and cost) to the final product as desired.

Speaking at last year's winter Consumer Electronics Show, Dr. E.A. Sack, Vice President for GI, stated that his company believes in the dedicated approach to microprocessor game designs. GI backed up this position by introducing its Gemini video game circuits that are capable of playing more than 50 different games. While some of the new chips allow a manufacturer to make stand-alone games that can be reprogrammed, others can be added to existing games that use the GI 8600 eight-game chip (tennis, hockey, soccer, squash, practice, gridball, basketball, and basketball practice). Using much of the 8699's video and player-control circuits and adding an 8603 chip, for example, the normal ball-type games can be transformed into a road race when game number 1 is selected on the control switch. The idea, of course, is to allow a manufacturer to upgrade his entire stock easily and relatively inexpensively simply by adding one IC chip.

GI has just recently begun delivery of its AY-3-8700 single-chip tank game. This is a 28-pin IC package that provides 32 rotational angles of tank control for two players. Video outputs from the chip include left and right player tanks, shells, shell bursts, mines, fixed barriers, score, blanking, background, sync, and color-burst locator. Audio output circuitry is just as complete with tank-1 and tank-2 motor sounds, bearing and track squeals, and explosion and gun-fire envelopes. The chips are $9.95 each, but don't send in an order unless it is for 50,000 or more chips.

Among other companies in the electronic game business, APF Electronics has a broad line of video paddle games with two new additions—the Model 500 with 20 space-type games, including Space War, and an M1000 microprocessor programmable game at $149.95.

Sears, too, has increased its line of games, which begins at $20 and goes on up to a sophisticated programmable game that sells for $179.95 Sears' program library ranges from antiaircraft torpedo shooting to an outer-space game. Mid-priced dedicated games are available for other games like "Tank."

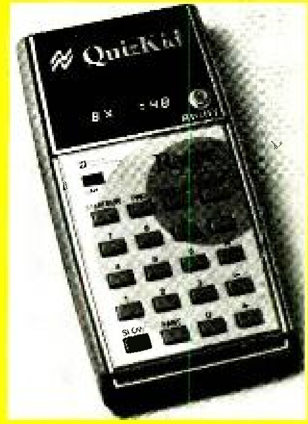
Microelectronic Systems' "Interact" is a joystick-and-keyboard-operated game that can be programmed by a *tape* system. Running at 810 bits/inch, the tapes set up the game to play Trail Blazers, Blackjack, or Regatta racing. You can also draw computerized color pictures on a TV screen. With a built-in cassette machine and alphanumeric keyboard input, it lists for $249.

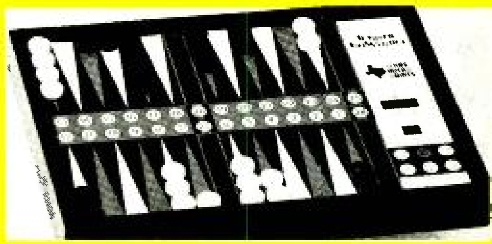
Even though game manufacturers are now designing games for the home, office, and shirt pocket, this is just the beginning of a whole new era of gamesmanship. Datatime Corp. may be saying this with its new wristwatch, which gives time and date on a liquid-crystal display as well as allowing you to play Jackpot, Dive, and Roulette. A backlighted display on the $100 timepiece keeps you in action no matter what the hour.

Too, let us not overlook the home computer while we're exploring electronic games. Though computers are at the peak of the triangle in terms of numbers expected to be sold this year (owing to higher costs), a myriad of fun games can be played on a TV screen if you have your own computer. There are more possibilities, in fact, than any programmable-type video game has because you can create your own game programs as well as having access to an overwhelming amount of game software and written programs.

In spite of predictions in numbers and dollars for the future of electronic games, perhaps their real interest for all of us was best expressed by Nolan Bushnell, Chairman of Atari: "Only after you've experienced the sheer joy of slaughtering your best friend will you know the true meaning of fun." ◇

MORE NONVIDEO GAMES





Three nonvideo games, clockwise from above: Parker Brothers' "Code Name: Sector," a microprocessor-based sub pursuit game; National Semiconductor's "Quiz Kid" calculator; and Texas Micro Games' "Computer Backgammon."

Microcomputers like Radio Shack's TRS-80 can be used to play video games or as educational tools.

BY RONALD W. REESE

BUILD "Charge!"

A digital electronic bugle-call generator with an audio amplifier for mobile or home use.

IF YOU have ever seen a Western movie, you're no doubt familiar with the bugle call played as the U.S. Cavalry charges over the hill to the rescue. This project generates that bugle call electronically. Because digital circuitry establishes the musical intervals between the notes, it will never drift out of tune. "Charge!," as the project is called, can be built from readily available, inexpensive TTL logic, 555 timer IC's, and silicon transistors.

Two versions of the circuit are presented. One, incorporating a high-power output stage, requires a 12-volt dc supply and is well suited for use as a vehicle horn or a cheerleading device at parades and school sporting events. The low-power version, operated from the ac line, can be used as an annunciator, doorbell, alarm, or simply as an attention-getting conversation piece. Two controls allow the user to vary both the tempo and pitch of the bugle call.

About the Circuit. Free running timer *IC1* and its associated components (Fig. 1) form a tone oscillator whose operating frequency is governed by the setting of *R2*. The oscillator output, a square wave with a duty cycle close to 50%, is frequency divided by factors of 10, 12, and 15 by *IC2, IC3,* and *IC4*, respectively. In this way the three tones that form the bugle call melody are generated. Digital frequency division ensures that the intervals between the three notes remain constant. However, the pitch of the bugle call can be varied by adjusting *R2*.

Square waves from *IC1* are applied to the three frequency dividers simultaneously. The 7490 functions as a symmetrical ÷ 10 counter in the following manner. Input signals are routed to the internal ÷5 counter (pin 1). The output of this counter is connected to the input (pin 14) of the IC's ÷2 counter. Output signals appearing at pin 12 have a frequency one-tenth that of the input and a duty cycle of 50%. A ÷12 counter (*IC3*) is formed in a similar manner by interconnecting the ÷6 and ÷2 counters contained in a 7492 IC.

A different approach must be taken to realize a ÷15 function because 15 is not divisible by two and some other integer. In this project, a 74193 presettable up/down counter is used as the ÷15 stage. This counter IC has four data inputs (pins 15, 1, 10 and 9) and four corresponding outputs (pins 3, 2, 6 and 7). The counter outputs can be preset to

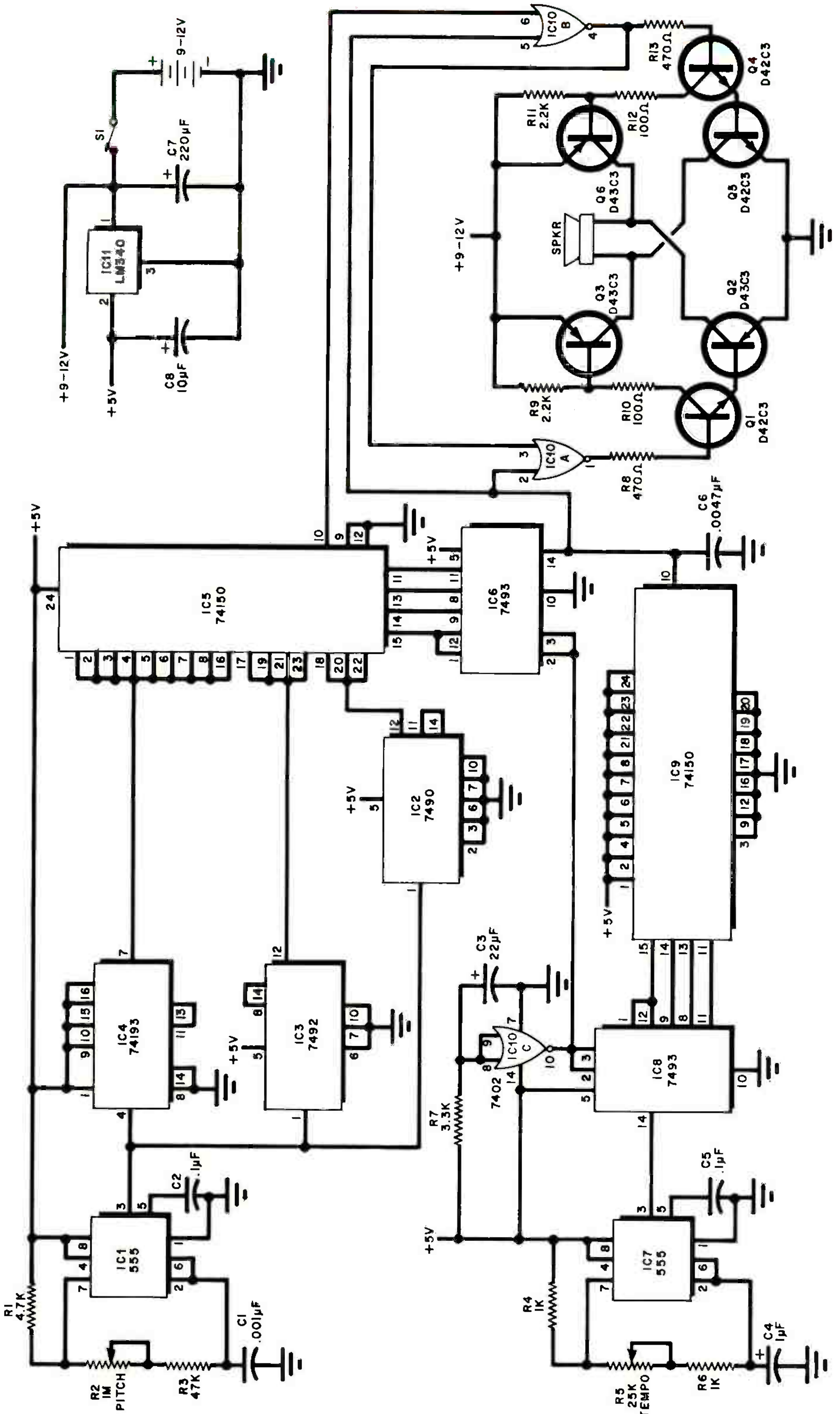


Fig. 1. Schematic diagram of "Charge!" Tempo and musical notes of the bugle call are generated digitally.

PARTS LIST

C1—0.001-µF disc ceramic capacitor
C2, C5—0.1-µF disc ceramic capacitor
C3—22-µF, 16-V electrolytic capacitor
C4—1-µF, 16-V electrolytic capacitor
C6—0.0047-µF disc ceramic capacitor
C7—220-µF, 16-V electrolytic capacitor
C8—10-µF, 16-V electrolytic capacitor
IC1, IC7—NE555 timer
IC2—SN7490 decade counter
IC3—SN7492 ÷12 counter
IC4—SN74193 synchronous 4-bit binary up/down counter IC with preset inputs
IC5, IC9—SN74150 16-line to 1-line data selector/multiplexer
IC6, IC8—SN7493 4-bit binary counter
IC10—SN7402 quadruple 2-input NOR gate
IC11—LM340 5-volt regulator
Q1,Q2,Q4,Q5—Silicon npn power tab transistor (GE D42C3 or equivalent)
Q3, Q6—Silicon pnp power tab transistor (GE D43C3 or equivalent)
The following are ¼-W, 10% carbon resistors:
R1—4700 ohms
R3—47,000 ohms
R4,R6—1000 ohms
R7—3300 ohms
R8,R13—470 ohms
R9,R11—2200 ohms
R2—1-megohm linear taper potentiometer
R5—25,000-ohm linear taper potentiometer
R10,R12—100-ohm, 1-W, 10% carbon composition resistor
S1—Spst 3-ampere switch
SPKR—8-ohm, 15-W weatherproof horn speaker
Misc.—Printed circuit or perforated board, IC sockets, suitable enclosure, control knobs, heat sink (if necessary), heat sink paste, screw-type terminal strips, machine hardware, hookup wire, solder, etc.

form a four-bit binary number by applying four bits to the data inputs and grounding the load input (pin 11) momentarily. When this is done, the four bits applied to the inputs appear at the outputs.

After the load input returns to the logic one state, the IC can count down if pulses are applied to the count down input (pin 4) while the count up input (pin 5) is at logic one, or count up if pulses are applied to the count up input while the count down input is at logic one. In this application, the 74193 is used as a down counter. It is loaded with the binary number 1111 (15_{10}), and is then allowed to count down as pulses are received from *IC1*. When the counter output reaches 0000 (0_{10}) and the count down input falls to logic zero, a logic zero appears at pin 13, the borrow output of the IC.

The logic zero at the borrow output indicates that 15 pulses from *IC1* have been counted by *IC3* and that the IC must be preset again to 15 for the next counting cycle. By connecting all data inputs to the +5-volt supply and the borrow output to the load input, the counter will automatically preset itself to 15 after it has counted down to zero. Square waves appearing at the Q output of the counter's D flip-flop (pin 7) are used as the output signal from this stage. The output of this flip-flop will be at logic one for seven pulses from *IC1* and at logic zero for eight pulses. This results in a duty cycle of about 47%, which is reasonably close to 50%.

A sequential tone selector is formed by *IC5*, a 16-line to 1-line data selector/multiplexer and *IC6*, a 7493 four-bit binary counter. Pulses from the beat generator, which will be discussed later, are counted by *IC6* over the range 0000_2 to 1111_2. The binary number generated by *IC6* is applied to the data select inputs of *IC5*. As *IC6* counts upward, *IC5* sequentially selects signals from frequency dividers *IC2*, *IC3*, and *IC4*. The three tones produced by the counters appear at the data inputs of *IC5* in the order in which they appear in the bugle call. In this way tones are selected and gated in proper sequence for application to the power amplifier.

The tempo at which the call is played is governed by the beat generator. This circuit also establishes the timing relationships between the notes and rests, and supplies a clock signal to counter *IC6* in the tone selector circuit. The beat generator is formed by interconnecting *IC7*, a free-running 555 timer, *IC8*, a 7493 four-bit binary counter, and *IC9*, a 74150 16-line to 1-line data selector/multiplexer. The oscillating frequency of *IC7*, determined by the setting of potentiometer *R5*, sets the amount of time allotted to each beat.

A repetitive beat can be used due to the nature of the song. The notes in the bugle call are played in pairs. That is, one note is played, followed by a short rest, and then the next note is played, followed by a longer rest. All notes are of the same duration—five beats. The short rest separating the two notes forming a pair is one beat long. The longer rest separating pairs of notes is five beats long. Therefore, a total of 16 beats is required by one pair of notes and two rests (one short, one long).

Binary counter *IC8* will count 16 pulses and automatically overflow to zero, providing a convenient way to determine the passage of 16 beats. The four binary outputs of the counter (pins 12, 9, 8 and 11) are connected to the four data select inputs of multiplexer *IC9*. The data inputs of the multiplexer are connected to either +5 volts or ground. The first five inputs (zero through four, pins four through eight) are tied to the +5-volt line. An internal NOR gate is the multiplexer's output stage, so a logic zero appears at pin 10 (the multiplexer output) for the first five beats. This allows NOR gates *IC10A* and *IC10B* to pass an inverted version of the output signal at pin 10 of multiplexer integrated circuit *IC5*.

Input five (pin 3) of multiplexer *IC9* is connected to ground, so a logic one appears at the multiplexer's output on the sixth beat. This causes the outputs of *IC10A* and *IC10B* to remain at logic zero regardless of what is applied to the other input of each gate. No signals can pass to the power amplifier during this interval, resulting in a one-beat rest. Inputs six through ten, pins 2, 1, 23, 22, and 21, are connected to +5 volts. When *IC9* selects input six, its output goes low, causing two things to happen. Decade counter *IC6* counts up one pulse, allowing *IC5* to select the next note. Also, NOR gates *IC10A* and *IC10B* pass signals from the tone multiplexer to the power amplifier. The output of *IC9* remains low through the tenth beat.

The last five inputs, 11 through 15 at pins 16 through 20, are connected to ground. This causes the output of *IC9* to go high, disabling the power amplifier. By this time, two notes have been played and the beat generator counter, *IC8*, has overflowed to 0000 and the beat sequence will repeat itself. The sequence must be repeated eight times for

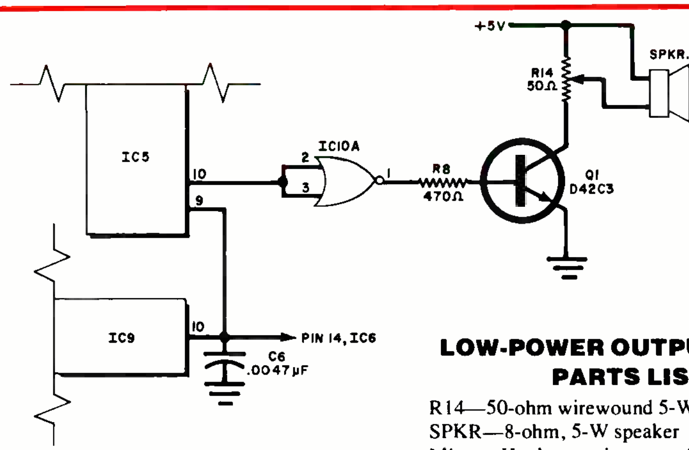
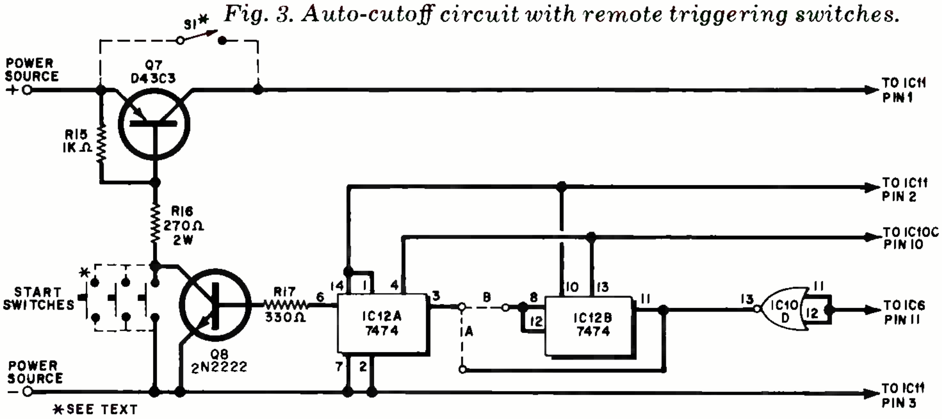


Fig. 2. Output stage for the low-power version.

LOW-POWER OUTPUT STAGE PARTS LIST

R14—50-ohm wirewound 5-W potentiometer
SPKR—8-ohm, 5-W speaker
Misc.—Hookup wire, small enclosure if speaker is mounted remotely, machine hardware, terminal strip, solder, etc.

Fig. 3. Auto-cutoff circuit with remote triggering switches.



AUTOMATIC CUTOFF PARTS LIST

IC12—SN7474 dual D-type edge-triggered flip-flop
Q7—Silicon pnp power tab transistor (GE D43C3 or equivalent)
Q8—2N2222 npn switching transistor
The following are 10% carbon composition resistors.
R15—1000 ohms, ½ W
R16—220 ohms, 2 W
R17—330 ohms, ½ W
S1—Spst 3-A switch (optional)
Misc.—Normally open momentary-contact pushbutton switches (optional), IC socket, heat sink, mica washer, heat sink paste, machine hardware, hookup wire, solder, etc.

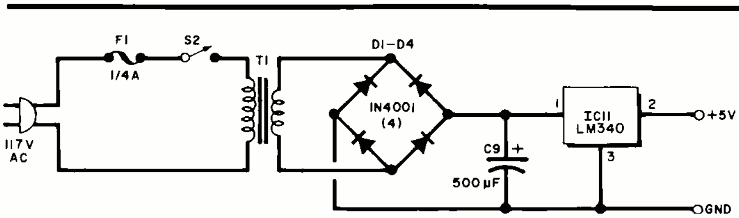


Fig. 4. Ac supply for low-power "Charge!"

LOW-POWER LINE-OPERATED SUPPLY PARTS LIST

C9—500-µF, 25-V electrolytic capacitor
D1 through D4—1N4001 silicon rectifier diode
F1—¼-ampere fuse
S2—Spst 1-ampere switch
T1—12.6-V, 1-A filament transformer

all the notes to be selected and played. When all notes have been played, both beat generator counter *IC8* and note selector counter *IC6* will overflow to 0000, and the bugle call will repeat until power is removed. An auto start circuit comprising *IC10C*, *R7* and *C3* ensures that *IC6* and *IC8* start counting at 0000 when power is applied.

Transistors *Q1* through *Q6* and resistors *R8* through *R13* form the power amplifier. The tone selected by *IC5* is applied to one input of *IC10B*. The output of this gate provides base drive for *Q4* and is also applied to one input of *IC10A*. Gate *IC10A* inverts and passes the signal to *Q1* when the output of *IC9* is low. When the square wave applied to *IC10B* goes low, the output of the gate goes high, turning on transistors *Q4, Q5,* and *Q6,* which energize the speaker. The logic one at *IC10B*'s output also produces a logic zero at the output of *IC10A*, cutting off transistors *Q1, Q2,* and *Q3*.

When the output of *IC10B* goes low, *Q4, Q5* and *Q6* are cut off, the output of *IC10A* goes high, and *Q1, Q2,* and *Q3* turn on. Current again flows through the speaker, but in the opposite direction. The transistors are, of course, turning on and off at the audio frequency of the selected tone. This arrangement is considerably more complex than the more commonly used switching circuits, but provides much more output power.

The amplifier draws current directly from the power source. The TTL integrated circuits, however, require +5 volts, which is provided by *IC11*.

Circuit Options. Your particular application might not require the high output power and/or continuous play capability of the circuit shown in Fig. 1. Therefore, a low-power output stage (Fig. 2) and an automatic cutoff circuit (Fig. 3) are possible options.

The manual cutoff, high-power circuit will start playing the bugle call each time power switch *S1* is closed. It will continue to play the call until *S1* is opened. This version of Charge! is suitable for use in a vehicle or as a cheerleading device. However, if the unit is intended for indoor use, the low-power output stage should be employed. (A line-powered supply for the low-power version is shown in Fig. 4.)

If Charge! is to be operated so that it plays the tune once after a momentary switch (such as a doorbell switch or magnetic door switch) closes, the automatic cutoff circuit should be included. Either circuit option can be employed separately, or both used together. The power supply shown in Fig. 4 can accommodate the auto cutoff as well as the low-power output stage.

The auto cutoff circuit controls power to regulator *IC11*. A momentary switch closure latches the circuit on until the bugle call has been played in its entirety. If the "A" wiring is used, flip-flop *IC12A* will then toggle and turn off *Q8*. This, in turn, cuts off pass transistor *Q7*. If the "B" wiring is used, *IC12A* will not toggle until the bugle call has been played twice. Of course, you can install an SPDT switch to select either the "A" or "B" connection. Similarly, you can connect power switch *S1* across *Q7* to provide a choice of either continuous or automatic cutoff operation.

Transistors *Q2* through *Q6* and resistors *R9* through *R13* are omitted in the low-power output stage. Gate *IC10A* inverts the tone square waves at the output of multiplexer *IC9* and applies them to the base of *Q1*. When the output of *IC10A* is high, *Q1* conducts and current flows through the speaker. Potentiometer *R14* functions as an output level control. When the output of *IC10A* is low, the transistor is cut off and the speaker coil passes no current. Referring to the previous description of the high-power output stage, it can be seen that the average current through the speaker is doubled by that circuit as compared to the low-power stage. This results in a four-fold increase in output power.

If you decide to employ the low-power stage, be sure to connect the output of multiplexer *IC9* to the strobe input of multiplexer *IC5*. When the strobe input is high, the multiplexer output remains high no matter what logic levels appear at the data and data select inputs. A logic zero at the strobe input of *IC5* allows the chip to pass signals (in inverted form) from the selected input to the output. All other connections remain the same whether the high- or low-power output circuit is used.

Construction. Printed circuit, point-to-point, or Wire Wrap assembly techniques can be used. Parts placement is not critical. Wire Wrap sockets should be used with the IC's if this method of duplicating the circuit is chosen. Wire no smaller than No. 24 should be used for all power supply and output stage connections. All ground connections should be made to one common point.

If Charge! is housed in a metallic utility box, *IC11* should be mounted on the enclosure with thermal coupling through heat sink paste. The utility box will then be connected to the circuit common or ground. If desired, a small heat sink approximately 1" x 1" (2.5 x 2.5 cm) with ½" (1.3-cm) fins can be used with *IC11*. A heat sink is a necessity if the project is housed in a nonmetallic enclosure.

Power switch *S1*, PITCH control *R2*, and TEMPO potentiometer *R5* can be mounted at convenient spots on the enclosure. The power switch must be able to handle at least 3 amperes dc at 12 volts. If the automatic cutoff circuit is used, the momentary contact switches should be rated for 50 mA, and, if preferred, *S1* can be eliminated.

For automotive applications, tap +12 volts at a convenient point and route it to the project's power input. (Screw-type terminal strips mounted on the project enclosure simplify connections.) If the circuit is housed in a metallic enclosure, bolting it to the vehicle chassis will furnish a ground return. When connecting a speaker to the audio output, note that both sides of the speaker coil are floating. It's important, therefore, not to let one side of the speaker become inadvertently grounded. Mount the speaker, which should be a horn-type transducer for outdoor use, in or on the vehicle at a suitable location. The box housing the circuitry should be installed so that the power switch, TEMPO and PITCH controls can be easily reached. ◇

The Spectrum Analyzer in Hi-Fi Measurements

Frequency-domain instrument provides graphic solution of distortion products undetected by other means.

BY JULIAN HIRSCH

ONLY a few years ago, the spectrum analyzer was an exotic, expensive, and relatively unknown test instrument to most people in the audio industry. By contrast, spectrum analysis today is almost a household word (albeit not always fully understood) among audio design engineers, recording engineers, and technically minded hobbyists.

The spectrum analyzer is, in the frequency domain, what the oscilloscope is in the time domain. As shown in Fig. 1A, a scope displays the signal amplitude as a function of time, which we know as the *waveform*. A laboratory-grade scope, with its accurately calibrated time base and deflection sensitivity, can be considered as a voltmeter with virtually instantaneous response, able to display and measure signal voltage variations over any selected period of time from microseconds to minutes.

Every signal also has a unique *spectrum signature* in the frequency domain which can be broken down into one or more different components whose amplitudes and frequencies are related to the amplitude and waveform of the signal (Fig. 1B). Mathematically, there is a direct relationship, via the Fourier transform, between the amplitude and frequency characteristics of a signal, so that the spectrum analyzer and oscilloscope actually display the same information in two very different ways. Each has its peculiar advantages and limitations for revealing certain characteristics of a signal. For example, in digital or pulse circuits, the time of occurrence, and duration, of pulses or signal level states are of greatest interest, making the scope the logical tool for digital circuit analysis. The frequency analysis of most complex digital signals would convey little or no information about their timing. On the other hand, the scope is of little value in distortion analysis of linear systems (such as hi-fi amplifiers). Unless the distortion is severe, the test signal looks like a "perfect" sine wave on the scope. The spectrum analyzer, however, clearly resolves the distortion components, whose frequencies and amplitudes can be determined directly from the display.

Types of Analyzers. Two basic types of spectrum analyzers are used in audio measurements. The so-called *real-time* analyzer is widely used for acoustic measurements, since it is able to display the distribution of energy throughout the entire audio spectrum. The frequency content of a musical performance or a recording can be analyzed as it takes place, hence the term "real time".

A real-time analyzer consists of a series of contiguous band-pass filters, whose cut-off slopes intersect at their −3-dB response frequencies. The filter group usually covers the entire audio band of 20 to 20,000 Hz, and their outputs are normally displayed as vertical lines on a cathode ray tube (CRT), the heights of the lines being proportional to the signal levels in the individual passbands. The filter outputs are electroni-

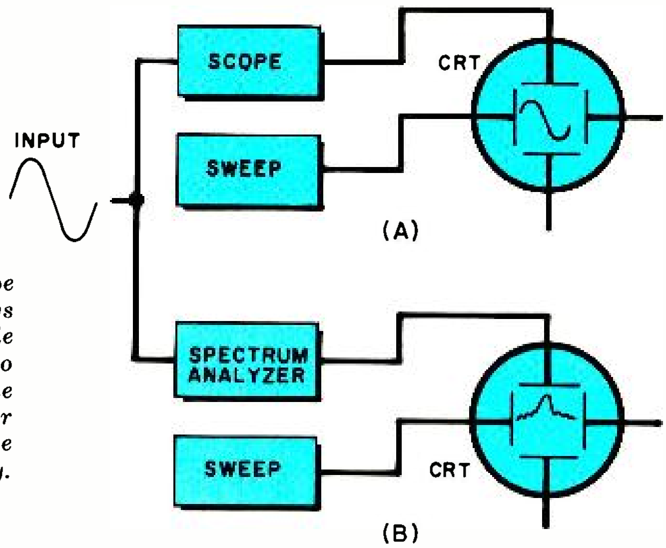


Fig. 1. Scope display (A) shows wave amplitude with respect to time, while spectrum analyzer (B) shows amplitude versus frequency.

cally commutated rapidly enough to avoid a flickering display. For certain specialized applications such as monitoring programs at a recording console, an array of light emitting diodes (LED's) is sometimes used as an inexpensive substitute for a CRT display.

The individual filter bandwidths are typically a fixed percentage of their center frequencies (*for example,* ⅓ octave or 1/10 octave). For practical reasons, the "skirt" widths of the filters are quite broad, so that lower-order harmonics cannot be resolved. Also, the range of amplitudes that can be shown simultaneously on the display is rather limited, rarely exceeding 40 dB. These characteristics do not limit the application of real-time analysis to acoustic measurements, or other relatively broad-band measurements. However, for circuit measurements or performance testing, in which the presence and levels of distortion products or other spurious signals are of interest, the real-time analyzer lacks the frequency resolution (selectivity) and dynamic range to be a useful tool. For such applications, a *scanning analyzer* is used.

The scanning spectrum analyzer, as we still consider it, is basically a superheterodyne receiver with a highly selective i-f amplifier, whose local oscillator is tuned automatically and repetitively through a selected frequency range. As signals are "tuned in", their amplitudes are detected and used to deflect a CRT beam vertically. The horizontal sawtooth sweep voltage that deflects the CRT beam along its horizontal axis is also used to sweep the oscillator frequency, so that the horizontal axis becomes a frequency scale. This is shown in Fig. 2.

Most of us are accustomed to thinking of a superheterodyne receiver as an r-f device, but the principle is applicable to any frequency range. For example, a low-frequency scanning (sweeping) spectrum analyzer typically uses a 100-kHz i-f with the oscillator sweeping from 100 kHz to 150 kHz. Thus, input signals from 0 to 50 kHz will be successively heterodyned to the intermediate frequency and displayed as "pips" on the CRT. Scanning analyzers normally have a number of selectable, fixed i-f bandwidths that make it possible to resolve and measure individual frequency components closely spaced in frequency. Since only one filter is involved, as compared to the dozens employed in real-time analyzers, the skirt selectivity of a scanning analyzer can be made very sharp without incurring prohibitive expense.

One might think that by simply sweeping the audio band at a rapid rate, comparable to the commutation rate of a real-time analyzer, a scanning analyzer could be used to make essentially "real-time" measurements. Unfortunately, electronic "laws" require that a high-resolution (narrow-band) analysis be made slowly. A finite time is required for the output of a filter to reach its final value after a signal is applied to its input, and with very sharp filters, this time can be in the order of seconds. A frequency band must be swept at a rate that allows each component of interest to remain within the filter pass-band long enough for the full output level to be reached. Even a relatively crude measurement over the 20-to-20,000-Hz band requires about 1 second, and high-resolution scans, even over limited bands, may take many minutes. Thus, the scanning analyzer is poorly suited to measuring transient or nonrepetitive signals, and is most useful with continuous, or periodic signals—the types normally used in testing high-fidelity components.

Advantages of Spectrum Analyzers. The most common audio measurements (frequency and distortion) can be made with simpler, less expensive instruments than spectrum analyzers. What unique advantages of spectrum analysis justify its considerable cost? Most often, the speed of measurement is greatly increased. For example, a total harmonic distortion (THD) measurement with a null-type distortion analyzer is made by setting its controls for a reference full-scale meter indication, then tuning it to the fundamental signal frequency and carefully nulling it out with the controls. Depending on the specific design of the instrument, this can require 30 seconds to 1 minute each time the frequency is changed (although some recent analyzers have automatic nulling that reduces measurement time to a few seconds).

The distortion meter reading, known as the THD, includes all harmonics of the fundamental frequency, plus any noise, hum, and other spurious signals that may be present. It does not distinguish in any way between these several signals. Therefore, it is good practice to display the distortion products on an oscilloscope, which gives a rough indication of the residual signal components included in the THD measurement. In the case of the best modern amplifiers, whose distortion may be 80 to 90 dB below the fundamental (0.01% to 0.003%), the nulling process can be quite time consuming, and the oscilloscope usually shows that most of the "distortion" is really hum, hiss, or stray r-f pickup. A somewhat similar situation exists when making FM tuner measurements, since the signal may contain appreciable amounts of 19- and 38-kHz stereo subcarrier signals in addition to noise and distortion. In fact, meaningful measurements of channel separation in most tuners cannot be made without some sort of filtering to remove these unwanted signal components which otherwise would mask the weaker signal crosstalk.

In contrast, a good spectrum analyzer shows the frequency and amplitude of each discrete frequency component, clearly separated on the CRT display (and usually in a single scan requiring only a second or two). All significant harmonic and intermodulation products can be readily identified and measured, even in the presence of much stronger hum or noise signals. Since each harmonic is measured as "X dB" below the amplitude of the fundamental, it is necessary to convert the decibel readings to percentages, and combine all significant readings by taking the square root of the sum of their squares, to obtain a true total harmonic distortion reading (less noise and hum, of course). With the aid of a good scientific calculator, this is a simple and rapid procedure.

A major advantage of the scanning spectrum analyzer is its ability to discriminate against random noise. A THD meter, or any other wide-band instrument, is sensitive to noise over a wide range of frequencies. In general, this is "white" noise (equal energy per unit of bandwidth) so that each octave of frequency coverage contains as much energy as the total of all lower octaves. No matter how quiet an amplifier may be, if its distortion is very low, it is likely to be submerged in the noise, especially at low power levels. This is why THD measurements made on very clean amplifiers usually rise as the power output is reduced to a small fraction of one watt. The distortion is below the fixed noise level, which becomes a greater percentage of the reference level as power is reduced.

The narrow bandwidth of the spectrum analyzer drastically reduces its susceptibility to noise. Signal components which are totally submerged in noise in a wide-band measurement can easily be seen and measured with the analyzer. The resulting "THD" figure, computed as described previously, is not only lower than the reading of a distortion analyzer, but is more meaningful as well.

Applications. It would be impossible to list, even in a cursory manner, the many applications of a spectrum analyzer in audio equipment testing. In general, it can be used in any situation where one would use an oscilloscope, since it is capable of analyzing the same signal from a different viewpoint, so to speak. By viewing the signal simultaneously on a scope and an analyzer, the maximum amount of information can be obtained in a minimum time.

It is possible, by a simple heterodyning process, to generate a constant amplitude sine-wave signal at the exact frequency to which the analyzer is tuned. Sometimes this requires an accessory instrument, but many spectrum analyzers now have this capability built-in. If the signal is applied to the device under test, such as an amplifier or filter, and the output of the device is connected to the spectrum analyzer input, it becomes possible to measure frequency response characteristics over an almost incredible dynamic range. For example, if the rejection characteristics of a filter are to be measured conventionally using a broadband meter or chart recorder to display its output, it is difficult to measure the actual depth of the rejection notch, which can become obscured or filled in by noise, hum, or other extraneous signals. With the combination of an analyzer and synchronous sweeping generator, a narrow i-f bandwidth can be used to virtually eliminate noise, so that the lower limit of measurement is set only by the available signal voltage and the analyzer sensitivity. Measurement dynamic ranges of 100 to 120 dB are routine, and even greater ranges can be achieved with care.

Just as scopes are made with narrow or wide amplifier bandwidths, depending on their application, spectrum analyzers are available for all frequency ranges from subsonic to microwave. The resolution and stability requirements, and the input impedance required for the different frequency ranges vary widely, as do the specific applications.

Using an Analyzer. At Hirsch-Houck Laboratories, we have recently acquired a Hewlett-Packard 3580A spectrum analyzer. This is one of the most advanced scanning analyzers yet developed for the low-frequency range from 5 Hz to 50 kHz. The 3580A has a digital tuning dial that sets the frequency corresponding to either the start (low end) or the center of the swept range, anywhere in its 50-kHz operating range. The sweep width can be set (in steps having a 1,2,5 sequence) to values from 5 Hz to 5 kHz per horizontal division of the display, or 50 Hz to 50 kHz overall. Depending on the measurement requirements, the bandwidth (resolution) can be switched over a 1-to-300-Hz range, in a 1,3,10 sequence.

Earlier, we mentioned the importance of scanning slowly enough for the highly selective filter to "build up" to its full response. An ingenious interlocking logic system between the sweep width, bandwidth, and sweep time controls warns the user of excessive scanning velocity (the frequency range covered in a given time) by turning on a front-panel LED. In this case, the sweep must be slowed down, or the bandwidth increased, until the LED is extinguished. The scan time can be adjusted from 0.01 seconds per division to 200 seconds per division, corresponding to full scan times from 0.1 seconds to 2000 seconds (more than 33 minutes).

Since typical scanning times in audio measurements are often 10 seconds to a minute or more, an ordinary CRT display would be of little value (one would see only a slowly moving dot of light, rather than a complete trace). Sometimes a storage cathode ray tube is used to "hold" the display, but H-P has chosen to incorporate a highly effective digital storage system to achieve the same result with a relatively inexpensive, conventional cathode ray tube. A random

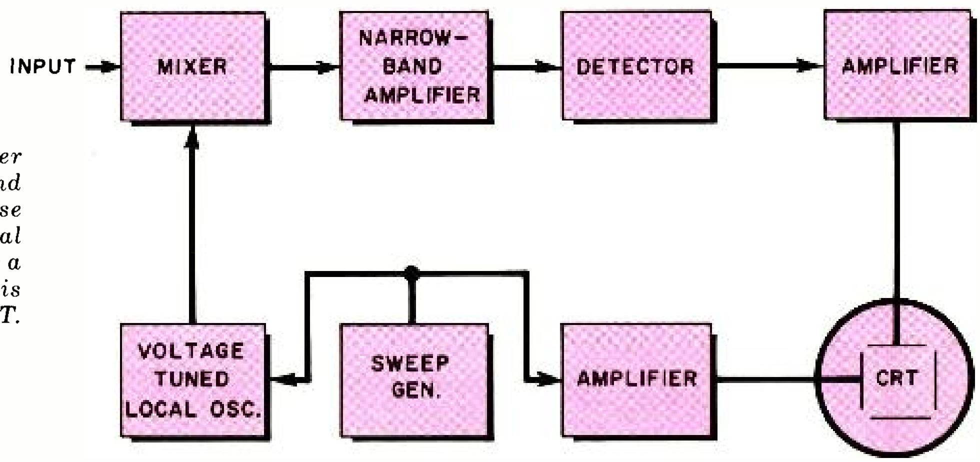


Fig. 2. A swept spectrum analyzer is basically a narrow-band superheterodyne whose voltage-controlled local oscillator is swept across a narrow frequency. Output is displayed on a CRT.

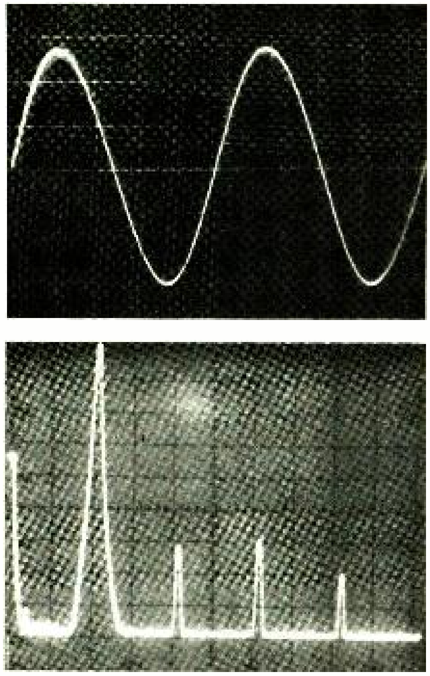


Fig. 3. Harmonics don't show in scope photo (A, top) of 1-kHz sine wave, but they do in photo of analyzer display (B, bottom).

access memory (RAM) is used to hold the horizontal and vertical CRT spot position information. The frequency scan data, corresponding to the horizontal axis of the display, is stored sequentially in the 1024 memory addresses of the RAM. At each address, the signal amplitude (vertical axis) is converted to an 8-bit "word" by an A/D (analog-to-digital) converter, and stored in that address. The 8 bits gives a total of 256 amplitude levels, and the maximum resulting error of 0.4% is well within the instrument's ratings. The information is stored in "real time", as it is being developed by the slow analyzer scan. However, it is simultaneously read out of the memory at a fixed rate of 50 times per second, passed through D/A (digital-to-analog) converters, and used to position the spot on the CRT display. The display is seen as a bright, nonflickering trace, which moves more or less slowly across the screen as the analyzer scan proceeds.

It is possible to store any one trace indefinitely by using the "single sweep" capability of the analyzer. If one wishes to store a trace and have it available for comparison to a later scan, pressing the STORE button on the panel retains the existing scan information in half the addresses, while the remaining 512 addresses are used for the subsequent scan storage. By reading out all 1024 addresses, one sees both scans simultaneously.

The amplitude display of the H-P 3580A has an effective range of about 90 dB, with each vertical division corresponding to a 10-dB level change. The amount of noise visible on the baseline depends on the i-f bandwidth and the signal characteristics, but in most cases signal measurements can be made over a range of more than 80 dB. For a more detailed study of small amplitude variations, the vertical scale can be changed to 1-dB per division, with the top 10 dB of the full display covering the entire screen height. In addition, there is a linear vertical scale, providing an absolute voltage readout. Depending on the input attenuator setting, a full-screen deflection can be obtained with signal amplitudes as great as 100 volts (across the 1-megohm input impedance of the analyzer) to as little as 100 nanovolts (0.1 microvolts).

An intriguing and unique feature of the 3580A is its "adaptive sweep". To accelerate a very slow scan analysis, when only a few signal components are expected to be present, the scan can be adjusted to speed up by a factor of about 20 times until a signal greater than the pre-determined level is encountered. At this point the sweep stops, "backs up" slightly in frequency, and scans through the signal at the selected slow rate, to give an accurate frequency and amplitude readout. Then, it speeds up until the next signal is encountered.

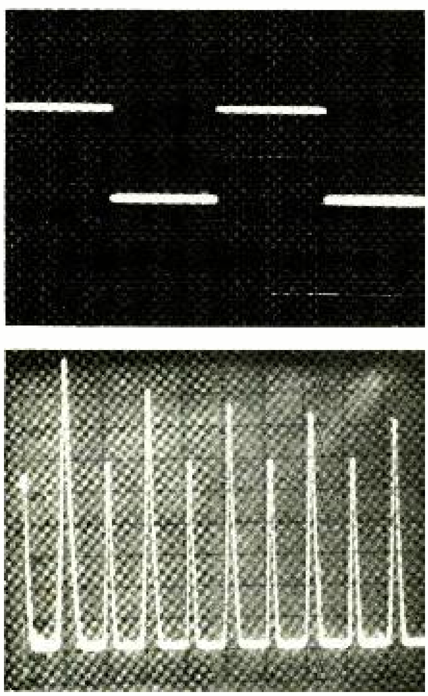


Fig. 4. Spectrum analyzer (B, bottom) shows undesirable even harmonics in square wave which appears clean on scope (A, top).

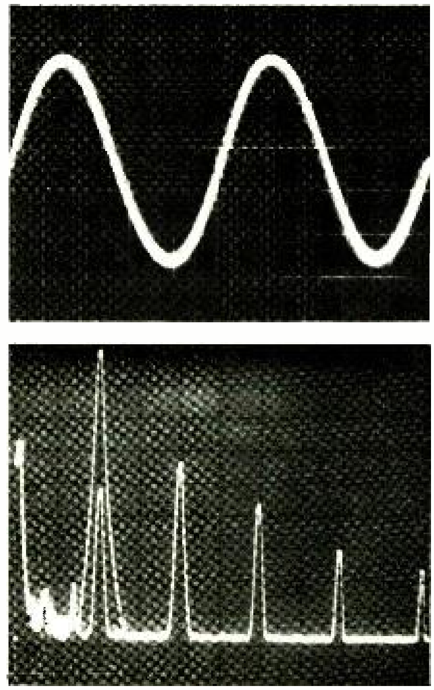


Fig. 5. Top (A) is output of one channel of FM tuner with 1-kHz signal. Spectrum analysis (below) shows 42-dB channel separation.

Especially in audio-frequency response measurements, it is often desirable to expand the lower frequency portion of the display to show greater detail in the few octaves which would otherwise be compressed into a small portion of a linear frequency scan. A logarithmic sweep is provided for this purpose, spreading the 20-to-20,000-Hz audio band across almost the full screen width in three equal decades of frequency.

Waveform Examples. To illustrate the capabilities of a high-resolution scanning spectrum analyzer in audio testing, we have taken photographs of its display in some typical measurement situations, contrasting them with the appearance of the same signal on an oscilloscope screen. Fig. 3A shows two cycles of a 1000-Hz sine-wave signal at an amplifier output. To the eye, it appears to be a pure, undistorted sine wave. The same signal displayed on the spectrum analyzer, sweeping from 0 to 5000 Hz is shown in Fig. 3B. The 2nd, 3rd, and 4th harmonics are visible, at amplitudes of −62 dB, −59 dB, and −70 dB. The equivalent THD reading (which was confirmed by our distortion analyzer) was 0.014%. Obviously, much lower distortion percentages, down to 0.003% or less, can be displayed on the analyzer screen.

To all appearances the 1-kHz square wave shown in Fig. 4A has good

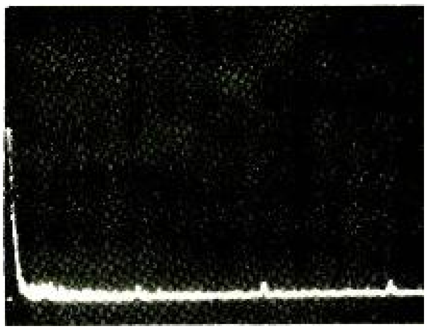


Fig. 6. Spectrum analysis of line power shows hum components at 60, 120, and 180 hertz.

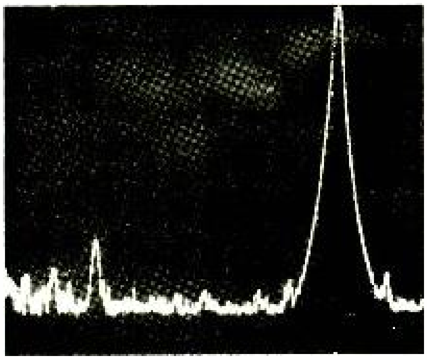


Fig. 7. Analysis of FM tuner has 1-kHz component at right, 400-Hz AM near left, indicating AM rejection is about 68 dB.

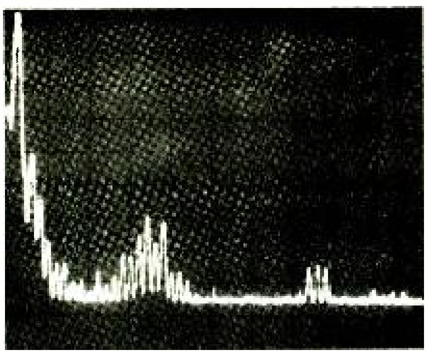


Fig. 8. Analysis of FM tuner has 1-kHz modulation signal followed by harmonics. Also shown are 19-kHz pilot carrier, its modulation products, and 38-kHz signal leakage.

symmetry and rise-time characteristics. The same signal, viewed on the spectrum analyzer scanning from 0 to 10 kHz (Fig. 4B) shows higher than theoretical amplitudes for the 3rd, 5th, 7th, and 9th harmonics, and the presence of all even harmonics (which should be entirely absent in a true square wave) at a level of about −30 dB, or 3%, relative to the fundamental frequency. The even harmonic content shows a lack of symmetry in the square wave, which is not easily seen in the scope photo.

We supplied an FM stereo tuner with an r-f signal modulated 100% in the left channel by a 1000-Hz sine wave. The tuner's left channel output is shown in Fig. 5A as it appeared on the scope, essentially a sine wave. However, in Fig. 5B, the spectrum analyzer displays both the left and right channel tuner outputs (using its storage facility), over a range of 0 to 5000 Hz. The fundamental 1000 Hz output is seen at two levels, showing that the channel separation of the tuner was a good 42 dB. Note that the various harmonics of the modulating frequency appear at the same amplitude in both channels. If the channel separation measurement had been made with a meter, the 2nd harmonic would have dominated the measurement, making the separation appear to be about 33 to 34 dB. The analyzer display also shows that the THD of the tuner under these conditions was 2.1%, or −33.7 dB.

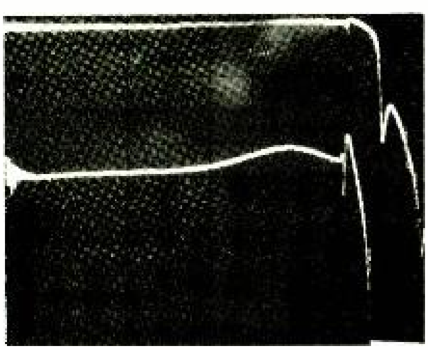
We next examined the tuner output for signs of power line hum, using a 0-to-200-Hz sweep with an analyzer bandwidth of 1 Hz. The time required for this measurement (Fig. 6) was 500 seconds, or more than 8 minutes. The reference (0-dB) level was set to the output from a 100% modulated test signal. The presence of hum components at 60, 120, and 180 Hz can be seen, with respective amplitudes of −85 dB, −84 dB, and −84 dB.

Another common tuner measurement is for AM rejection, using a signal which is frequency modulated 100% at 1000 Hz, and simultaneously amplitude modulated 30% at 400 Hz. The resulting spectrum centered at 700 Hz is shown in Fig. 7 with a scale factor of 0.1-kHz per division. At the right is the output from the FM modulation, and at the left is the 400-Hz component resulting from the tuner's inability to completely reject the AM portion of the signal. Nevertheless, the AM rejection of 68 dB represents excellent performance.

The total output of the FM tuner, over the full range of the analyzer, is shown in Fig. 8. The frequency scale is 5-kHz per division. At the left is the 1000-Hz audio output, followed by its harmonics. The 19-kHz pilot carrier leekage is down 68 dB (very good) and it is flanked by a number of modulation products. Note that any of these products below 15 kHz are more than 70 dB below program level, and therefore inaudible. Finally, there is a small amount of 38-kHz leakage from the multiplex demodulator, with adjacent sidebands at 37 and 39 kHz.

To make a frequency-response measurement on the tuner, we passed the synchronously swept signal from the spectrum analyzer through the Sound Technology 1100A Signal Conditioner (a precision FM preemphasis unit) and modulated the S-T 1000A Signal Generator with its output. Using the LOG sweep of the spectrum analyzer, we can see in Fig. 9A that the response is essentially flat to just beyond 15 kHz, dipping sharply at 19 kHz and higher frequencies. Noticing a "glitch" at about 10 kHz, we repeated the scan using the 1-dB per division amplitude scale, shown as the lower trace on the photo (again, a convenience afforded by the dual-trace storage capability of the instrument). This reveals a response flat within 1 dB from 20 Hz to just below 15 kHz, but with a definite, sharp irregularity at about 10 kHz. For a still better look, we repeated these measurements with the linear scan from 0 to 20 kHz (Fig. 9B). This shows the response "glitch" in better detail, and also shows that the high-frequency roll-off becomes significant above 14 kHz (the LOG scan cannot be read as accurately).

These examples illustrate but a few of the audio measurements which can be made more rapidly, thoroughly, and accurately with the spectrum analyzer than with more conventional instrumentation. With the addition of this powerful tool to our laboratory, we expect to provide even more definitive test information in our future product reports. ◇



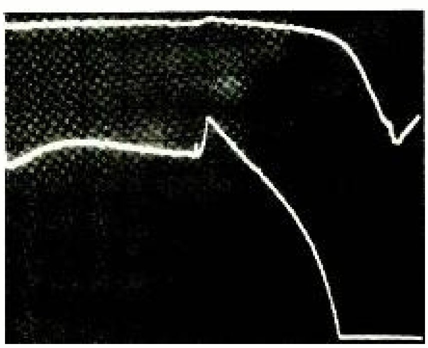


Fig. 9. Upper trace (A, left) shows tuner response flat to about 15 kHz. Note "glitch" at 10 kHz. Lower trace is on 1-dB scale. Linear scan (B, right) shows more detail.

FM tuner specifications can help you assess how well a given model will work in a particular area, given a good FM antenna. You won't find many of these specifications in most advertisements, but you will likely read them in manufacturers' literature on FM tuners (and on the tuner sections of receivers).

In the accompanying tables, you'll find the most important specifications (as listed by their manufacturers) for nearly 100 separate tuner models, grouped by suggested retail prices for easy comparison. Bear in mind, though, that manufacturers reserve the right to change these suggested prices without notice, and dealers need not adhere to them.

BY IVAN BERGER, Senior Editor

1978 STEREO FM TUNER BUYING DIRECTORY

Specifications and features of today's most popular FM tuners

Sensitivity. The single most-advertised tuner specification, IHF monophonic sensitivity, is among the least useful ones in judging tuner performance. This "usable sensitivity" figure defines the input signal a tuner requires for a signal-to-noise and distortion ratio of only 30 dB—hardly "usable," in hi-fi terms. Still, in many cases, it's the only sensitivity specification provided.

More significant is the second sensitivity figure, the signal needed for 50 dB of quieting—listenable, if still not quite hi-fi by current standards. Since most listening is done in stereo, the 50-dB *stereo* sensitivity figure is more significant still. Though *usable* sensitivity figures are usually given in microvolts of signal *voltage* level, the *50-dB* figures are usually given in "dBf"—that is, dB above a signal *power* level of one femtowatt (10^{-15} watt).

The dBf figure is significant for two reasons. First, because it measures power, not voltage, it is the same for measurements taken at a tuner's 300-ohm and 75-ohm antenna inputs. A tuner rated at 1.0 μV across its 75-ohm input (common practice, overseas) is *not* more sensitive than one rated at 2.0 μV across 300 ohms (as is the practice here)—both are equivalent to 11.2 dBf. Second, because the figures are logarithmic, as all dB figures are, they emphasize the real meaning of differences in sensitivity. A difference in tuner sensitivity of 3 dBf always means one tuner is twice as sensitive as the other, whether the figures we're comparing are 9.8 and 12.8 or 35 and 38 dBf. But a sensitivity difference of 0.5 microvolts, quite significant when we're comparing 1.5 and 2.0 μV, is of almost no significance when comparing 35 with 35.5 μV.

Whether in dBf or μV, sensitivity is most important to listeners in weak signal areas. If that's your problem, try a better antenna before replacing your tuner. It can often make your current tuner the equivalent, for all practical purposes, of a rather more expensive one. Even if you then find you still need a better tuner, the new antenna will help your new model deliver all the performance you're paying for.

The smaller the sensitivity figure the better, whether it's expressed in microvolts across a 300-ohm input or in dBf. (Note that dBf, which expresses signal power, remains constant for both 75-ohm and 300-ohm antenna inputs. For the same power, only half as many microvolts are needed at a tuner's 75-ohm input as at its 300-ohm one; 75-ohm microvolt figures should therefore be doubled before comparing them with 300-ohm figures.)

Selectivity. This measures the tuner's ability to reject signals on frequencies near that of the station to which it is tuned. The alternate-channel selectivity figures given here indicate ability to reject signals 400 kHz above or below the desired frequency. An IHF selectivity figure of 70 dB, for example, means that it takes an alternate-channel signal 70 dB stronger than the desired-channel signal to produce interference 30 dB below the level of the desired signal. Interference from signals less than 70 dB stronger would produce much less interference than that.

Tuners with variable i-f bandwidth (see under *Features*) are more selective at their narrow-band settings. (However, not all makers of dual-bandwidth tuners give both narrow-band and wide-band figures.) The higher the selectivity, the less potential interference. High selectivity is especially desirable in suburban and metropolitan areas where signals from different towns or cities are sometimes found on alternate channels. (Selectivity figures for adjacent-channel signals—those 200 kHz above or below the desired frequency—are rarely published by manufacturers, and are always considerably lower than alternate-channel figures.)

Capture Ratio. FM tuners can distin-

(Continued on page 57)

FM TUNER COMPARISON TABLE

Make & Model	Price ($)	Sensitivity in µV (&dBf)			Selectivity (IHF) (in dB)	Capture ratio (in dB)	Ultimate S/N (in dB)	Distortion (percent)		Separation (in dB) at	Rejection (in dB)			Meters[1]	Features					Remarks
		IHF Mono	50-dB Quieting Mono	50-dB Quieting Stereo				Mono	Stereo	1K/10K Hertz	AM	Image	Spurious		Dolby	Deemphasis	Hi-Blend	Rec. Osc.	Bandwidth	
I: UP TO $200																				
Akai AT-2200	165	1.9(10.8)	—(—)	—(—)	60	1.3	70	0.3	0.5	40/—	50	55	85	S,C						
Akai AT-2400	185	1.8(10.3)	—(—)	—(—)	80	1.0	75	0.2	0.3	42/—	55	90	100	S,C			X			
Fisher FM2110	160	1.8(10.3)	2.8(14.1)	38(36.8)	70	1.0	72	0.4	0.5	40/30	60	60	85	S,C						
Harman-Kardon T403	195	1.7(9.8)	3.8(16.8)	45(38.3)	50	2.0	73	0.5	0.7	40/30	55	45		Q						
Heath AJ-1219	110	2.0(11.2)	—(—)	—(—)	60	2.0	—	—	—	—/40	50	—	—	—						Kit only.
JVC JT-V31	170	1.9(10.8)	4.0(17.2)	40(37.2)	60	1.2	72	0.2	0.35	45/35	50	—	—	S,C						
JVC JT-V11	150	1.9(10.8)	—(—)	40(37.2)	60	1.0	72	0.2	0.4	40/30	—	—	—	S,C						
Kenwood KT-5300	140	1.9(10.8)	5.0(19.2)	—(—)	60	1.0	70	0.2	0.3	30/30	50	—	70	C						
Lafayette LT-40	150	2.0(11.2)	3.1(15.0)	39(37.0)	68	1.6	72	0.2	0.6	40/—	—	50	90	S,C						
Marantz 2100	200	1.9(10.8)	2.5(13.2)	40(37.2)	80	1.0	75	0.15	0.3	45/40	55	85	90	S,C		X				
Nikko FAM-450	140	2.0(11.2)	—(—)	—(—)	55	1.6	65	0.4	—	42/—	—	45	—	—			X			
Onkyo T-4	200	1.9(10.8)	3.5(16.1)	40(37.2)	60	1.5	70	0.2	0.4	40/30	50	60	85	S,C		X				
Optonica ST-1515	180	1.7(9.8)	5.5(20.0)	44(38.1)	60	1.2	72	0.2	0.3	45/35	50	82	80	S,C			X	X		
Pioneer TX-6500 II	200	1.9(10.8)	2.8(14.1)	44(38)	60	1.0	75	0.15	0.3	40/30	50	60	—	C						
Pioneer TX-5500 II	150	1.9(10.8)	2.8(14.1)	44(38)	60	1.0	72	0.15	0.3	35/30	50	60	—	C						
Realistic TM-1000	170	2.0(11.2)	—(—)	—(—)	65	2.0	—	—	—	35/—	—	—	—	S						
Rotel RT-725	200	1.8(10.3)	3.0(14.7)	44(38.1)	60	1.5	70	0.2	0.3	42/31	50	—	—	S,C		X	X			
Rotel RT-425	170	1.9(10.8)	3.1(15.0)	44(38.1)	50	1.5	70	0.2	0.3	40/30	50	—	—	C		X				
Sansui TU-3900	160	2.0(11.2)	—(—)	—(—)	60	2.0	70	0.3	0.4	40/—	—	55	70	S,C		X				
Sansui TU-217	175	1.85(10.5)	2.7(13.8)	—(—)	50	—	71	0.12	0.13	—/—	—	—	—	S,C						
Sanyo FMT 1001K	150	2.0(11.2)	—(—)	—(—)	—	1.0	70	0.4		40/—	55	60	—	C			X			
H.H. Scott T-516	150	2.2(12.0)	3.5(16.1)	70(42.1)	55	1.5	68	0.3	0.5	40/34	50	50	80	S			X			
Superscope T-210	105	—(—)	10(25.2)	55(40.0)	25	6.0	60	1.0	—	30/15	35	—	—	S						
Technics ST-7300	180	2.0(11.2)	3.0(14.8)	45(38.3)	75	1.0	75	0.5	0.5	45/35	55	55	80	S,C				X		
Webcor 291	130	—(—)	—(—)	—(—)	45	1.2	65	0.2	0.4	30/25	45	50	—	S,C						
Average	165	1.9	(16.2)	(38.1	60	1.6	71	0.3	0.4	38/32	48	57	84							
II: $201–$280																				
Akai AT-2600	275	1.7(9.8)	—(—)	—(—)	100	1.0	75	0.2	[illegible]	45/—	55	110	110	S/D,C			X			
Armstrong 624	250	3.0(10.3)	—(—)	—(—)	56	1.75	65	0.2	0.2	40/—	50	50	—	S/C						FM only; 6-station preselect.
Fisher FM-2310	250	1.7(9.8)	2.5(13.2)	34(35.8)	75	0.8	75	0.1	0.15	46/36	65	80	100	S,C,M/D				X		
Hitachi FT/520	240	1.7(9.8)	3.5(16.1)	39(37.0)	80	1.0	74	0.15	0.25	45/—	55	85	100	S,C						
JVC JT-V71	270	1.8(10.3)	3.8(16.8)	38(36.8)	75	1.0	75	0.1	0.1	50/45	55	—	—	S,C			X			
Kenwood KT-7500	275	1.7(9.8)	2.8(14.1)	35(36.1)	30[2]	1.0[2]	75	0.08	0.1	50/43[2]	—	105	110	S,C					X	
					100[3]	2.0[3]				45/38[3]										
Mitsubishi DA-F10	260	2.5(13.2)	5.5(20.0)	55(40.0)	45[2]	0.8[2]	75	0.06[2]	0.1[2]	45/40[2]	55[2]	75	90	S,C					X	
					75[3]	1.5[3]	—	0.2[3]	—	35/30[3]	50[3]	—	—							
Nikko NT 850	230	1.8(10.3)	—(—)	—(—)	35[2]	1.0[2]	75[2]	0.08[2]	0.15[2]	48/40[2]	60	—	—	S,C			X		X	Multipath indication.
					90[3]	1.5[3]	70[3]	0.2[3]	0.4[3]	35/32[3]	—	—	—							
Onkyo T-9	280	1.7(9.8)	3(14.7)	35(36.1)	80	1.5	—	0.15	0.3	40/35	50	83	95	S,C		X	X		X	
Sansui TU-5900	230	1.8(10.3)	3.5(16.1)	45(38.3)	60	2.0	70	0.25	0.35	40/30	55	50	65	S,C		X	X			
H.H. Scott T-527	250	1.8(10.3)	3.5(16.1)	40(37.2)	55	1.5	68	0.3	0.5	40/34	50	70	80	S,C		X				
H.H. Scott T-526	230	1.9(10.8)	3.5(16.1)	40(37.2)	55	1.5	68	0.3	0.5	40/34	50	50	80	S,C		X				
Sherwood ST-8080	250	2.0(11.2)	—(—)	—(—)	—	1.0	70	—	—	45/—	55	85	—	S,C						
Sony ST-2950SD	220	2.0(11.2)	4.0(17.2)	50(39.2)	50	1.0	73	0.2	0.3	40/35	54	45	75	S,C	X		X			
Technics ST-8080	250	1.9(10.8)	2.5(13.2)	28(34.1)	85	1.0	75	0.15	0.3	45/35	55	85	95	S,C			X			
Toshiba ST-420	220	1.9(10.8)	—(—)	—(—)	70	1.0	72	0.2	0.3	45/—	55	85	100	S,C			X			
Yamaha CT-810	250	1.8(10.3)	3.2(15.3)	40(37.2)	80	1.0	80	0.08	0.1	50/45	55	90	100	S/Q,C			X	X		
Average	250	1.9	(16.0)	(37.3)	73	1.1	73	0.14	0.27	41/34	55	76	92							
III: $281–$380																				
Armstrong 623	359	3.0(10.3)	—(—)	—(—)	65	1.75	65	0.2	0.2	40/—	50	50	—	S/C						3 FM & 3 AM preselect.
Dynaco FM-5	319	1.75(10.1)	5.0(19.2)	—(—)	65	1.5	65	0.5	0.9	40/30	58	—	—	S,CL	X[4]					FM only. Also as kit, $199.
Heath AJ-1515	380	1.8(10.3)	—(—)	—(—)	100	1.5	70	0.3	0.35	40/25	65	90	90	S,C	X					Kit only. Dig. readout.
Hitachi FT/920	300	1.6(9.3)	3.1(15.0)	34(35.8)	80	1.0	74	0.15	0.25	45/—	55	—	100	S/M,C						
Lux T-88V	345	2.0(11.2)	2.8(14.1)	—(—)	60	1.8	72	0.2	0.3	43/30	50	75	—				X			
Marantz 2120	300	1.8(10.3)	2.5(13.2)	35(36.1)	—	—	80	—	—	50/42	55	90	100	S,C	X[4]	X		X	X	
Nikko Gamma 1	350	1.8(10.3)	4.5(18.3)	34(35.8)	35[2]	1.0	75[2]	0.05[2]	0.08[2]	50/40[2]	60	—	110	S,C					X	FM only.
					85[3]	—	72[3]	0.08[3]	0.2[3]	35/32[3]	—	—	—							
Optonica ST-3636	300	1.7(9.8)	—(—)	—(—)	80	2.0	77	0.2	0.4	50/40	50	120	120	S,C/M				X		
Pioneer TX-8500 II	300	1.8(10.3)	3.5(16.1)	40(37.2)	35[2]	0.8[2]	79[2]	0.15	0.8[2]	45/35[2]	55	85	90	S,C			X	X	X	
					80[3]	2.0[3]	75[3]	0.15	0.9[3]	45/30[3]	—	—	—							
Rogers T-75, Series 2	319	1.5(8.75)	4.0(17.2)	30(34.7)	60	1.5	70	0.3	0.7	40/35	50	—	—							
Rotel RT-925	340	1.7(9.9)	3.0(14.7)	35(36.1)	80	1.5	70	0.1	0.3	45/31	60	—	—	S,C/M		X	X			
Sansui TU-717	320	1.75(10.1)	2.45(13.0)	40(37.2)	50[2]	1.2[2]	80	0.07[2]	0.07[2]	45/38	60	86	90	S,C		X	X	X	X	
					80[3]	1.7[3]	—	0.15[3]	0.22[3]	—	—	—	—	—						
Setton TUS-600	380	1.8(10.3)	4.0(17.2)	40(37.2)	80	1.5	70.5	0.09	0.11	55/45	65	—	—	S,C		X				
Sony ST-3950 SD	300	1.7(9.8)	3.0(14.7)	40(37.2)	80	1.0	75	0.15	0.25	40/35	56	80	90	S/M,C	X		X			
Sony ST-4950	350	1.9(10.8)	—(—)	—(—)	80	1.0	70	0.15	0.3	40/—	53	70	100	S/M,C			X			
Technics ST-8600	330	1.9(10.8)	—(—)	—(—)	85	1.0	80	0.15	0.2	—/—	—	—	95	S,C			X[5]	X		
Yamaha CT-1010	350	1.9(10.8)	3.2(15.3)	40(37.2)	85	1.0	80	0.07	0.1	52/45	65	110	110	S/Q,C				X		
Average	350	1.85	(15.7)	(36.5)	78	1.3	74	0.18	0.33	45/36	57	72	100							

[1]C = center of channel
D = deviation
d = digital indication
L = light indication

M = multipath
Q = signal quality (S/N or signal-minus multipath)
S = signal strength

[2]With i-f bandwidth set at "wide" position.
[3]With i-f bandwidth set at "narrow" position.
[4]Optional.

[5]Automatic.
[6]Estimated.

FM TUNER COMPARISON TABLE (Continued)

Make & Model	Price ($)	Sensitivity in µV (&dBf): IHF Mono	Sensitivity: 50-dB Quieting Mono	Sensitivity: 50-dB Quieting Stereo	Selectivity (IHF) (in dB)	Capture ratio (in dB)	Ultimate S/N (in dB)	Distortion (percent) Mono	Distortion (percent) Stereo	Separation (in dB) at 1K/10K Hertz	Rejection (in dB) AM	Rejection Image	Rejection Spurious	Meters[1]	Features: Dolby	Deemphasis	Hi-Blend	Rec. Osc.	Bandwidth	Remarks
IV: $381–$600																				
Accuphase T-101	500	2.0(11.2)	4.5(18.3)	45(38.3)	55[2]	2.0	75	0.1	0.2	45/30	55	80	100	S,C,M					X	FM only.
					100[3]															
Dynaco AF-6	395	1.75(10.1)	5.0(19.2)	—(—)	65	1.5	65	0.5	0.9	40/30	58	—	—	S,CL						Kit $269
Harman-Kardon Citation 18	595	2.0(11.2)	3.2(15.3)	40(37.2)	70	1.5	74	0.15	0.3	50/—	55	63	100	Q,CL		X				
Heath AJ-1510A	500	1.8(10.3)	—(—)	—(—)	95	1.5	68	0.3	—	40/25	—	—	90	S/M			X			Kit only. Dig. synth. Autoscan & 3 presets.
Heath AN-2016 "Modulus"	600	1.7(9.8)	3.5(16.1)	35(36.1)	100	1.3	68	0.3	0.35	40/20	68	90	90	S,C	X[4]					Kit only. Incl. 2/4-channel preamp. Dig. display.
JVC T-3030	600	2.0(11.2)	3.8(16.8)	38(36.8)	70	1.0	75	0.08	0.1	50/45	65	110	110	SL		X		X		Dig. synth. 7 preselects. Autoscan.
Kenwood L-07T	500	1.6(9.3)	2.8(14.2)	38(36.8)	30[2]	1.0[2]	80	0.08[2]	0.1[2]	50/45	65	110	110	S,C		X			X	FM only.
					100[3]	1.5[3]	—	0.15[3]	0.15[3]											
Kenwood 600T	600	1.6(9.3)	2.8(14.1)	38(36.8)	110	0.8	84	0.05	0.08	50/45	65	120	120	S,C,M/D		X			X	FM only. 3 i-f bandwidth.
Kenwood KT-8300	450	1.6(8.3)	2.8(14.1)	30(34.8)	40[2]	1.0[2]	78	0.08	0.1	50/45[2]	60	110	110	S,C,M/D					X	
					110[3]	1.5[3]				45/35[3]										
Lux T-110	525	1.6(9.3)	2.2(12.0)	34(35.8)	70	1.3	78	0.08	0.08	48/38	53	100	—	S,C		X				FM only.
Nakamichi 430	400	1.8(10.3)	4.0(17.2)	40(37.2)	60[2]	1.5[2]	70	0.06[2]	0.09[2]	50/35[2]	60	100	100	CL	X[4]		X		X	FM only.
					40[3]	4.0[3]		0.02[3]	0.04[3]	30/30[3]										
Phase Linear 5000	499	2.0(11.2)	4.0(17.2)	30(34.7)	75	1.5	70	0.2	0.25	40/30	60	110	120	S,C,ML		X				FM only. With expanders.
Philips AH673	600	1.6(9.3)	2.5(13.2)	30(34.7)	110	1.0	75	0.09	0.1	47/38	50	110	110	S,C/M						
Pioneer TX-9500 II	400	1.5(8.7)	2.5(13.2)	35(36.1)	35[2]	0.8[2]	82	0.05[2]	0.07[2]	50/35[2]	65	120	110	S,C				X	X	Audible multipath check.
					85[3]	1.0[3]	—	0.07[3]	0.25[3]	35/30[3]	—	—	—							
Rotel RT-1024	570	1.5(8.7)	2.1(11.6)	35(36.1)	80	1.0	75	0.1	0.2	47/35	60	—	—	S,C,M,D	X	X	X	X		
Sansui TU-9900	460	1.5(8.7)	3.0(14.7)	—(—)	55[2]	1.0[2]	80[2]	0.06[2]	0.08[2]	50/40[2]	58	96	100	S/M,C		X	X	X	X	
					90[3]	3.0[3]	76[3]	0.5[3]	0.8[3]	30/30[3]	—	—	—							
Sherwood HP-5500	500	1.6(9.3)	2.5(13.2)	25(33.2)	85	1.0	70	0.12	0.15	55/40	65	120	120	S,C		X	X			
Sony ST-5950 SD	470	1.5(8.7)	2.8(14.1)	35(36.1)	85	1.0	76	0.1	0.2	50/40	66	90	100	S/M,C	X					
Technics ST-9030	400	2.4(12.8)	4.4(18.1)	44(38.1)	25[2]	0.8[2]	90	0.08[2]	0.08[2]	50/40[2]	58[2]	135	135	S,C			X[5]		X[5]	
					90[3]	2.0[3]	—	0.15[3]	0.3[3]	40/30[3]	—	—	—							
Average	510	1.7	(15.5)	(36.2)	87	1.2	75	0.14	0.2	47/36	60	104	109							
V: $601 and up.																				
Accuphase T-100	750	2.0(11.2)	4.5(18.3)	45(38.3)	70	1.5	75	0.1	0.2	45/30	60	90	100	S,C,M						
Lux 5T50	1495	1.7(9.8)	2.5(13.2)	35(36.1)	72	1.1	70	0.08	0.1	45/40	55	100	100	Sd	X		X			Digital synth. FM only. Audible multipath detector. 7-station preselect.
McIntosh MR 78	899	2.0(11.2)	—(—)	—(—)	55[2]	2.5	75	0.2	0.2	40/—	—	100	100	S/M,C					X	FM only. 3 i-f bandwidths.
					90[3]															
McIntosh MR 77	699	2.0(11.2)	—(—)	—(—)	50	2.5	—	0.2	0.2	40/—	—	100	100	S,ML,C						FM only.
McIntosh MR 74	699	2.5(13.2)	—(—)	—(—)	58	1.5	—	0.3	0.5	35/—	69	100	100	S,ML,C						
Nakamichi 630	630	1.5(8.7)	5.0(19.2)	—(—)	45[2]	1.0	55	0.05[2]	0.08[2]	55/35[2]	69	100	100	SL,CL	X	X			X	Combined with stereo preamp. FM only.
					90[3]	—	--	0.1[3]	0.1[3]	30/30[3]	—	—	—							
RAM Audio 102	639	1.6(9.3)	2.2(12.0)	34.5(36.0)	70	1.5	75	0.08	0.08	46/35	53	—	—			X				FM only.
Revox B760	1145	2.0(11.2)	2.0(11.2)	20(31.2)	80	0.9	75	0.15	0.15	42/—	70	106	106	S,C	X	X	X			Digital synthesis. 15-station preselect.
SAE 8000/Mark VIII	650	1.6(9.3)	2.2(12.0)	25(33.2)	120	1.5	70	0.15	0.2	45/35	100	100	100	S,C		X				Digital readout. FM only.
H.H. Scott T-33S	1000	1.8(10.3)	3.5(16.1)	40(30.3)	55	1.2	70	0.2	0.4	40/40	75	75	90	S,M		X				Dig. Synth. Pre-programmed channel select. Dig. readout.
Sequerra Model 1	3000	—(—)	1.7(9.8)	15.5(29)	100	0.75	75	0.07	0.07	52/38	70	90	—	Scope	X	X	X			Built-in oscilloscope.
Sequerra Model 2	1750[6]	—(—)	1.7(9.8)	15.5(29)	100	0.75	75	0.07	0.07	52/38	70	90	—	S,M	X	X	X			3-station preselect.
Setton RC3 X1000	3500	1.2(6.8)	5.0(19.2)	20(31.2)	—	1.0	72	0.2	0.4	55/30	—	80	90	SL,CL		X[5]		X		Digital display. Built-in preamp.
Sherwood Micro CPU 100	2000	1.7(9.8)	2.6(13.5)[2]	30(34.7)[2]	18[2]	0.5[2]	75	0.07[2]	0.15[2]	50/40[2]	65	130	130	S,M		X			X	Dig. Synth. FM only. Call-letter display.
			2.1(11.7)[3]	25(33.4)[3]	80[3]	1.0[3]	—	0.1[3]	0.2[3]	45/35[3]										
Toshiba ST-910	1800	1.8(10.3)	—(—)	—(—)	70	1.0	75	0.15	0.2	—/40	65	100	100	SL						Dig. synth. Autoscan. 7-sta. preselect. FM only.
Yamaha CT-7000	1200	2.0(—)	—(—)	—(—)	18[2]	0.7[2]	78[2]	0.08[2]	0.15	50/35	60	120	120	S/Q,C			X[5]		X	
					85[3]	1.0[3]	0.2[3]	0.3[3]												
Average	1390	1.5	(13.6)	(33.2)	81	1.2	74	0.13	0.18	45/33	67	100	104							

[1]C = center of channel
D = deviation
d = digital indication
L = light indication

M = multipath
Q = signal quality (S/N or signal-minus multipath)
S = signal strength

[2]With i-f bandwidth set at "wide" position.
[3]With i-f bandwidth set at "narrow" position.
[4]Optional.

[5]Automatic.
[6]Estimated.

(Conntinued from page 54)

guish between two signals on the same channel, even when they are of almost equal strength, suppressing the weaker to "capture" the stronger one. Capture ratio is the minimum ratio in dB between co-channel signals which will allow the tuner to suppress the weaker one's interference by 30 dB. The *smaller* this figure, therefore, the better. (Note that, unlike selectivity, capture ratio improves at a tuner's wide-band setting.) Capture ratio is likely to be most important for listeners in fringe areas equidistant from two stations on the same frequency.

Ultimate S/N. This is the maximum signal-to-noise ratio the tuner can deliver. Since most tuners will reach this maximum with signals of 65 dBf (978 microvolts) or less, ultimate S/N is usually measured at that point. The monophonic figure is listed here; the stereo figure would be lower. As with all signal-to-noise ratios, the higher the figure, the cleaner the sound.

Distortion. Manufacturers differ in their distortion specification methods. Some list harmonic distortion only at one frequency (usually 1 kHz), others list it at several. Some list harmonic distortion only, while others give intermodulation distortion figures, too. When only a single distortion figure is given, assume it to be harmonic distortion at 1 kHz, which is the figure listed here. Note that stereo distortion figures tend to be higher than mono.

Separation. This figure measures the crosstalk between stereo channels. The more separation, the greater the potential stereo effect. Since separation tends to decrease at higher audio frequencies, it is listed in the table, wherever possible, for both 1 kHz and 10 kHz. Separation commonly decreases at bass frequencies, too, but its effects are less audible at those frequencies.

AM Suppression. This has nothing to do with AM broadcasting, but rather with the tuner's ability to reject amplitude variations in the FM signal. This gives some indication of how well the tuner can cope with multipath interference, which causes such amplitude modulation of the FM signal.

Multipath interference, created by the simultaneous reception of a signal and of several delayed signal echoes, is most troublesome in cities and in mountainous or hilly regions, where there are many reflective surfaces from which the signals can bounce. The higher the AM suppression figure, the more resistant the tuner is to such interference.

Image Suppression. This measures the tuner's ability to reject signals 21.4 MHz above the desired signal (21.4 MHz is twice the tuner's i-f frequency of 10.7 MHz). This is most important to those who live near airports, as air-to-ground channels (108-136 MHz) are within the image-frequency range for FM tuners.

Spurious Response Rejection. The interaction of two strong signals (neither of them necessarily within the FM band) can cause a tuner with a nonlinear front end to "receive" nonexistent signals which are actually the sum of or difference between the two interacting signals. A strong station's popping up at several points along the dial would be a typical spurious-response symptom. If your tuner suffers from this or other strong-signal overload problems, look for a tuner with a high spurious-response rejection figure.

Meters. Several types of meters are provided as tuning aids. *Center-channel* meters (C) help you tune accurately to the station's exact frequency. They're found on virtually all tuners except the lowest-priced ones—and some of the highest-priced tuners, whose digital-synthesis circuits render these meters superfluous because they always tune directly to the channel's center. *Signal-strength* meters (S) provide some help in finding the exact station frequency (the signal presumably peaks at that point), but are more useful in orienting the antenna for maximum signal strength.

Multipath meters (M) or *signal-quality* meters (Q) are even more useful in orienting the antenna, as they help you find the direction which yields the cleanest signal. (This may not necessarily be the same direction that yields the strongest one). *Deviation* meters (D) measure the station's modulation level, which you can use as a guide in setting modulation levels on your tape recorder when taping off the air.

Oscilloscopes show multipath, tuning accuracy, modulation and signal level all at once; such a scope is built into the Sequerra Model 1; and many others have connections for use with external scopes. The Sequerra's scope also shows the presence of other signals on nearby frequencies.

Features. We have listed here only some of the more common and significant features. A few significant ones are listed under "Remarks."

Dolby decoding is built into several of the tuners in our table, and available as a plug-in option for a few more. A *de-emphasis switch*, necessary for correct frequency response when using an external Dolby decoder, is available on several tuners also.

High-blend is a very useful aid in listening to marginal stations in stereo. By blending together the higher frequencies of both stereo channels, it reduces noise and distortion while maintaining separation at the middle frequencies to keep some stereo effect.

A *recording oscillator* is simply an aid to setting recording levels for taping off the air. The oscillator's output corresponds to the tuner's output at a specified signal modulation level (usually 50% modulation), allowing the recording level to be adjusted for best signal-to-noise ratio and minimum distortion.

Bandwidth switching allows the user to trade selectivity (at its maximum when the i-f bandwidth is narrowest) for better capture ratio, signal-to-noise ratio, distortion and separation (all best at wider bandwidths). When extra selectivity is needed to pick a particular station out from a clutter of strong ones on nearby frequencies, the user can narrow the tuner's bandwidth to get extra selectivity at the expense of a slight reduction in the other parameters. Tuners with three-position bandwidth selectors are noted under "Remarks."

Digital tuning comes in two flavors: Tuners with *digital displays* may be otherwise conventional in that they tune continuously across the FM band. *Digital synthesis* tuners, though, also have digitally controlled local oscillators that allow them to tune in direct jumps from one station frequency to another without observably moving through any of the frequencies between. This also simplifies the addition of such features as automatic scanning and station preselects, which are often found on such tuners.

There remain a few features and specifications which we have not listed. Some, such as i-f rejection, were omitted because they are of little practical significance to the listener. Others, such as muting and stereo threshold, are not listed consistently enough for us to cover them reliably. ◇

HOW FM TUNERS WORK?

PART 2 *The detector and modulation/ demodulation circuits.*

BY JULIAN HIRSCH

LAST MONTH, in the first part of this article, we discussed the basic principles of frequency modulation and started dissecting the "innards" of an FM tuner by examining the front and the i-f section. We continue here with the detector section and stereo modulation and demodulation.

The Detector. The ratio detector is the most widely used circuit for converting FM r-f to audio signals. The Foster-Seely discriminator originally used in FM tuners has fallen into disuse. Quadrature detectors are sometimes found, especially in lower-priced tuners that use a single IC for i-f amplification, limiting, and detection functions. It also has the virtue of requiring only a single external tuned circuit, which simplifies alignment. A little-used detector with a clear theoretical advantage is the so-called "pulse counter," which generates a short pulse each time the 10.7-MHz i-f signal voltage crosses the zero axis. These pulses can be created with a constant amplitude and duration so that the average value of a series of pulses from an FM signal follows the modulating waveform. This is the most linear type of FM detector (it is often used to measure the inherent distortion of an FM signal generator) but it is rarely used in consumer products. Apparently its advantages are more theoretical than practical, due to limitations elsewhere in the broadcast chain. In other words, a tuner with a pulse counter detector does not necessarily have less distortion than one with a more conventional circuit.

Stereo Modulation/Demodulation. Earlier, we referred to the spectrum of a stereo FM signal as having a 38-kHz double-sideband, suppressed-carrier component that contains L − R program information. Figure 2 is a spectrum analyzer display of the composite modulating signal from our Sound Technology Model 1000A signal generator with a 2000-Hz external signal used to 100% modulate the left channel. The frequency scale is 5000 Hz/division, with the scan covering from 0 to 50 kHz. The base band audio signal at 2000 Hz can be seen at the left with a 0-dB reference amplitude. The 19-kHz pilot carrier can be seen near the center, followed by the two difference sidebands spaced 2000 Hz above and below the 38-kHz carrier. The latter is suppressed to about 54 dB below the difference sidebands.

The relative amplitudes of the base band and subcarrier band signal levels vary in a complex manner according to the spatial distribution of the program. But the general appearance of the signal that modulates the transmitter, and which is recovered at the output of the tuner's detector, resembles the spectrum of Fig. 2.

Although this is one way to look at the stereo signal, it is easier to consider the signal as being created by a sampling process at the transmitter. The left and right channels are alternately selected at a 38-kHz switching rate, and the composite signal modulates the transmitter. Since the normal program bandwidth does not exceed 15 kHz, this meets the requirement that the sampling rate be at least twice the highest frequency in the program. The 38-kHz switching signal does not appear in the output of the switching system (except as the result of inevitable unbalance conditions). Hence, it is divided down to 19 kHz, after which it is transmitted with the audio and subcarrier programs as a pilot carrier.

There are several ways in which the composite detected signal can be separated into its left and right channel components in the tuner. Basically, tuners use the 19-kHz pilot carrier to either synchronize or generate (as by frequency doubling in a full-wave rectifier, or through a PLL) a 38-kHz demodulating carrier. It is imperative that this signal be in-phase with the 38-kHz switching signal at the transmitter, since an error of a few degrees can seriously degrade channel separation.

In a switching demodulator, the composite signal is sampled by the 38 kHz waveform, which reverses the process employed at the transmitter and separates the composite signal into left and right channels. In a matrix demodulator, the composite signal is first separated by filters into the base band (up to 15,000 Hz) and the subcarrier band (23 to 53 kHz). The latter is detected in a balanced modulator, where it is heterodyned with the 38-kHz signal. The output of the modulator is the L − R program (the base band contains the L + R program). The two are then combined in a resistive matrix that adds and subtracts them to derive the left and right program channels.

Following separation, each program channel is individually deemphasized to compensate for the 75-μs preemphasis used at the transmitter and usually passes through a low-pass filter to remove any residual 19- or 38-kHz signal components. These cannot be heard because the tuner's deemphasis reduces even the 19-kHz component to greater than 20 dB below the 100% modulation level. However, even at that level, the 19-kHz signal can interfere with the operation of a Dolby circuit, which interprets its presence as signifying high-frequency program content and alters its frequency response accordingly. With some tape recorders, it is also possible to have harmonics of the pilot carrier beat with the bias oscillator, giving rise to "birdies."

Ideally, the low-pass filter should have a flat response to 15,000 Hz but should attenuate 19-kHz signals (and those at higher frequencies) by at least 30 dB. Such filters can be made, but they are relatively complex and costly, and most tuner manufacturers use simpler filters whose responses begin to roll off above 10,000 or 12,000 Hz and may be down 2 or 3 dB at 15,000 Hz. This is responsible for some of the subtle differences sometimes heard between tuners. In a few deluxe tuners, a switch allows the low-pass filter to be bypassed at the user's option, giving a flat high-frequency response (and with no ill effects, if neither Dolby processing nor tape recording is involved).

Other Features. The multiplex demodulator uses the 19-kHz pilot carrier in the received signal to operate a stereo indicator light. In the absence of the 38-kHz signal, the internal oscillator is disabled and the detected signal passes unchanged through both channels of the demodulator and goes to the amplifier as a mono signal. A control voltage from the tuner's limiter also disables the 38-kHz oscillator when the signal is too weak for noise-free stereo reception. The stereo/mono switch on most tuners does the same thing, under the listener's control.

Interstation noise muting is often controlled by the same signal-derived voltage that operates the stereo switching circuit. In some tuners, multiplex IC's contain muting circuits, while in other tuners, the muting voltage acts on the limiter IC. A preferable system, used in a few tuners, is to combine the signal sensing voltage with the detector output so that the tuner "un-mutes" only when a signal is sufficiently strong *and* when it is tuned with sufficient accuracy for low-noise, low-distortion reception.

Perhaps the most serious cause of distortion in FM reception is multipath interference. When a signal is reflected to the tuner over several different path lengths, the various components arrive with random phase relationships. The result is a partial or total cancellation of some of the frequency components of the FM signal. This appears to the tuner like a severely distorted amplitude modulation of the signal. To the extent that the FM detector is able to respond to amplitude modulation, the audio output from the tuner will be distorted by the multipath condition.

The most effective way to deal with the multipath problem is to use a directional antenna, oriented to favor one component of the arriving signal (preferably the earliest arrival) over the others. The AM resulting from the multipath condition, and its distortion, will be reduced, depending on how "selective" the antenna is. If the distortion is not severe, it may not always be heard in an easily identified form. It is useful, therefore, to have some indication of the multipath condition as an aid to orienting the antenna.

For some years, this has been offered in the better tuners and receivers in the form of external oscilloscope jacks. The horizontal output is taken from the detector, so that it represents frequency deviation with the channel center located at the center of the CRT screen when a station is correctly tuned. The vertical output, taken from the limiter, is proportional to the amplitude of the signal as it reaches the limiter section of the tuner. The display traces the i-f passband of the tuner on the screen if there is no multipath distortion present, showing the peak deviation of the signal and whether it remains within the tuner's linear response region. Any amplitude modulation present in the signal appears as ripples on the top of the trace. (The antenna should be oriented to give the smoothest and most nearly horizontal display.)

In many cases a meter is used as a multipath indicator. Usually the signal strength meter can be switched for this purpose. The exact mode of operation of the multipath meter differs from one manufacturer to another, as does effectiveness. Typically, the meter "kicks" on program modulation if AM is present, so that the antenna can be adjusted for the steadiest pointer indication. Most meters are not sensitive enough to show up moderate amounts of multipath that would be instantly visible on an oscilloscope; fortunately, this level of distortion is not often disturbing to the listener. ◇

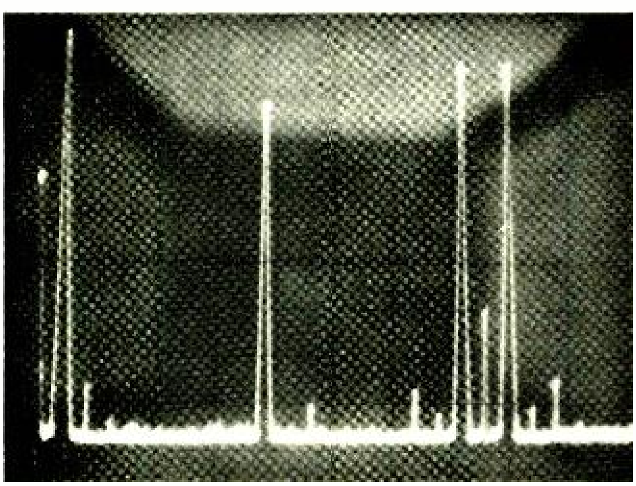
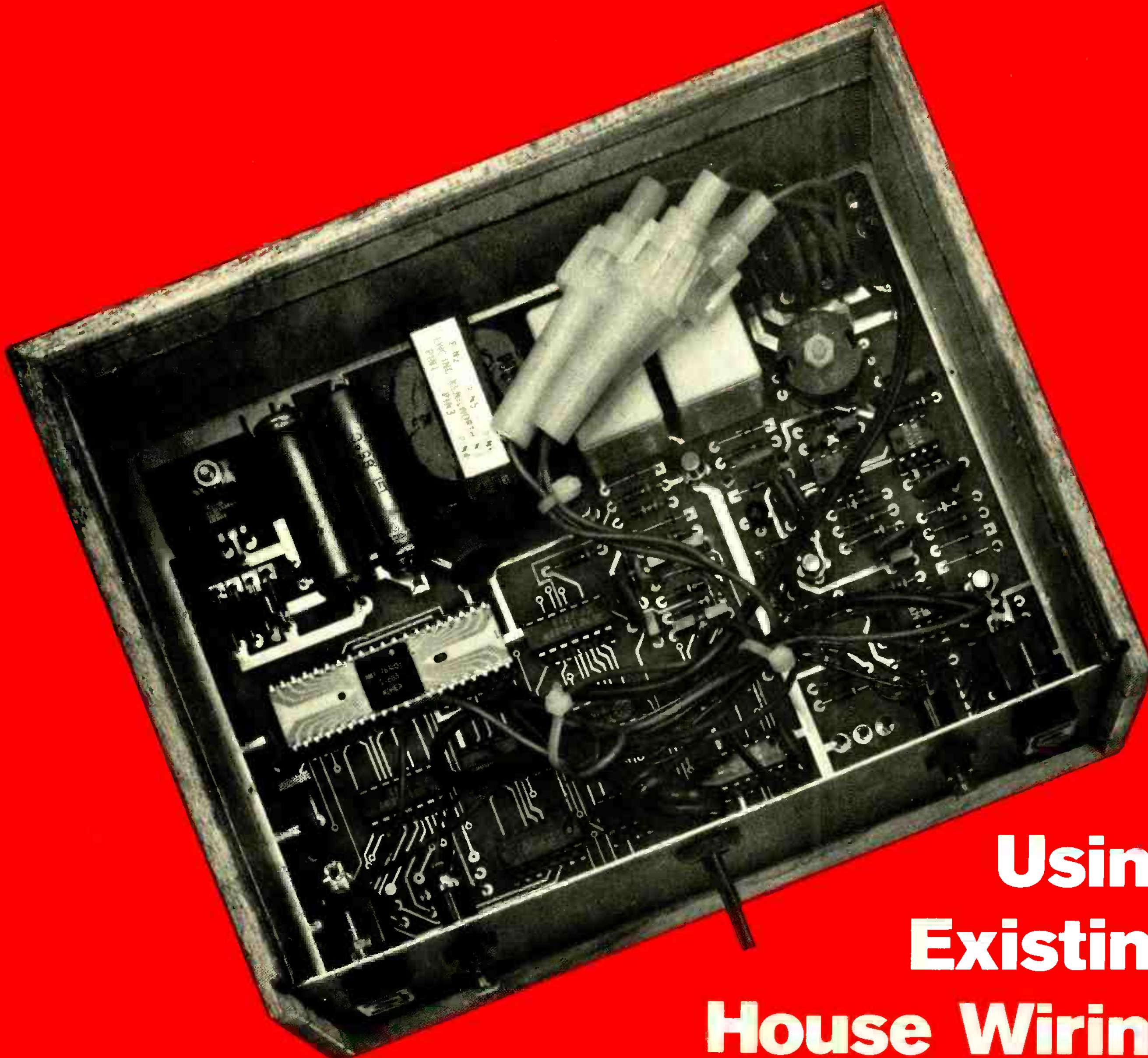


Fig. 2. Spectrum analyzer display of composite stereo modulation, with 100% modulation at 2000 hertz.



Using Existing House Wiring for Computer Remote Control

PART 2

How to build a typical remote.

BY DAN SOKOL, GARY MUHONEN, AND JOEL MILLER

LAST MONTH, we described the theory and construction of an Intelligent Remote Controller that utilizes a building's standard ac wiring for communicating between a computer and appliances. In this concluding part, we cover the details of a typical two-channel remote unit (sometimes called just a "remote") and discuss some software to get the composite system "up and running."

The basic block diagram of a remote is shown in Fig. 1. Note that many sections of the remote resemble their counterparts in the controller because both devices can send and receive data over an ac power line.

How It Works. The user determines which remote he wishes to communicate with and what command he wishes to issue. For example, if he wants to toggle remote 41, a 233 must be outputted to the controller output port. The computer then executes the assembly language command OUT 5. (5 is the num-

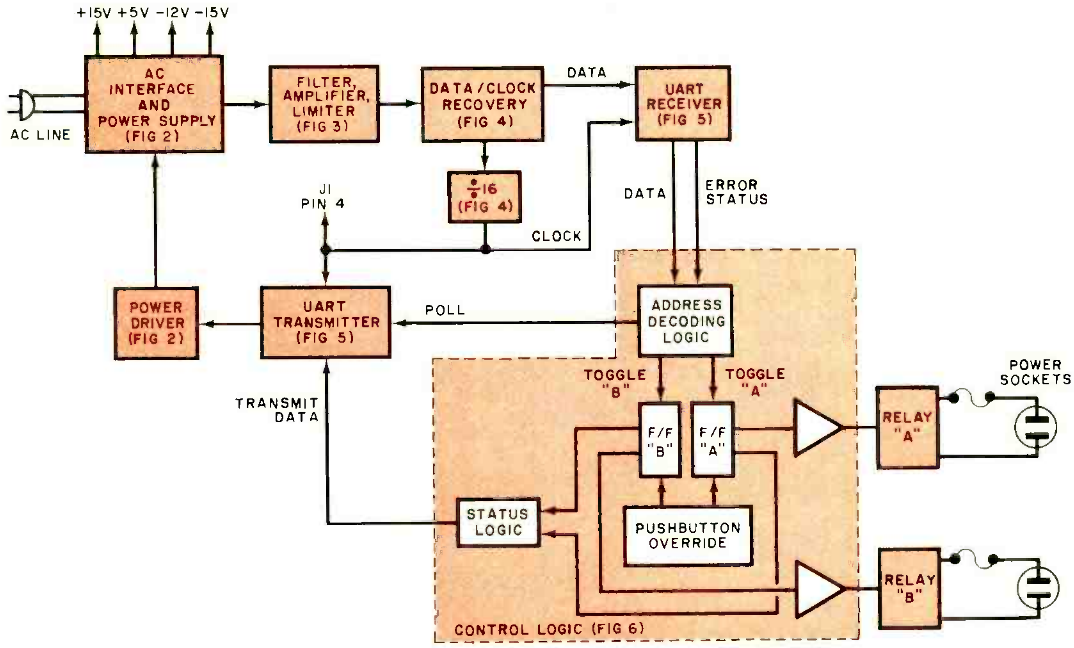


Fig. 1. Block diagram shows similarity of remote to last month's main controller.

ber of the output port while 233 is data.) The I/O port decoding logic on the controller board determines that the controller is being addressed with an output instruction. The controller UART transmitter then reads the data bus, formats the word, and sends it out to the power driver as a serial stream of data bits.

The power driver impresses the signal on the ac line via the ac interface adapter. The data appears on the ac line as a digitally modulated signal at about 50 kilohertz.

All the remotes are constantly monitoring the ac line for possible commands. Each remote contains two independent channels, each capable of controlling one external device plugged into its power socket. This means that each remote is assigned two sequential addresses (selected by the user by putting jumpers on the remote board).

The signal received by the remote is coupled through an ac interface adapter tuned to 50 kHz. A high-pass filter (rolling off at 6 dB per octave below 20 kHz) removes the 60-Hz line frequency and all its relevant harmonics. The filtered output is amplified and used to drive a phase-locked loop (PLL). There, the vco output from the loop is divided by 16 and used as the clock for the internal UART. The received data is recovered at the lock output of the PLL, and this signal is used as the input to the UART receiver.

When the receiver detects a data word, that word appears on its eight parallel output lines, along with error and flag information. The address and decode logic then determines whether or not that word is intended for that remote.

The three valid outputs from the address and decode logic are toggle-A, toggle-B, or poll. The latter is actually two commands—poll-A or poll-B—and the

PARTS LIST

C1,C2, C14, C15—0.1-μF, 200-V capacitor
C3—0.015-μF capacitor
C4,C5—0.001-μF capacitor
C6 through C10, C16, C17, C22 through C27, C34—0.1-μF, 25-V capacitor
C11—0.39-μF capacitor
C12, C18, C19, C28 through C33—0.01-μF, 200-V capacitor
C20, C21—470-μF, 25-V electrolytic
D1 through D5, D10, D11—1N4148
D6 through D9—1N4001
F1—¼-A fuse and holder
F2,F3—5-A fuse and holder
IC1—TR1602 UART
IC2, IC3—4069 CMOS hex inverter
IC4,IC8—4001 quad 2-input NOR gate
IC5—4011 quad 2-input NAND gate
IC6—74C107 dual JK flip-flop
IC7—74C30 8-input NAND gate
IC9—74LS93 4-bit binary counter
IC10, IC11—NE535 op amp
IC12—NE567 PLL tone decoder
K1, K2—Spdt, 5-A contact-rating relay (Stancor MS64-931 or similar)
Q1, Q2, Q4—2N2907 transistor
Q3, Q5, Q6, Q7—2N2222 transistor
Following resistors are ¼-watt, 5% unless otherwise noted:
R1—15,000 ohms
R2—3900 ohms
R3, R13, R17, R18, R19, R23, R24—1000 ohms
R4, R11—2200 ohms
R5, R6—10,000 ohms
R7, R8, R9, R20, R21, R22—3300 ohms
R10—390 ohms
R12—27,000 ohms
R14—1800 ohms
R15—1000-ohm, 10-turn trimmer potentiometer
R16—10 ohms
R25—200 ohms
R26, R28, R30—100,000 ohms
R27, R29—270,000 ohms
RV1, RV2,—V33MA1A varistor (GE)
SΦ,S1—Spst normally open, pushbutton switch
T1—Coupling transformer (see Note)
T2—25-V CT 180-mA transformer
VR1—7805 5-volt regulator
VR2—79L12 −12-volt regulator
Misc.—In-line fuseholders (3), 117-volt, chassis-mount ac sockets (2), line cord, suitable enclosure, mounting hardware, etc.
Note: The following are available from Mountain Hardware, Inc., P.O. Box 1133, Ben Lomond, CA 95005 (Tel: 408-336-2495): T1 (MH-T1) for $6.00; complete kit for one dual-channel remote including walnut case for $99.
Diodes are identified by letters "CR" and IC's by letter "U" in parts placement guide in Fig. 7.

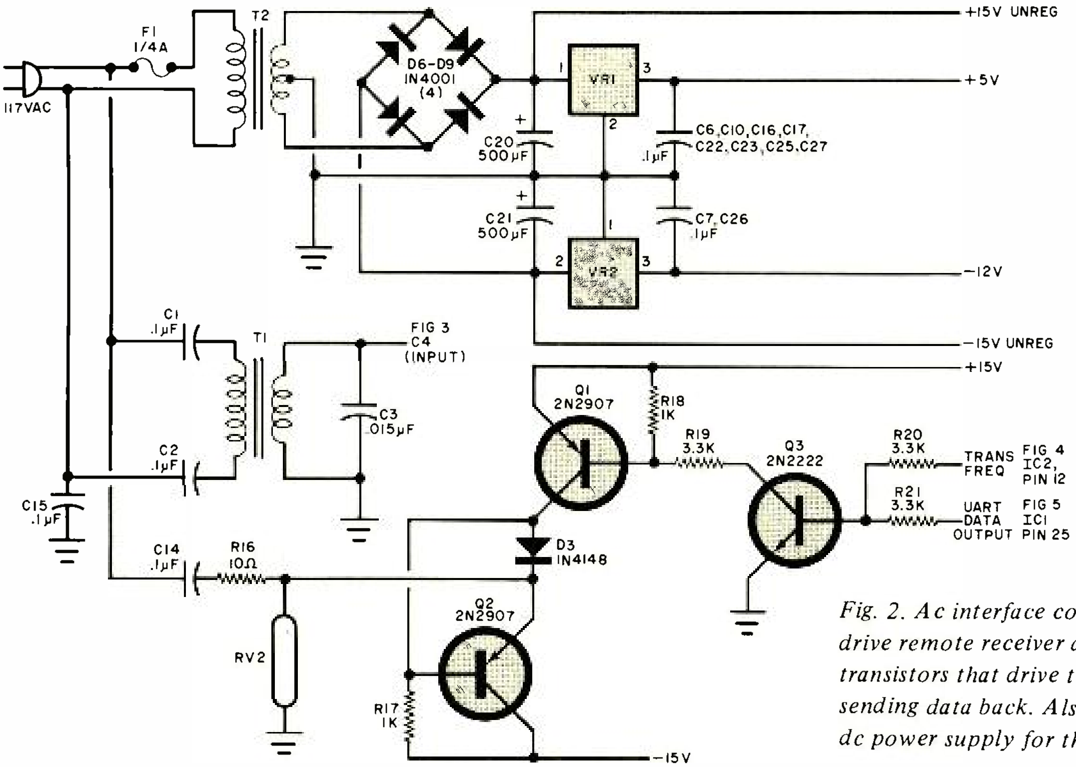


Fig. 2. Ac interface consists of T1 to drive remote receiver and three transistors that drive the ac line for sending data back. Also shown is the dc power supply for the remote.

status logic determines which of the two is acted upon.

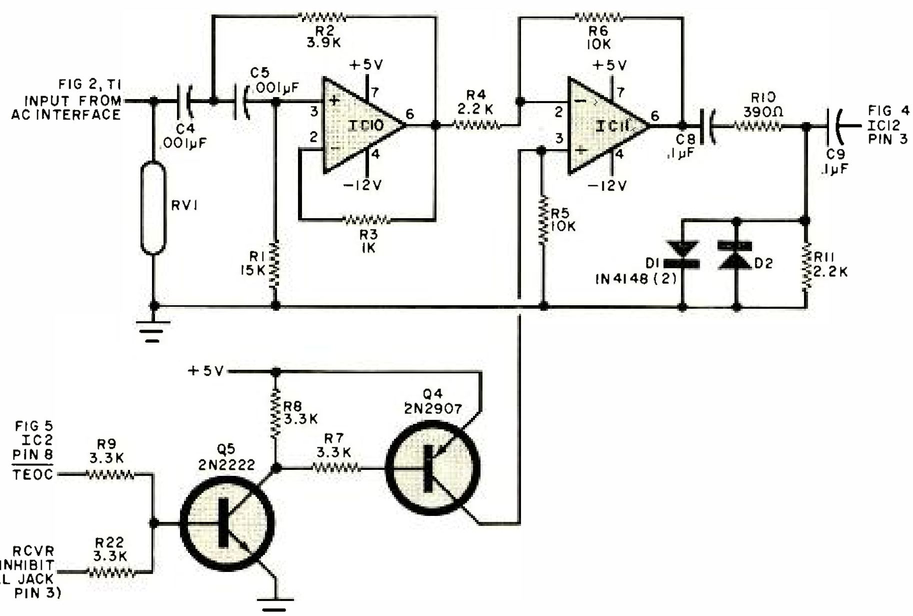
A toggle command causes one of the two flip-flops to change states. This opens or closes a relay associated with that channel and controls the external device connected to that socket.

A poll command causes the status logic to place a word into the UART transmitter buffer in accordance with the following format. The first five bits of the data word contain the address of the remote channel being polled. The sixth bit contains the status of the remote device (on or off), while the seventh bit is set to zero to inform the system that a remote is responding to the controller. This indicates to all other remotes that the digital word on the ac line is not a command. The word is then formatted by the UART transmitter and sent via the ac interface to the power line.

AC Interface and Power Supply. This circuit (Fig. 2) forms the power supply to the electronic system and provides the interface between the digital receiver, the transmitter, and the ac line. Transformer *T2* and its associated components provide regulated +5 and −12 volts. Other components provide the unregulated ±15 V required by the various circuits.

Transformer *T1*, resonant at 50 kHz, provides the actual interface and isolation from the ac line.

Filter, Amplifier, Limiter. This circuit (Fig. 3) operates in exactly the same way as its companion circuit in the controller described last month. See the December issue for details.



Next month, Part 3 will conclude this article with the final circuit discussions, construction and software.

This is Coby 1.™

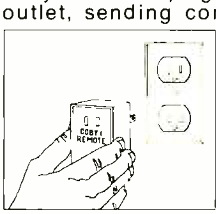
A brand new electronic home control center that will change your way of life.

You can *automate* your home with the Coby 1 System.

- **Coby 1 Control plugs in anywhere to give you computerized ON/OFF control over *electrical devices in your home.***
- **It's the most sophisticated timer you can buy. It turns things on or off at precise times, at the preset intervals you select, and can be programmed *up to 11 months in advance.***
- **It's an instant control center for electrical devices right from your bedside—or wherever you and Coby 1 Control happen to be.**
- **Its elegant digital clock gives you the month, day, hour, minute, and second, with accuracy to within *five seconds per month.***

COBY 1 CONTROL NEEDS NO WIRING —PLUGS IN ANYWHERE.

The compact control panel, which we call Coby 1 Control, plugs into any ordinary wall outlet, sending computer-coded pulses



through your present wiring. The pulses trigger **Coby 1 Remotes**—small remote switches to go between plug-in appliances and wall sockets. Soon (by March) we will also have Coby 1 Remotes to replace wall switches and Coby 1 Remotes to take care of built-in appliances like water heaters and air conditioners. It's safe, simple, and sure. There's nothing like it.

A REMARKABLE APPLICATION BREAKTHROUGH IN MICROELECTRONICS AND PULSE-CODE COMMUNICATION.

The Coby 1 System™ is the result of brilliant engineering by a team of aerospace electronics people. Coby 1 Control includes an Intel 8085 Microprocessor—**a complete tiny computer**—plus control circuitry, power supply electronics, coding and signal-generating circuits, an emergency power cell, and memory. The memory contains 2048 words of low-power, programmable random access memory (RAM) and 2048 bytes of read-only memory (ROM). It stores device numbers, commands, and status information for **up to one hundred Coby 1 Remotes.**

The coding and signal-generating hardware translates commands and distributes them through your home wiring (but without interfering with any of your other appliances) to the Coby 1 Remotes, which decode the signals and turn things ON or OFF.

As you enter commands through the keyboard, the display lights up to confirm. It can also be used to review commands stored in memory. All programs are entered, stored, and modified through 12 function and control keys and a 10-key numeric pad (plus AM and PM keys).

ITS ACCURACY IS BLACKOUT-PROOF.

Power blackout? Built-in battery power keeps Coby 1's memory fresh. Unlike a conventional timer or clock radio, Coby 1's clock won't lose a second. When power comes back on, the batteries automatically recharge. This feature also lets you **unplug your control unit and plug it in again anywhere.** Its handsome digital clock gives you the year, month, day, hour, minute and second with accuracy to five seconds per month. The calendar will show the correct date until 2021.

We've protected Coby 1's sophisticated brain with a handsome, precision-aluminum package that is spillproof. Since Coby 1 has no moving parts, it requires no maintenance.

IT'S FUN TO USE COBY 1.

Each Coby 1 Remote is assigned an identification number. If the front hall lamp is Number One, you simply tell Coby 1 Control to turn Number One on or off—now, Tuesday, any day or every day, if you like. And if you've ever operated a pocket calculator, you'll have no problem whatsoever with Coby 1.

COBY 1 IS AMONG THE GREATEST LUXURIES YOU CAN OWN.

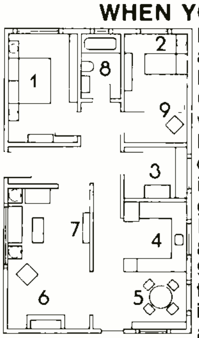
Picture yourself on a frigid winter morning. Coby 1 can wake you with your hi-fi system and a lamp.

You rise to a warm bathroom. When you come out, the coffee is ready to pour. Coby 1 turns the hi-fi off and the TV on, while you enjoy your coffee and paper.

Coby 1 has warmed the car engine for you, so it starts readily and warms up quickly.

At bedtime, with Coby Control now plugged in at bedside, you turn off all the lights and switch off the TV—**without getting up.** You go to sleep knowing things will be ready for you again in the morning. If, during the night, you want to turn on the outside or living room light, you have the comfort and security of being able to do so from your bedside table.

IT'S A CARETAKER WHEN YOU'RE GONE.



Now you can go away for a week (or a month) and leave Coby 1 in charge. Consider a potential thief watching your house: lights (Nos. 1–6) go on and off as if people were moving around. The TV (No. 7) goes on; then goes off. Finally, the bathroom (No. 8) and bedroom lights (No. 9) go out. **You can repeat the pattern daily or vary it for up to a year** in cycles as short as a second or as long as 100 hours. Yet **it will use less energy** and suggest more activity than leaving lights or a radio on constantly.

When you come home, Coby 1 can have the house warm (or cool, in summer), the porch light on, the sofa lamp on, and the hi-fi on to welcome you.

CONSIDER THE ENERGY SHORTAGE.

Coby 1 can do wonders for your electrical bill. It never forgets to turn things off. It can turn car heaters, air conditioners, or electric heaters on just far enough ahead to make things comfortable—no need to have them on constantly. You can change the times from your easy chair. No mechanical timers; no wasted power.

WE'RE INTRODUCING THE COBY 1 SYSTEM AT A SPECIAL LOW PRICE.

We're anxious to get the first factory run into the hands of users as quickly as we can because we're interested in how you put Coby 1 to work. **So until February 15, 1978, we'll accept advance orders for a Coby 1 Control at $399.00, the price to include a free Coby 1 Remote.** Other remotes will be extra.

Simply fill out the coupon and send it with your check, money order, or credit card data. You can also call in your order or get more information by calling (505) 526-3358. We'll ship your Coby 1 along with full instructions and suggestions on its use, after our first production run in January. We'll also include our 90-day parts-and-labor limited warranty.

WHO ENERGY TECHNOLOGY IS:

The company was started by the three of us, Brook Reece, Phil Reed, and Keith Burn. We developed the system ourselves. We're excited about Coby 1 because everyone we've talked to has expressed real interest in the product and sees a need for it.

We've been working on Coby 1 for months. Development and testing of production models is now complete. They'll be ready to ship in January.

Dealer inquiries invited. Energy Technology, Incorporated, 1601 South Main St., P.O. Box Q, Las Cruces, NM 88001. Phone: (505) 526-3358

Mail to:

Energy Technology, Inc.

1601 South Main St., P.O. Box Q, Las Cruces, NM 88001

Put me down for one of the first Coby 1's. I understand that this is an advance order, and that shipment is expected after January 15, 1978.

Ship me one Coby 1 Control and one 10-amp plug-in Coby 1 Remote at the *Special Introductory Price* of $399.00, shipping included. $399.00

In addition, I want to order the following:

___ more 10-amp plug-in Coby 1 Remotes @ $39.95 ______

___ 25-amp plug-in Coby 1 Remotes @ $49.95 ______

Total ______

New Mexico residents: please add Gross Receipt tax ______

☐ Check ☐ BA/V
☐ Money Order ☐ MC
Total ______

Card No ______

Interbank No ______ Card Exp date ______

Ship to ______

Address ______

City ______ State ______ Zip ______

PE 1/78

Signature ______

Solid State

By Lou Garner

"FOR I DIPT INTO THE FUTURE . . . ."

THE WORDS in the title of this month's column are from Lord Tennyson's famous poem, "Locksley Hall." Written in the mid-1800's, it contained some rather startling predictions: the invention of the airplane, air freight service, great aerial battles, and, many feel, the formation of the United Nations, although he referred to it as "the Parliament of Man, Federation of the World."

Did Tennyson have the Gift of Prophecy? Did he receive advice from noted scientists? Or was he just plain lucky in his predictions? Perhaps none of these, perhaps a bit of each, but one thing is certain—long-range predictions always have been "safer" to make than short-term forecasts.

This explains, perhaps, why our annual guessing game with the electronics industry is such a challenge. It's strictly a short term proposition—one year! As always, we have a few predictions for 1978; but, first, let's check the record for 1977. Some of you may recall that, in my January 1977 column, I predicted the following:

• *A drop in the price of simple pocket calculators to the "five-dollar" range.* Right on! Not only are five-dollar (give or take a buck) pocket calculators available from a number of sources, even lower prices may prevail during special sales. In early Fall, for example, a major national department store chain offered 8-digit LED "4-bangers" *for less than three dollars each*, with a limit of "two to a customer."

• *Similarly, basic digital electronic watches, probably 3-function LED types, retailing in the ten-dollar range.* Another winner! In last September's column, you may recall, I announced that Texas Instruments, Inc. had cut the suggested retail price of their Model 503 sports/youth watches to a low $9.95. Since then, a number of watch manufacturers have introduced low-priced models, with some types available for less than eight dollars during special promotions.

• *Basic microcomputer kits for less than fifty dollars each in small quantities, greatly expanding their appeal to hobbyists and experimenters.* On target! In recent advertisements in these pages as well as in other electronics magazines, the Digi-Key Corporation (P.O. Box 677, Thief River Falls, MN 56701) has offered a basic 8080A chip kit for only $49.95, plus handling. The kit includes an 8080A, an 8212, an 8224,

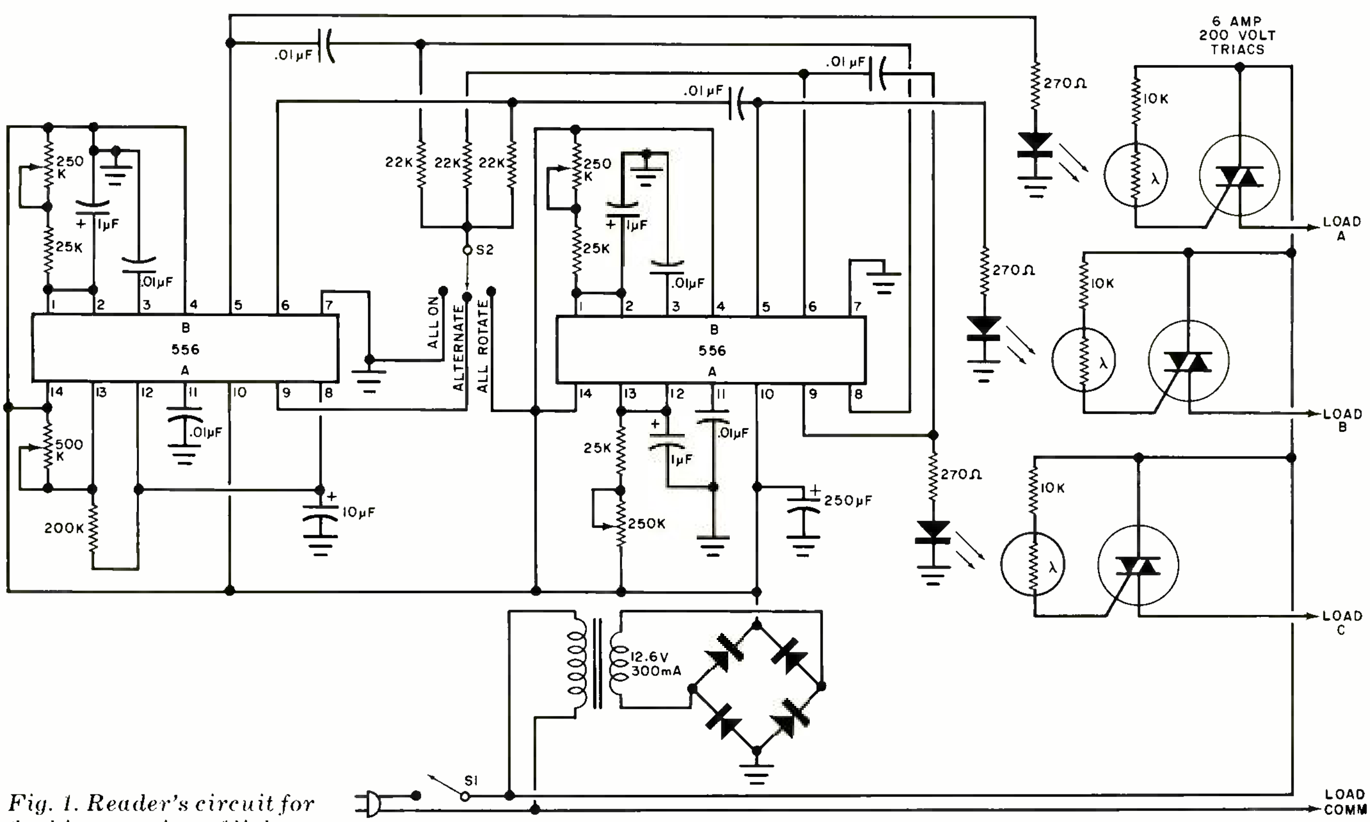


Fig. 1. Reader's circuit for flashing a string of lights.

an 8338 and sixteen 2102-1's, virtually all the IC's required for a basic microcomputer. Naturally, you'll need a suitable pc board and support components.

• *Commercial digital multimeters selling in the fifty-dollar, or less, price bracket.* Check (if I'm allowed the customary 20% tolerance—otherwise, a close miss)! In a full-page advertisement in our June 1977 issue, page 33, Sabtronics International, Inc. (P.O. Box 64683, Dallas, TX 75206) offered a 3½-digit DMM kit for only $59.95. On the other hand, if you're willing to settle for a single-range DPM (digital panel meter), you can buy one of these fully assembled, less power supply, for only $35.00 each in unit quantities and as low as $29.00 each in quantities over 100 from Datel Systems, Inc. (1020 Turnpike Street, Canton, MA 02021). If you prefer to assemble a DPM from a kit, you can purchase a 3½-digit LED kit for $24.95 or a comparable LCD kit for $29.95 from any distributor stocking *Intersil* products.

• *A marked increase in the availability and use of analog (linear) devices.* Still on target! Virtually every major semiconductor manufacturer introduced new linear devices (both discrete and IC) during the year and these are being used in ever increasing quantities by equipment manufacturers. RCA has expanded its line of arrays (see this column in the October 1977 issue); TI is pushing its dual-technology BIFET line of operational amplifiers; Siliconix is making waves with VMOS devices (see our May 1977 column); and National Semiconductor, Signetics, Motorola, Fairchild, and Delco have all expanded their lines of linear devices, with special emphasis on voltage regulators, audio amplifiers, operational amplifiers and special purpose devices.

• *A breakthrough in solar-cell technology, leading to price reductions of up to fifty percent in the dollar/watt cost ratio of solar-powered electrical systems.* A hit and a miss on this one! There *was* a breakthrough in solar-cell technology when Motorola Semiconductor Products, Inc. entered the field with a new type of high-efficiency cell featuring a unique textured surface to provide maximum light absorption, as reported in our October column. However, although the expected major reduction in solar-cell prices did not materialize, a recent sales bulletin from Poly Paks (P.O. Box 942, South Lynnfield, MA 01940) did offer a single solar cell with a rated output of 1 ampere at 0.5 volts for only $9.95! Prices are dropping, but slowly.

• *The development of fast-response liquid crystal displays, paving the way for the eventual development of practical flat-screen TV receivers.* Check! Sparked by the increasing use of LCD's in watches, clocks and digital instruments, significant developments have been made in the field, with response times reduced from a substantial fraction of a second down to the millisecond range. Although the microsecond response needed for television reproduction has not been achieved in commercial units, it is possible to build slow-moving displays with off-the-shelf LCD's today. Progress is continuing, however, and many scientists doing liquid crystal research seem to feel that flat-screen TV LCD's are "just around the corner" (although none will vouchsafe *which* corner).

• *Increasing sophistication and complexity in solid-state video and calculator-based games.* A super winner! For confirmation, refer to the editorial by Art Salsberg which appeared in last September's issue—or you could just check any major department store or large mail-order firm's catalog!

• *Solid-state/fiber-optic control and/or communication projects and kits for experimenters and hobbyists.* A clear miss! Unless a press release, advertisement, or flyer slipped by without my noticing it, I really bombed out on this prediction. Interestingly, industrial and commercial interest in fiber-optic applications continues at fever pitch, with a number of firms offering fiber-optic "cable," connectors, and fittings, as well as transmitter and receiver sub-assemblies and complete systems. But none of this seems to have filtered down to the hobbyist level. In fact, the only fiber-optic projects I've seen offered to the experimenter are novelty lamp kits.

Things to Come. Considering the result of my last prediction, I'm sorely tempted to swap my old crystal ball for a cup of tea leaves. But nonetheless, for 1978 watch for:

• *The introduction of ultrasophisticated solid-state games involving a broader range of control—perhaps even voice commands and audible responses (other than simple "sound effects").* Actually, the possibilities for game designs are virtually unlimited, given a large enough market, and, eventually, each designer and manufacturer will try to "out-do" all others to maintain a competitive edge.

• *Along with the introduction of more sophisticated μP-based video and nonvideo games, substantial reductions in the prices of conventional games.* It would come as no surprise if a basic "table tennis" type game for B/W receivers were to be offered in the ten-dollar range before year's end, with complex programmable video games in the $50 to $100 range.

• *The development of a new solid-state microwave device.* The details are fuzzy, but the device may be a unit capable of challenging the long reign of TWT's . . . or it might be a FET with substantial power output in the GHz range.

• *The introduction of solid-state portable security alarm systems.* Portable, self-contained, fool-proof, and difficult to defeat, which business travelers, tourists, and campers can use to protect a motel or hotel room or, perhaps, even a tent or camper-trailer.

• *The development of a new type of solid-state sensor or transducer.* A number of new devices are needed in this area, for often the measurement or control system is superior in performance to the device used to interface with the rest of the physical world.

• *The development of a new family of logic devices.* For some time, now, TTL has been "King of the Mountain," even though challenged by I^2L, low-power Schottky, and CMOS. The new family may be an adaptation of an existing technology, such as VMOS, or may represent a completely new concept. It's all a bit misty.

• *Dedicated home computers—not kits—in the $200.00 price range.* Regardless of what the optimists believe, I can't visualize home computers as a mass market item unless the programming problem can be solved. Most people — other than hobbyists — look for products which save time, work and effort. And mental work (i.e., programming) is the toughest of all. Therefore, means must be used to greatly simplify or eliminate this task if computers are to achieve widespread public acceptance. . . And, generally, this means a "dedicated" computer—one designed to perform a specific series of tasks with a minimum of input data.

• *The introduction of dual-technology IC's (not BiFET's, which are now available) but devices combining digital and analog (linear) circuits in a single package, if not on a single chip.* There is an increasing need for devices which can operate in both the linear and digital domains without costly A/D and D/A converters. Where there is a need, someone will find a suitable solution.

Reader's Circuit. Searching for an attention-getting display for their popcorn stand, the members of a local Jaycee club in Michigan looked at several ideas. Someone suggested a movie-style marquee with rotating lights. All agreed it was a terrific idea but, unfortunately, too costly for the budget, inasmuch as these displays required a motor-driven, heavy-duty sequential switch to activate the multiple lamp strings in order. Then one of our readers, Jim Harvey, WB8NBS (15026 Sunbury, Livonia, MI 48154), tackled the problem. Applying his ingenuity and doing a little research with Signetics Application Notes, Jim decided he could do the job electronically using solid-state circuitry and a combination of "junk box" and low-cost surplus components. His circuit, capable of flashing up to three strings of lamps, is illustrated in Fig. 1. Jim writes that his total cost (exclusive of lamps) was a fraction of the $75.00 price asked for a motor-driven sequential switch.

Jim's design has a pair of 556 dual timers, *IC1* and *IC2*, three simple opto-couplers, and three medium power Triacs, which serve to switch the (lamp) loads. Dc power is obtained from a simple supply comprising a 12.6-volt step-down transformer, a bridge rectifier, and a 250-μF, 20-volt electrolytic capacitor. The Triacs are isolated from the control circuit by the opto-couplers. Three of the timer IC sections, *IC1B*, *IC2A*, and *IC2B*, are wired as one-shots, inter-connected through RC differentiating networks so that they trigger each other sequentially. The remaining timer section, *IC1A*, is connected as a free-running multivibrator with about a 4-second period. It is used in one mode to control the sequential circuits for special lighting effects.

Any of several operational modes can be selected by means of three-position switch *S2*. With this switch in its ALL ON position, the one-shot inputs are all grounded, forcing their outputs high and switching all three LED's on, thus activating the Triacs and furnishing line current to all lamp loads continuously. The ALL ON position is used both for general illumination and when the operator wishes to identify any burnt out lamps. In the ALL ROTATE position, *S2* applies V_{CC} to the one-shot trigger inputs, permitting the circuits to cycle on and off sequentially and creating an optical rotation effect as lamp loads "A," "B," and "C" are switched on and off in order. Finally, with *S2* in its ALTERNATE position, the free-running multivibrator (*IC1A*) serves to switch the one-shot trigger inputs alternately between ground and V_{CC}, causing the lamp loads to "rotate" for a half period (about 2 seconds) and then stop for a half period, repeating the cycle over and over.

With cost a critical factor, Jim used inexpensive, readily available components in his design. As indicated earlier, the IC's are type 556, while the Triacs are 200-V, 6-A types; any commercial units with these ratings should be acceptable. The optocouplers are home-made, with each consisting of a "jumbo" red LED, a small CdS photocell, a piece of heat-shrink tubing for assembly, and a dab or two of black paint. Except for the potentiometers, which may be either Trimpots or small volume controls, all resistors are standard ½-watt types. The electrolytic capacitors, identified by a polarity sign, are 20-volt units, while the other capacitors may be either low-voltage ceramics or small tubular paper or plastic film types. The bridge rectifier used in the dc power supply can be either a standard bridge assembly or four diodes with (at least) a 36-PIV rating and minimum 500-mA current handling capacity. Finally, *power* switch *S1* may be a toggle, slide, or rotary spst unit, while *function* switch *S2* is a single-pole, three-position lever or rotary type.

Since layout and lead dress are not overly critical, the flasher circuit may be assembled on perf board using point-to-point wiring or on a suitable pc board, at the builder's option. Heat sinks should be provided for the Triacs if they are to be loaded to near maximum ratings. All dc polarities must be observed, or course, and the assembled circuit should be double-checked for accidental shorts, opens, and wiring errors *before* power is applied. When connecting the load lamps, which are wired in parallel within each string, make sure that Triac maximum ratings are observed. While the 6-A Triacs can handle almost any standard 120-V incandescent lamp, the greater the number of lamps, the better the overall optical effect, hence low-wattage bulbs (7½-W units or even 120-V Christmas tree strings) are preferred to permit a maximum number of lights within each string without overload. Naturally, the lamps in each load string should be arranged in alternate patterns to achieve the desired effect . . . A-B-C-A-B-C-A-B-C, and so on. Jim offers the following hints to insure optimum performance:

(1) Since the one-shots require an initial trigger to begin cycling, the circuit may not operate if *S2* is in its ALL ROTATE position initially. In this case, switch *S2* to the ALL ON or ALTERNATE position momentarily before switching back to the ALL ROTATE position.

(2) Once the display is operating in the ALL ROTATE mode, "tweak" each one-shot's potentiometer until equal *on* times are achieved for each load string . . . or simply until the effect is pleasing when viewed from a distance.

(3) Finally, switch *S2* to the ALTERNATE mode and adjust *IC1A*'s potentiometer for the most eye-catching display. ◇

Experimenter's Corner

By Forrest M. Mims

READ/WRITE MEMORIES (RAM's), PART 2

IN LAST month's column we discussed the 7489 RAM, a TTL chip that can store up to sixteen 4-bit words. This month we'll complete our experiments with the 7489 and get to know the 74193 4-bit counter.

First, let's cover a few facts about the 7489 we didn't have room for last month. We already know that the 7489 is a RAM, that is, a random access, read/write memory. But did you know you can also think of the 7489 as a string of sixteen 4-bit latches? Each storage element in a 7489 is a latch flip-flop, so it's a perfectly valid way of describing the 7489.

Thinking of the 7489 as a string of 4-bit latches is a good way to better appreciate this important TTL memory chip. How would you like to make your own 7489 from a handful of 4-bit latches? I don't think you would. Besides the latches, you would need a decoder chip and some gates.

RAM Demonstration Circuit. Did you build the RAM demonstrator described in last month's column? If so, you've probably learned a fair amount about working with bipolar (TTL) RAM's. If not, you might want to consider retrieving last month's POPULAR ELECTRONICS and collecting the necessary parts. You can buy 7489's for as little as a couple of dollars or so from suppliers who advertise in this magazine.

Programming. Let's discuss programming procedures for the RAM demonstrator. Programming is semi-automatic since the 7490 address pointer (see Figure 4 in last month's column) will advance to the next address if you apply a single clock pulse. The best way to do this is to slow down the clock to about one pulse per second by adjusting the one-megohm potentiometer and disconnecting the clock input from pin 14 of the 7490. To advance the pointer to the next address, simply touch the clock lead to pin 14 of the 7490 long enough for the clock LED to flash one time.

After you learn to advance the 7490 in single address increments, you're ready to load data into the RAM. Set up the data by grounding the input pins that are to be at logic 0 and leave floating the inputs that are to be at logic 1. You can use switches or jumpers to load data.

Momentarily grounding the 7489's WE input (pin 3) will load the data word into the selected address slot. The word that was previously in the selected address will be lost. After the word is loaded, you're ready to move on to the next address. Remember, you're using a 7490 *decade* counter for an address pointer. That means you can select only the first ten (0000 through 1001) of the RAM's sixteen addresses.

If you want an easy way of knowing

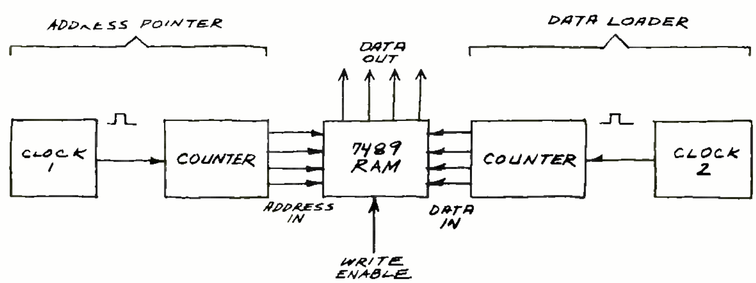


Fig. 2. Block diagram of pseudo-random data loader.

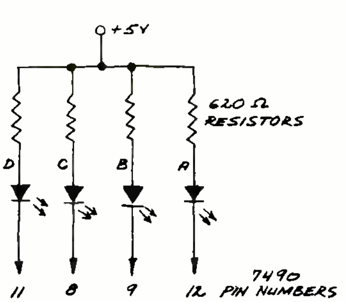


Fig. 1. Circuit indicates address pointer output.

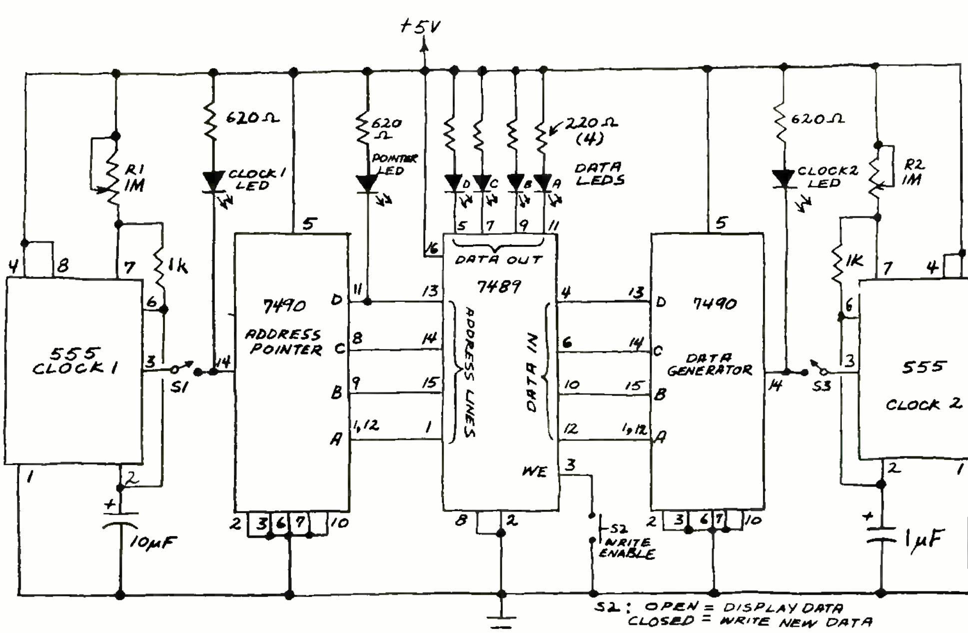


Fig. 3. Automated RAM demonstrator with pseudo-random data generator.

exactly what address the 7490 is pointing to, connect LED's and 620-ohm series resistors between the four 7490 outputs (pins 11, 8, 9, and 12) and plus 5 volts. Be sure to arrange the LED's in the proper sequence (Fig. 1).

You don't really need to know to which address the 7490 is pointing if you let it recycle to address 0000. Then you can simply load ten words, one at a time, using the programming procedure outlined above.

How do you know when the 7490 is pointing to 0000? The pointer LED is on when the D bit in the address is logic 0 and off when it is logic 1, as shown:

Decimal count	Address pointer (7490 output) D	C	B	A	Pointer LED
0	0	0	0	0	On
1	0	0	0	1	On
.	.	.	.	.	.
.	.	.	.	.	.
.	.	.	.	.	.
8	1	0	0	0	Off
0	1	0	0	1	Off

To find the 0000 address, slow the clock down and watch the pointer LED. Eventually it will turn off for two clock pulses. As soon as it flashes on again, disconnect the clock lead from pin 14 of the 7490. The RAM will be at address 0000 and you can begin programming.

Expanding the Demonstrator. It's easy to expand the RAM demonstrator by adding an automatic, pseudo-random data loader. The data loader is merely a decade counter that rapidly cycles between 0000 and 1001 again and again. The output lines of the counter are connected to the data imputs of the 7489. Whatever number is present when the 7489 is advanced to the next address is loaded into the RAM.

Figure 2 is a block diagram that shows how the data loader is connected to the RAM. As you can see, the data loader is identical to the combination clock and address pointer that automatically advances the RAM to its next address. The complete circuit diagram for the expanded circuit is shown in Fig. 3, where the data loader is literally a mirror image of the address pointer circuit.

Since you already know how the address pointer portion of the circuit works from last month's installment, there's no need to describe the detailed operation of the data loader here. You'll find a few operating tips helpful, however.

First, the RAM will accept (write) new data from the data loader when *S2* (WRITE ENABLE) is closed. Otherwise, the RAM will continue to store any existing data. Second, both *S1* and *S3* should be closed when you want to load pseudo-random data, unless you want all the RAM addresses to contain the same number. (In that case, leave *S3* off after the data loader reaches the number you want to store in each address.)

Third, remember to turn *S2* off when you want to read out the contents of the 7489 with the help of the four output LED's. The LED's will be blanked (off) when *S2* is on and data is being loaded. Finally, be sure to experiment with the settings of both *R1* and *R2*. Decreasing the effective resistance of *R2* increases the count rate of the 7490, and this will

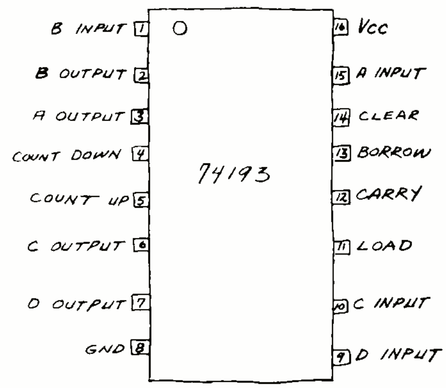


Fig. 4. 74193 pin diagram.

improve the "randomness" of the data loaded into the RAM. Similarly, lowering the resistance of *R1* will speed up the address pointer and let you load new data in a fraction of a second.

Incidentally, be sure to slow down the address pointer with the help of *R1* when you want to read out the data with the LED's.

Improving the Demonstrator. Since we're using a decade counter as an address pointer, we can only gain access to ten of the sixteen storage slots in the 7489. You can remedy this by replacing the 7490 address pointer (and the 7490 data loader if you want to load (1010 through 1111) with a 74193 4-bit (0000-1111) counter. Figure 4 is the pin diagram for this chip.

An important advantage of the 74193 is the CLEAR input (pin 14). In normal use, this input is grounded. Disconnecting the ground clears the counter to 0000. The 74193 has lots of other features including carry, borrow, count up, and count down. Its count can even be preset to any desired value between 0000 and 1111. ◇

Hobby Scene Q&A

By John McVeigh

RECEIVER OVERLOAD

Q. ***A CB'er about a half mile away from my house uses a beam antenna and a power mike. When he transmits, he puts out a very strong signal (about 30 over on my S meter), and his audio is superb—no distortion at all. However, he causes interference to all the other channels. Sometimes, the signals on the other channels drop in strength (the S meter drops several S units) and my receiver gets very quiet. Why does this happen, and is there anything I can do to my radio to help stop the interference?—Andy Gill, Carrollton, KY.***

A. You mention that the CB'er is putting out clean-sounding audio. This seems to imply that he is not overmodulating his transmitter—which often occurs when a power mike is abused. If there was severe overmodulation, "splatter" would appear on many channels. But the situation sounds more like a case of receiver overload. If his signal is very strong, it can cause distortion and/or override the selective circuits in the receiver i-f and cause the automatic gain control to cut back on receiver gain. The net result is a reduction in signal strength on the channel you're tuned to.

There's no practical filter that could be inserted in the transmission line and would be sharp enough to attenuate the undesired signal but not affect the desired one. If your rig has an r-f gain control, you could try backing down on it. An attenuator in the feedline to the receiver might help if you had separates, rather than a transceiver. You might try asking the CB'er to back off on the modulation, or perhaps turn his beam so that you're off its side!

SOUND VIA POWER LINE

Q. ***Instead of running extension speaker wires, I'd like to build a unit that would sense the audio signal over the ac wiring in my house. Another unit would pick up the signal at the wall socket and feed the signal to a speaker. Do you know where I can find suitable schematic diagrams?—David Mast, Holland, MI.***

A. The January 1976 issue of POPULAR ELECTRONICS contains a construction project that does exactly what you're interested in. If you can't find that issue, you can order a back issue for $1.50 (includes postage and handling) from the Ziff-Davis Consumer Service Division, 595 Broadway, New York, NY 10012. Readers outside the U.S. can order back issues for $2.00. Copies are available for magazines from April 1974 through the present issue.

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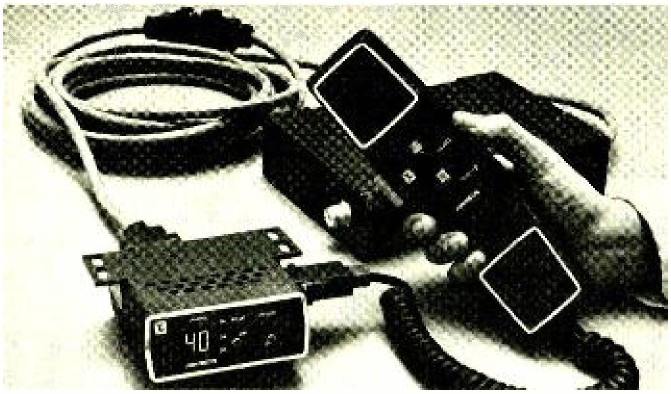
Product Test Reports

E.F. JOHNSON VIKING 4360 REMOTE CONTROL MOBILE AM CB TRANSCEIVER.

Features telephone-type handset and speaker interconnect box.



THE 40-channel Viking 4360 AM CB transceiver from E.F. Johnson differs from other digitally frequency-synthesized, remote-control mobile rigs in that it consists of three pieces. One is a telephone-type handset, the second is a main electronics unit that can be tucked out of sight, and the third is a small dashboard-mounted interconnect box that contains a 3" loudspeaker and numerical LED channel display. The handset assembly contains a small speaker, VOLUME and SQUELCH controls, and up- and down-channel pushbuttons for switching to the various channels.

Other features found in this transceiver include: LED dimmer switch (off/dim/bright); external-speaker jack; nonswitchable anl (automatic noise limiter); speech compressor circuit; and a transmitter output network designed to minimize harmonics that can cause TVI. Operation is from a nominal 13.8-volt dc, negative- or positive-ground source.

The main unit measures 8⅝"W × 6⅛"D × 2⅞"H (21.9 × 15.6 × 7.3 cm), while the interconnect box is 4½"W × 3⅞"H × 1⅝"D (11.4 × 9.8 × 4.1 cm), less mounting flanges. Supplied with handset and 8' (2.4-m) cable for interconnecting the main unit with the interconnect box, the transceiver's price is $229.95.

Technical Details. The receiver employs double conversion to a 455-kHz i-f, which is obtained by heterodyning the CB signal with a local-oscillator signal that is 455 kHz lower in frequency than the input signal. The heterodyning signal is obtained by sum-mixing the output of the voltage-controlled oscillator (vco) in the PLL system with a 5120-kHz signal from a crystal-controlled oscillator. (The standard reference signal is also derived from the 5120-kHz oscillator.) The heterodyning signal is mixed down and digitally divided for a comparison reference that is fed to the phase comparator along with the standard reference to provide the error voltage for the vco.

The i-f selectivity is obtained with a lumped-constant, bandpass-coupled circuit. There are two i-f stages, a detector, an audio anl, and an audio preamplifier following the r-f section. An IC that contains the output stage (it also modulates the transmitter) rounds out the receiver section. An agc amplifier and detector system is included.

The channel-indicating system consists of the usual seven-segment LED displays and decoder/driver electronics.

On transmit, the heterodyning signal from the receiver is shifted upward by 455 kHz to generate the on-channel carrier frequency. This signal then goes to a predriver, driver, and r-f output-power amplifier. A multi-element output network matches to 50-ohm loads and minimizes spurious output responses to maximize the attenuation in the TV range. On "power up," channel 19, the most popular CB highway channel, is automatically switched in.

The driver and power amplifiers are collector-modulated by the audio section in the receiver, where a compression circuit provides automatic modulation control. Transmit/receive transfer is via diode switches.

Laboratory Measurements. We measured a 0.55-μV receiver sensitivity for 10 dB (S + N)/N at 30% modulation with a 1000-Hz test tone. The agc held the audio output to within 15 dB with a 20-dB r-f input change at 1 to 10 μV and to 20 dB with an 80-dB input variation at 1 to 10,000 μV. The squelch threshold range was 0.7 to 200 μV.

Adjacent-channel rejection and desensitization measured 55 dB. Image rejection on channel 1 was 12 dB and gradually deteriorated to 5 dB on channel 40. I-f rejection was greater than 80 dB, and other unwanted signals were down a minimum of 40 dB.

The audio response at the 6-dB points varied between 240 to 2900 Hz and 215 to 3250 Hz, depending on the setting of the VOLUME control. Maximum sinewave output at 10% THD measured 1 watt into 8 ohms. However, at the start of clipping and with 12.5% THD, the output measured 1.4 watts.

Powering the transceiver from a 13.8-volt dc source, we measured a transmitter carrier output of 3.75 watts. At microphone input levels 16 and 25 dB greater than that required for 50% modulation, the THD with a 1000-Hz signal was 3.5% and 11%, respectively, with the modulation averaging a nominal 90%. The THD with a 500-Hz tone under the same conditions was 6% and 24%.

Splatter greater than ± 5000 Hz from the carrier was 60 and 55 dB down at +16- and +25-dB levels. However, the splatter with a 2500-Hz tone was nominally only 40 dB down. Nevertheless, at maximum voice levels, the splatter was more than 60 dB down. The modulation peaks held to just short of 100%.

The audio response measured 500 to 4000 Hz at the 6-dB points. Slight downward modulation (negative carrier shift) was noted during these tests. The output frequency held to within ±30 Hz, referred to +176 Hz on channel 21.

User Comment. The main electronics package that makes up this transceiver's system can be mounted up forward in a vehicle. Alternatively, it can be mounted under a seat or in the trunk. The interconnect box is designed to be installed on the dashboard or wherever its controls can be conveniently reached and its LED display affords an unobstructed view. This box has a toggle switch for turning on and off the power and dimming the channel displays.

Another switch permits the operator to select either the box speaker or the speaker in the microphone's housing. The speaker in the box faces downward. The handset connects to the interconnect box via a multipin connector at the end of its heavy coiled-cord cable.

The speaker in the handset is located at the top of the housing, while the microphone element is at the bottom. In the middle of the handset are two pushbuttons, labelled PLUS and MINUS, for stepping through the channels in either an upward or a downward sequence. Either button can be operated momentarily for single-step operation or held down for continuous (and fast) scanning of the channels. We determined that only a light tap of either button is all that is needed to step through the channels. One must be careful here to press and quickly release the button to avoid going into the scan mode.

The VOLUME and SQUELCH controls are thumbwheel types, located at the right side of the handset. With a little practice, one quickly becomes accustomed to this arrangement and the directions in which the controls must be rotated to obtain the desired effects.

The rationale behind the usual remote-control CB rig is to have the transceiver out of sight or in a safe place as a theft deterrent. With this rig, however, mounting of the interconnect box is somewhat revealing, though not on the order of conventional-type rigs. Even so, locating the main section of the system in the trunk should minimize the possibility of it being stolen.

Since the interconnecting cable between the box and main unit is just 8′ long, for trunk installations it may be necessary to obtain Johnson's optional 12′ extension cable.

Although the modulation distortion at low audio frequencies measured somewhat greater than usual at high compression levels, the transmissions sounded very good under most voice conditions. Additionally, adverse splatter was absent. The quality on receive was good, too.

As noted by our measurements, the image rejection on some channels was less than usual for a single conversion to a 455-kHz i-f.

The anl was not especially effective in our rigid bench tests with an impulse-noise generator. However, in on-the-road tests in our noisy vehicle, its performance was very good indeed.

Overall, the Viking 4360 transceiver is a most satisfactory performer. Of special importance is its user-operation conveniences. For example, the lightweight handset can be held comfortably, partly as a result of using a larger speaker in the interconnect box instead of in the handset itself. Also, the slight compromise of having a third small unit—the interconnect/speaker housing/channel display—makes it easier and safer for the driver to view under typical motoring situations. Lastly, the handset offers true one-handed operation.

CIRCLE NO. 104 ON FREE INFORMATION CARD

SENCORE MODEL DVM37 DIGITAL MULTIMETER

Portable DMM boasts 0.1% dc accuracy, automatic zero and switch-controlled probe.

THE MODEL DVM37 digital multimeter from Sencore features a 3½-digit, 0.3″ (7.6-mm) high red seven-segment LED display, 0.1% dc measuring accuracy, and 15- or 30-megohm input resistance to keep circuit loading and erroneous readings to a minimum. Automatic zeroing, polarity indication, and decimal-point placement provide for fast direct measurements. The instrument is designed to permit resistance and ac and dc voltage and current measurements.

The multimeter measures 7″H × 5″W × 4″D (17.9 × 12.8 × 10.2 cm) and weighs 2.25 lb (about 1 kg), including its internal battery pack. Power for the DMM can be from throw-away standard carbon-zinc or alkaline cells (four C size), rechargeable nickel-cadmium cells, or from an optional ac adapter/battery charger.

The Model DVM37 multimeter price is $248. Available as options are a No. 39G90 ac power adapter/battery charger for $9.95 and a No. HP200 50-kV high-voltage probe clip-on for $25.

Technical Details. A total of 28 ranges is provided. Dc voltages can be measured in four ranges to 2, 20, 200, and 2000 volts full-scale with an accuracy of 0.1% (0.2% on the 2000-volt range). Resolution is 1 mV on the 2-volt range. The input resistance is 15 megohms, which can be extended to 30 megohms via a switch on the built-in probe. Using this switch rescales the ranges to 4, 400, and 2000 volts full-scale, with an accuracy of 1.1%. Ac rejection is 60 dB at 50/60 Hz, and the input is protected to 2000 volts dc plus peak on all ranges.

There are four ac voltage ranges that go up to 2, 20, 200, and 1000 volts full-scale. Accuracy on the three low ranges is 0.5%, while on the 1000-volt range, it is 0.75%. Measurements can be made down to 1 mV on the 2-volt range. The input impedance is rated at 1.5 megohms shunted by less than 100 pF. The frequency response is from 40 to 5000 Hz ±0.5 dB. The average-detecting measuring system provides rms readings. Input protection is to 2000 volts peak and dc or 1400 volts rms. The five ac and dc current ranges go to 200 μA, 2 mA, 20 mA, 200 mA, and 2 A full-scale. Measuring accuracy is 0.3% on dc and 1.0% of reading plus three digits on ac. Resolution is rated at 0.1 μA on the 200-μA range. The internal shunt resistance on the respective ranges is 1000, 100, 10, 1, and 0.1 ohms. The voltage drop is 200 mV on the three lower ranges, 250 mV on the 200-mA range, and 1 volt on the 2-A range. The input is protected up to 2000 volts dc and peak.

Resistance measurements can be made with either high or low power. The high-power ranges (to 2 k, 20 k, 200 k, 2 megohms, and 20 megohms full-scale) deliver a 1-volt maximum test potential to the test probes. The low-power ranges (200 ohms, 2 k, 20 k 200 k, and 2 megohms full-scale) deliver a 0.2-volt test potential to the probes. Accuracy is rated at 0.2% ±3 digits on all but the 20-megohm range, where it is 0.5% ± 3 digits. Resolution is 0.1 ohm on the 200-ohm range. Maximum current through the resistance being measured is 1 mA, 100 μA, 20 μA, 1 μA, and 0.1 μA on the low-power-ohms ranges and 500, 50, 5, and 0.05 μA for the high-power ranges. Input protection is provided to a maximum of 2000 volts dc and peak on all ranges.

The multimeter is made more useful by a permanently connected probe assembly, which consists of a flexible ground lead terminated in an insulated alligator clip and a signal lead terminated in the actual probe tip. Because these test leads are a permanent part of the DMM, they cannot be misplaced.

The special probe tip features two touch switches. The one labelled PUSH ON turns on power to the meter for as long as it is held down and instantly removes the power when released, which saves on battery power. Of course, the main power ON/OFF switch on the instrument's front panel can be used to turn on the power for continuous operation when desired. The second probe switch, labelled ISO DCV+2, provides an extra 15 megohms of isolation for critical circuits where loading presents problems, as in oscillators, very-high-impedance CMOS circuits, and the like. Operating this switch not only adds isolation resistance. It also doubles the measurement capability of the range on which it is used, as mentioned above.

User Comment. For our tests, we installed four C cells in the DMM. Then we used our usual laboratory voltage and current standards and high-tolerance resistors to check out the various functions and ranges. In each case, the instrument performed comfortably within its published specifications.

After completing our standard bench tests, we put the DMM to work under actual in-service conditions for a month, both on a service bench and in a field-service vehicle, taking no particular care to treat it gently. At the end of the test period, we could find not one fault in the instrument's performance or handling, based on combined bench and field experience. In fact, we feel it was among the most convenient multimeters we have ever used for the full range of different test and measuring conditions encountered.

At the end of the in-service test, we again examined the DMM, both physically and electrically. The DMM easily survived the rough environment of a service van. When we performed accuracy tests again, we noted no degradation from the results obtained in the original bench tests.

We like Sencore's new approach to test probes, particularly the switch that allows us to control the power to the instrument right at the probe body. The impedance and range doubling switch is a nice touch that adds practical utility to the instrument. It greatly simplified our measurements under some very trying conditions. The body of the probe itself is triangular in shape, making it comfortable to handle and easier to manipulate under actual measuring conditions than is usually the case.

In sum, the Model DVM37 combines all the utility, accuracy, and human engineering one could expect of a well-designed digital multimeter. Its high-impact case and recessed control knobs are particularly suitable for the rigors of actual servicing conditions.

Computer Bits

By Hal Chamberlin

BUS SYSTEMS

ALL HOBBYIST computers have some kind of bus system for tying the various computer elements together. Component computers use a "motherboard" which contains only the bus connected to a number of pc board sockets. Each component of the system such as the CPU board or a memory board plugs into a socket and communicates with the rest of the system over the bus. Even an all-on-one-board system has a bus running around on the board to connect the CPU, memories, and input/output circuits together. For expansion purposes, the on-board bus is usually brought out to the edge of the main board.

Actually a bus sytem by itself is nothing more than a set of parallel wires. These wires can be conveniently broken down into four major groups. The most basic is the *power* group which supplies operating voltages to the circuits tied to the bus. On some systems this may consist of only two lines—one for +5 volts and the other for ground while others may have three separate power voltages, typically +15, +5, and −15 volts. Some systems may even distribute *unregulated* power voltages on the bus expecting the individual circuits to regulate the voltages as required. Often several of the bus wires are assigned as grounds in order to reduce the possibility of ground loops.

The next major group is the *data lines*. These lines carry binary data around to the various sytem components. In most systems, data either flows from a peripheral device or memory into the CPU during a *read cycle*, or flows from the CPU to a memory or peripheral during a *write cycle*. One widely used bus system has 8 lines for carrying data from the CPU *to* other system components and 8 more lines for carrying data into the CPU *from* other components. Most other systems use a single set of 8 lines for both purposes forming what is called a *bidirectional* data bus. This is allowable because none of the available microprocessor chips can simultaneously read and write.

Both schemes make use of integrated circuits having Tri-State® (National Semiconductor), sometimes called three-state, outputs which allow the outputs of several IC's on different boards to be tied onto the same bus lines. A three-state output can be in one of three conditions. Two of these are the familiar logic "0" and "1" states. The third is a *disabled* state in which the IC output essentially disconnects itself from the bus line. If only one of the three-state IC's connected to the bus line is enabled (in the "0" or "1" state) and all of the others are disabled, then the bus line assumes the logic state of the enabled IC output.

Another group is the *address lines*. Generally only the CPU supplies addresses, so frequently these are simply lines driven by the CPU and received by other system components.

The last major group is the *control signals*. These differ greatly in number and function among the various bus systems in common use; but in all cases they control the response of various system components. Many of the control signals are called *strobes*. Their purpose is to delay and qualify the response to an address or data change until the logic levels on the bus are stable. This prevents a response to erroneous address and data patterns caused by one bus line switching slightly faster than the others.

Occasionally the data lines and address lines are multiplexed onto the same physical bus wires. This is particularly advantageous in 16-bit systems since 16 bus lines and associated socket pins can be eliminated. In such a system, control lines indicate when an address or data appears on the bus. Flip-flop registers on the various system boards are used to remember the address while data transfer is taking place.

Often a bus system may have special features over and above what is required to read and write memory or I/O devices. One of these is called *direct memory access* or DMA. In a system with DMA capability, the CPU is not the only subsystem capable of generating addresses and reading or writing memory. DMA I/O devices are also allowed to do these operations. In a system with DMA capability, the address lines must also have three-state capability.

DMA is typically used by video display and floppy disk subsystems. Both of these require data transfer at such a high speed that conventional program-controled input/output techniques are not usable. In operation, a DMA device will temporarily stop the CPU and gain control of the bus for the duration of the data transfer. During this time, the full speed capability of the bus, which may easily reach 2-million bytes per second, can be utilized. When data transfer is complete, the CPU is allowed to resume normal operation. A couple of particularly sophisticated bus systems do not even stop the CPU during DMA operation. Instead, DMA transfers take place between the "cracks" when the CPU is not using the bus anyway.

The Altair Bus. By far the most popular bus system in use by hobbyists today is the original Altair bus. Although usually called the S-100 bus because of its 100 lines, its popularity approaches standardization. However, the fact remains that MITS introduced it in early 1975 with its Altair 8800 computer.

Of the 100 lines, only 81 are actually assigned. Six lines are used to distribute +8, +16 and −16 volts, all rectified and filtered but unregulated. Separate data-in and data-out groups of 8 lines each constitute the data lines. Another 16 lines form the address bus. There is an unusually large complement of 43 control lines; but they are not necessarily an advantage since they are provided in their raw, undecoded state.

The bus timing and control functions are entirely dependent on the 8080 CPU for which the bus was designed.

However, when newer microprocessors such as the 8085 or the Z80 are interfaced to the S-100 bus, true compatibility with the original bus specification can only be attained by adding circuitry to "fake" the same timing and control sequences as used by the 8080. Actually most peripheral board designs, particularly static memories, can tolerate considerable variation in timing and control details and still operate satisfactorily. However, more complex boards such as floppy disk controllers and graphic display interfaces may depend heavily on standard 8080 control timing. Thus, these more complex boards may not operate correctly with a Z80 CPU board that does a poor job of faking the 8080 control sequences.

Control and timing is not the only source of potential incompatibilities among "standard" S-100 boards. Some manufacturers have assigned their own functions to the 19 unused bus lines. Of course, with only 19 to go around, not everyone has assigned them to the same functions. Nevertheless, the S-100 bus is the closest thing to a standard bus this industry has.

Benton Harbor (Heath) Bus. Another bus structure that has just been introduced with the announcement of the H8 microcomputer is the "Heath" bus. Unlike the S-100 bus, this one was carefully planned with the benefit of 2 years hindsight of the hobby computer market. Major differences are the much smaller number of lines, 50 instead of 100, and more generalized control signal assignments. The smaller number of bus lines and use of less expensive board-bus connectors greatly reduces the cost of a motherboard/bus system over the S-100 equivalent. Generalized control signals make the transition to newer processors more orderly.

Eight lines are used to distribute +18,

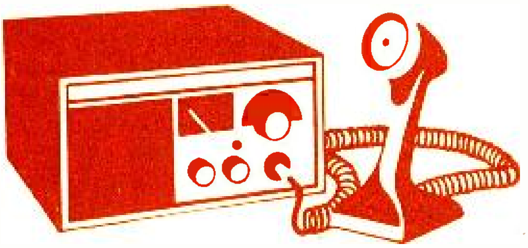
+8, and −18 volts, all unregulated. Four of these are grounds scattered among the other signals to further reduce noise. Although separate address and data busses are used, the data bus is bidirectional in order to conserve bus lines. The control signals are already decoded on the bus into the basic 4 operations; memory read, memory write, I/O read, and I/O write.

KIM-1 Bus. Probably the most popular "one board" microcomputer is the KIM-1. Although it has most of the subsystems needed for a complete system already on-board, it also has a 44-pin edge connector which brings the CPU bus out for expansion. While the busses described earlier were all TTL busses, capable of driving dozens of subsystems boards simultaneously, the KIM-1 bus is a "MOS" bus having limited drive capability. Using the signals raw, a maximum of four expansion boards can be driven and then only if they use "L" or "LS" TTL to connect to the bus. For greater expansion capability, a "bus expansion motherboard" can be used. This contains the typical parallel lines and board connectors as well as TTL buffers to drive a large number of boards. One of these in effect converts the KIM-1 bus to an S-100 bus and allows all of the less sophisticated S-100 boards to be used with a KIM-1 system.

General Purpose Interface Bus (GPIB). All of the bus systems discussed so far have been *processor* busses. That is, they connect both memory and I/O boards to the CPU. Although they are very fast and relatively simple to interface to, operational speed restricts the overall length to two feet or less. Running the parallel lines over a longer distance than this produces intolerable noise and crosstalk as well as a general slowdown of all signals. What this means is that all interface boards *must* plug directly into the bus in the computer cabinet. Since input/output is usually done much more slowly than memory access, it would be nice to have a parallel I/O bus that can be run through a cable to a variety of peripheral devices.

One bus designed for just this purpose is the General Purpose Interface Bus (GPIB), developed by Hewlett-Packard and adopted as a standard by the IEEE. The bus consists of 16 lines, 8 of which are bidirectional data/address lines and 8 of which are control lines. Although slower than the typical processor bus, it is much faster than a serial interface and uses full "handshake" control signal exchange to prevent data loss in the event a peripheral device is unable to receive data. Data transfers over the bus are in the form of 8-bit bytes and the control signals insure that devices on the bus are ready to receive or send data. Maximum bus length is about 16 feet, long enough to interconnect a table full of microcomputer peripherals. A maximum of 14 different devices can be addressed.

The significance of the GPIB is that the recently announced PET computer from Commodore has a GPIB connector on the back. Their plans call for interfacing add-on peripherals through this connector rather than adding boards inside the computer itself. Because of the large market expected for the PET computer and the fact that it is a formal industry standard not dominated by a single manufacturer, it is likely that the GPIB will soon become the preferred standard method of interfacing peripheral devices to a microcomputer. The familiar motherboard bus may disappear as 16k and 64k RAM chips make their appearance.◇



CB Scene

By Gary Garcia, KQI4178

AUTOMATIC TRANSMITTER IDENTIFICATION

MANDATORY USE of automatic transmitter identification systems (ATIS) was proposed (Docket 20351) in early 1975 as a means of alleviating the perplexing station identification problem and augmenting the enforcement efforts of the FCC. Two years later, in Docket 21137, the FCC again tendered the use of ATIS, this time for possible use on a voluntary basis. Here are some of the features of ATIS and its possible impact on the Citizens Band Radio Service.

Benefits. There are many benefits to be gained by CB'ers through the use of ATIS. Extensive application of ATIS will:

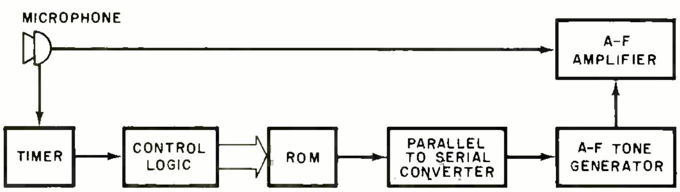
- Promote rules compliance, making for more reliable communications.
- Ease compliance with station identification requirements.
- Aid recovery of stolen transceivers.
- Simplify licensing procedures.
- Reduce necessary air time.

In addition, as pointed out by Stuart Lipoff of Arthur D. Little, Inc., ATIS and selective calling systems can easily be integrated. On our crowded channels, the functions provided by such an integrated system will certainly be a valuable communications aid to CB'ers.

Methodology. The purpose of an automatic transmitter identification system is easily accomplished. A basic system is shown in Fig. 1. The identifying information is stored in ROM, and the transmission of this identifier is regulated by timer circuitry. The output of the memory is converted from parallel to serial form before being fed into an audio-frequency tone generator. Finally, the audio-frequency tones are input to the audio-frequency amplifier of the transceiver.

Note that ATIS functions between the microphone and the transceiver's audio-frequency amplifier. This facilitates the addition of ATIS to equipment currently in use. An ATIS module could easily be inserted between the microphone and the microphone jack of a transceiver. In fact, if the use of ATIS were approved by the FCC, we could soon see commercial ATIS modules offered by those companies presently manufacturing automatic identification systems for the General Mobile Radio Service and amateur radio repeaters.

Fig. 1. Block diagram of a basic indentification system.



Your Electronic Fingerprint. The FCC has thus far proposed two methods of encoding the information used as identifier. Originally it was suggested that the identifier be transmitted in ASCII format by audio frequency-shift keying (AFSK) at a 100-baud rate. Using this method the identifier would be heard as a one-second burst. The audio-frequency tone used should not be over 4 kHz so as not to exceed FCC bandwidth limitations. In the first ATIS proposal, AFSK between two tones of 1115 and 1285 Hz is recommended.

Most recently, use of Morse Code transmitted at a rate of 25 words per minute has been suggested. On–off keying of a 750-Hz tone would be used here. The time required to transmit the identifier in this format is about five seconds. Currently, the EIA is working to standardize the format of signalling used in selective calling systems. It would be advantageous to use the same format for ATIS to allow integration of the two.

Whatever form of signalling and encoding is ultimately chosen, it probably will not be easily deciphered by the average CB'er. This will necessitate verbal transmission of callsigns in situations where the communicators require this information, such as when reporting an emergency on channel 9.

Another decision which must be made is what information to use as the identifier. If programming of the ATIS memory is to be done by manufacturers of CB transceivers and ATIS modules, it would be expedient to use, say, the serial number of the transceiver or module as the identifier. Programming of the licensee's callsign in the field, as was originally suggested by the FCC, would then be circumvented. However, if the transceiver's or module's serial number, or any other number other than the licensee's callsign, were used as an identifier, then the problem of station identification by use of the FCC-assigned callsigns remains unresolved. It is possible that the FCC would alter the regulations to allow identification by the number programmed into ATIS. Transmissions made using a transceiver equipped with ATIS, no matter what information is used as identifier, would all carry a unique "brand" which could be correlated with manufacturers' records to produce positive identification of the source of the transmissions.

Implementation. If ATIS were universally implemented on a mandatory basis, it would be necessary to retrofit the approximately 25-million CB transceivers now in use as well as all units "on the shelf." This is a seemingly impossible task. Certainly, if mandatory retrofitting of CB equipment with ATIS became law, it would just be another unenforceable regulation.

Voluntary implementation of ATIS is another possibility, as indicated in the FCC's most recent proposal. Though this would make concurrence with station identification requirements easier for those who are willing to apply ATIS, we can hardly expect CB's bad guys (those who use excessive r-f power, work DX, broadcast obscenities, etc.) to subscribe to ATIS.

If ATIS *is* eventually implemented by the FCC it will probably be on a voluntary basis for equipment now in use. It is possible, of course, that manufacturers of CB transceivers will be compelled to incorporate ATIS into their products in the future. But it's doubtful that this will occur on the present band. Certainly, if a new personal use radio service on a band other than 11 meters were opened to the public, ATIS will play an important part in helping the FCC police the band effectively. But initiating such a system would have to be mandatory at the onset, lest a situation similar to the present one develops. Besides, a new band is not in the cards in the near future.

For the present, it seems that the FCC will have to continue to rely on conventional, catch-as-catch-can enforcement techniques, as well as on self-policing among CB'ers. ◇

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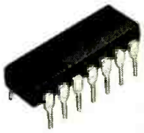

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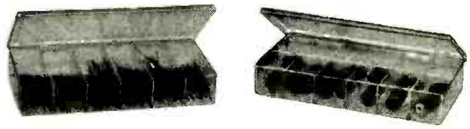

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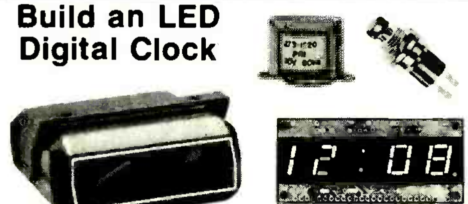

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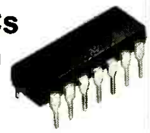

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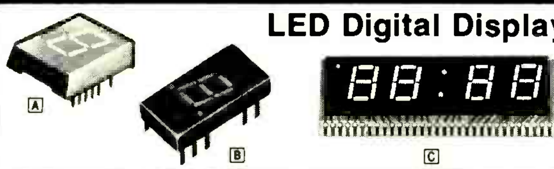

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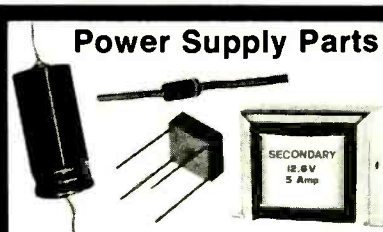

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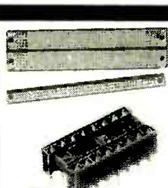

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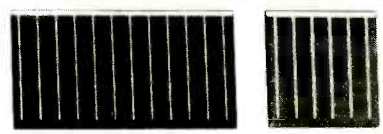

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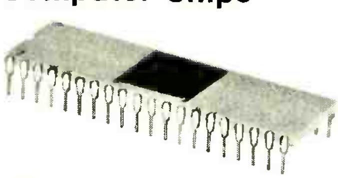

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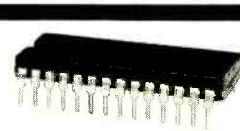

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TTL

7400	.21
7401	.21
7402	.21
7403	.21
7404	.21
7405	.21
7406	.25
7407	.25
7408	.25
7409	.21
7410	.21
7411	.21
7412	.21
7413	.25
7414	.89
7416	.25
7417	.25
7420	.21
7421	.25
7423	.35
7425	.35
7426	.25
7427	.33
7428	.28
7430	.21
7432	.25
7433	.30
7437	.25
7438	.25
7439	.50
7440	.21
7442	.53
7445	.70
7446	.70
7447	.70
7448	.70
7450	.21
7451	.21
7453	.21
7454	.21
7460	.21
7470	.30
7472	.30
7473	.30
7474	.30
7475	.49
7476	.32
7480	.70
7483	.70
7485	.89
7486	.28
7489	2.19
7490	.44
7491	.70
7492	.44
7493	.44
7494	.70
7495	.70
7496	.70
74100	1.28
74107	.30
74109	.33
74116	1.26
74121	.35
74122	.44
74123	.61
74125	.40
74126	.40
74128	.48
74132	.70
74141	.88
74145	.70
74147	1.63
74148	1.30
74150	1.16
74151	.70
74153	.65
74154	1.03
74155	.70
74156	.70
74157	.70
74160	.88
74161	.88
74162	.88
74163	.88
74164	.96
74165	1.15
74166	1.15
74170	2.64
74174	.98
74175	.93
74176	.79
74177	.79
74180	.70
74180	.70
74181	2.15
74182	.79
74184	2.15
74185	2.19
74189	3.50
74190	1.23
74191	1.23
74192	.88
74193	.88
74194	.88
74195	.88
74196	.88
74197	.88
74198	1.49
74199	1.49
74221	.86
74251	1.09
74279	.55
74298	.94
74365	.67
74366	.67
74367	.67
74368	.67

74LS00

74LS00	.28
74LS01	.28
74LS02	.28
74LS03	.28
74LS04	.29
74LS05	.29
74LS08	.29
74LS09	.29
74LS10	.28
74LS11	.28
74LS12	.28
74LS13	.47
74LS14	1.02
74LS15	.28
74LS20	.28
74LS21	.28
74LS22	.28
74LS26	.33
74LS27	.33
74LS28	.33
74LS30	.28
74LS32	.33
74LS33	.33
74LS37	.33
74LS38	.33
74LS40	.28
74LS42	.67
74LS47	.79
74LS48	.77
74LS51	.28
74LS54	.28
74LS55	.28
74LS73	.39
74LS74	.39
74LS75	.39
74LS76	.39
74LS78	.39
74LS83	.79
74LS85	.98
74LS86	.39
74LS90	.57
74LS92	.57
74LS93	.57
74LS95	.88
74LS96	.88
74LS107	.39
74LS109	.39
74LS112	.39
74LS113	.39
74LS114	.39
74LS125	.49
74LS126	.49
74LS132	.81
74LS136	.39
74LS138	.73
74LS139	.73
74LS151	.75
74LS153	.75
74LS154	1.10
74LS155	.75
74LS156	.75
74LS157	.75
74LS158	.75
74LS160	1.02
74LS161	1.02
74LS163	1.02
74LS164	1.02
74LS168	1.14
74LS169	1.14
74LS170	1.73
74LS173	1.34
74LS174	1.06
74LS175	.84
74LS181	2.50
74LS190	1.18
74LS191	1.18
74LS192	.98
74LS193	1.06
74LS194	.86
74LS195	.86
74LS196	.86
74LS197	.86
74LS221	1.06
74LS240	1.90
74LS241	1.90
74LS242	1.70
74LS243	1.70
74LS244	1.70
74LS247	.79
74LS248	.79
74LS249	.79
74LS251	.84
74LS253	.84
74LS257	.75
74LS258	.75
74LS260	.34
74LS261	2.00
74LS266	.39
74LS273	1.28
74LS279	.62
74LS283	.79
74LS290	.65
74LS293	.65
74LS295	1.12
74LS298	1.30
74LS365	.67
74LS366	.67
74LS367	.67
74LS368	.67
74LS377	1.50
74LS386	.39
74LS395	1.74
74LS670	2.34
81LS95	.77
81LS96	.77
81LS97	.77
81LS98	.77

INTERFACE

8093	.40
8094	.40
8095	.67
8096	.67
8097	.67
8098	.67
75450	.88
75451	.61
75452	.61
75453	.61
75454	.61
75491	.81
75492	.84
75493	1.09
75494	1.19
MC1488N	.90
MC1489N	.90

4000 CMOS

4000	.23
4001	.23
4002	.23
4006	1.23
4007	.23
4008	.79
4009	.44
4010	.44
4011	.23
4012	.23
4013	.40
4014	.96
4015	.96
4016	.40
4017	1.05
4018	1.05
4019	.50
4020	1.14
4021	1.14
4022	.96
4023	.23
4024	.79
4025	.23
4026	1.68
4027	.40
4028	.89
4029	1.14
4030	.40
4033	1.51
4034	3.50
4035	1.14
4040	1.14
4041	.79
4042	.79
4043	.79
4044	.79
4046	1.86
4049	.40
4050	.40
4051	1.26
4052	1.26
4053	1.26
4060	1.58
4066	.79
4071	.23
4072	.23
4073	.23
4075	.23
4081	.23
4082	.23
4502	.79
4510	1.14
4511	1.05
4514	2.80
4515	2.80
4516	1.23
4518	1.14
4520	1.14
4527	1.68
4528	.88
4585	1.23
74C00	.23

LINEAR

CA3046	.75
CA3086	.50
LF351N	.76
LF356N	1.20
LF357N	1.20
LF13741	.76
LM301AN	.44
LM307N	.64
LM308N	1.00
LM309K	1.80
LM311N	.90
LM317T	3.00
LM317MP	1.90
LM318N	2.70
LM320MP-5	1.30
LM320MP-6	1.30
LM320MP-8	1.30
LM320MP-9	1.30
LM320MP-12	1.30
LM320MP-15	1.30
LM320MP-18	1.30
LM320MP-18	1.30
LM320MP-24	1.30
LM323K	7.50
LM324N	.72
LM325N	2.70
LM326N	2.70
LM327N	2.70
LM339N	1.15
LM340T-5	1.25
LM340T-6	1.25
LM340T-8	1.25
LM340T-10	1.25
LM340T-12	1.25
LM340T-15	1.25
LM340T-18	1.25
LM340T-24	1.25
LM341P-5	.98
LM341P-6	.98
LM341P-8	.98
LM341P-10	.98
LM341P-12	.98
LM341P-15	.98
LM341P-18	.98
LM341P-24	.98
LM348N	1.60
LM349N	1.60
LM358N	.72
LM1310N	.84
LM1800N	1.70
LM1801N	1.70
LM1812N	4.80
LM1830N	1.30
LM1889N	2.00
LM2111N	1.50
LM2907N	1.50
LM2917N	1.50
LM3089N	1.30
LM3900N	.88
LM3900N	.88
LM3905N	1.40
LM3909N	.69
LM3911N	1.50
MC1456V	1.00
MC1458V	.53
MC1496N	.70
MC3302P	1.15
NE536T	2.50
NE540L	2.04
NE555V	.48
NE556A	.88
NE558N	2.40
NE559N	2.40
NE560B	2.50
NE561B	2.50
NE562B	2.50
NE565A	1.25
NE566V	1.88
NE567V	1.36
UA709CV	.44
UA710CA	.44
UA711CA	.53
UA723CA	.60
UA733CA	1.00
UA741CV	.40
UA747CA	.70
UA748CV	.49
UA7805CU	1.25
UA7806CU	1.25
UA7808CU	1.25
UA7812CU	1.25
UA7815CU	1.25
UA7818CU	1.25
UA7824CU	1.25
UA78L05ACZ	.40
UA78L06ACZ	.40
UA78L08ACZ	.40
UA78L10ACZ	.40
UA78L12ACZ	.40
UA78L15ACZ	.40
UA78L18ACZ	.40
UA78L24ACZ	.40
UA7905CU	1.70
UA7906CU	1.70
UA7908CU	1.70
UA7909CU	1.70
UA7912CU	1.70
UA7915CU	1.70
UA7918CU	1.70
UA7924CU	1.70

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.0022	.14	1.15/10	9.00/C	.047	.15	1.25/10	10.00/C
.0033	.14	1.15/10	9.00/C	.068	.15	1.25/10	10.00/C
.0047	.14	1.15/10	9.00/C	.1	.17	1.35/10	11.00/C
.0068	.14	1.15/10	9.00/C	.22	.23	1.85/10	15.00/C
.01	.14	1.15/10	9.00/C	.33	.30	2.50/10	20.00/C
.022	.15	1.25/10	10.00/C	.47	.36	3.00/10	24.00/C

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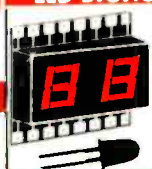
VALUE	RADIAL LEADS			AXIAL LEADS		
.47/50V	.08	.65/10	5.41/C	.11	.90/10	7.65/C
1/50V	.08	.65/10	5.41/C	.11	.90/10	7.65/C
2.2/50V	.08	.65/10	5.41/C	.12	.90/10	7.82/C
3.3/50V	.08	.65/10	5.41/C	.12	1.00/10	8.31/C
4.7/35V	.08	.65/10	5.41/C	.12	.95/10	7.91/C
4.7/50V	.08	.68/10	5.75/C	.12	1.00/10	8.31/C
10/16V	.08	.65/10	5.41/C	.11	.90/10	7.65/C
10/25V	.08	.65/10	5.66/C	.12	1.00/10	8.31/C
10/35V	.09	.70/10	6.12/C	.13	1.10/10	8.94/C
10/50V	.10	.75/10	6.58/C	.14	1.15/10	9.56/C
22/16V	.08	.67/10	5.66/C	.12	1.00/10	8.31/C
22/25V	.09	.70/10	6.09/C	.13	1.05/10	8.74/C
22/35V	.11	.85/10	7.29/C	.15	1.19/10	9.98/C
22/50V	.12	1.00/10	8.48/C	.17	1.32/10	11.22/C
33/16V	.09	.75/10	6.90/C	.12	1.00/10	8.48/C
33/25V	.10	.81/10	7.50/C	.14	1.15/10	9.56/C
33/35V	.13	1.05/10	9.65/C	.17	1.34/10	11.23/C
33/50V	.14	1.13/10	10.41/C	.19	1.52/10	12.89/C
47/10V	.09	.71/10	6.52/C	.13	1.04/10	9.50/C
47/16V	.10	.81/10	7.47/C	.14	1.15/10	9.56/C
47/25V	.13	1.05/10	9.65/C	.17	1.30/10	11.22/C
47/35V	.14	1.13/10	10.41/C	.19	1.51/10	12.89/C
47/50V	.15	1.21/10	11.16/C	.21	1.71/10	14.55/C
100/10V	.10	.77/10	6.58/C	.14	1.13/10	9.56/C
100/16V	.11	.85/10	7.28/C	.17	1.30/10	11.22/C
100/25V	.13	1.10/10	9.15/C	.20	1.55/10	13.30/C
100/35V	.17	1.41/10	11.85/C	.25	1.93/10	16.50/C
100/50V	.21	1.71/10	14.55/C	.29	2.30/10	19.70/C
220/10V	.13	1.08/10	9.15/C	.18	1.42/10	12.05/C
220/16V	.15	1.16/10	9.86/C	.20	1.55/10	13.02/C
220/25V	.21	1.71/10	14.55/C	.29	2.35/10	19.96/C
220/35V	.25	2.03/10	17.26/C	.35	2.79/10	23.70/C
220/50V	.29	2.35/10	19.96/C	.40	3.23/10	27.44/C
330/6V	.14	1.12/10	9.50/C	.19	1.48/10	13.71/C
330/10V	.15	1.16/10	9.83/C	.21	1.64/10	15.13/C
330/16V	.21	1.66/10	14.14/C	.31	2.45/10	22.70/C
330/25V	.23	1.86/10	15.79/C	.38	3.07/10	28.38/C
330/35V	.33	2.66/10	24.59/C	.43	3.43/10	31.68/C
330/50V	.54	4.30/10	39.73/C	.60	4.81/10	44.45/C
470/6V	.15	1.21/10	11.16/C	.20	1.64/10	15.13/C
470/10V	.21	1.71/10	14.55/C	.31	2.45/10	22.70/C
470/16V	.23	1.81/10	15.39/C	.33	2.66/10	24.59/C
470/25V	.29	2.35/10	19.96/C	.43	3.43/10	31.68/C
470/35V	.41	3.27/10	30.26/C	.47	3.78/10	34.99/C
470/50V	.54	4.30/10	39.73/C	.75	6.03/10	55.80/C
1000/6V	.22	1.90/10	16.50/C	.35	2.76/10	25.54/C
1000/10V	.24	1.96/10	16.62/C	.38	3.07/100	28.38/C
1000/16V	.29	2.35/10	19.96/C	.43	3.43/10	31.68/C
1000/25V	.42	3.33/10	28.27/C	.68	5.42/10	50.13/C
1000/35V	.60	4.81/10	44.45/C	.75	6.03/10	55.81/C
2200/6V	.36	2.86/10	26.48/C	.43	3.43/10	31.68/C
2200/10V	.42	3.33/10	28.27/C	.60	4.81/10	44.45/C
2200/16V	.54	4.30/10	36.58/C	.68	5.42/10	50.13/C

LED DIGITS AND LAMPS



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FND500	.5'' Single Digit CC Red	1.35
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FND800	.8'' Single Digit CC Red	2.50
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NSN373	.3'' Dual Digits CC Red	2.20
NSN374	.3'' Dual Digits CA Red	2.20
NSN583	.5'' Dual Digits CC Red	2.60
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¼ WATT RESISTOR ASSORTMENTS

Catalog Number	Description	PRICE
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RS225	Set of 5 each of the 73 standard 5% ¼ watt carbon film resistors in the series 1.1, 1.3, 1.6, 2.0, 2.4 etc. through 910 kilohm (360 total pcs.)	$9.90

½ WATT RESISTOR ASSORTMENTS

Catalog Number	Description	PRICE
RS150	Set of 5 each of the 73 standard 5% ½ watt carbon film resistors in the series 1.0, 1.2, 1.5, 1.8, 2.2 etc. through 1.0 megohm (365 total pcs.)	$9.90
RS250	Set of 5 each of the 73 standard 5% ½ watt carbon film resistors in the series 1.1, 1.3, 1.6, 2.0, 2.4 etc. through 910 kilohm (360 total pcs.)	$9.90

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MA1002C	.5'' LED 24 Hour Clock Module	$10.50
MA1002C SET	Module w/Transformer & Switches	$13.95
MA1003	12 Volt Car Clock with Switches	$24.95
MA1010A	.84'' LED 12 Hour AM/PM Clock Module	$13.00
MA1010A SET	Module w/Transformer & Switches	$16.45
MA1010C	.84 LED 24 Hour Clock Module	$13.00
MA1010C SET	Module w/Transformer & Switches	$16.45

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½ WATT ZENER DIODES

.15 1.30/10 11.00/C

1N5226B	3.3V	1N5242B	12V
1N5227B	3.6V	1N5243B	13V
1N5228B	3.9V	1N5244B	14V
1N5229B	4.3V	1N5245B	15V
1N5230B	4.7V	1N5246B	16V
1N5231B	5.1V	1N5247B	17V
1N5232B	5.6V	1N5248B	18V
1N5233B	6.0V	1N5249B	19V
1N5234B	6.2V	1N5250B	20V
1N5235B	6.8V	1N5251B	22V
1N5236B	7.5V	1N5252B	24V
1N5237B	8.2V	1N5253B	25V
1N5238B	8.7V	1N5254B	27V
1N5239B	9.1V	1N5255B	28V
1N5240B	10V	1N5256B	30V
1N5241B	11V	1N5257B	33V

HARDWARE

2-56 1/4 SCREW	.99/C
2-56 1/2 SCREW	.99/C
4-40 1/4 SCREW	.55/C
4-40 1/2 SCREW	.60/C
6-32 1/4 SCREW	.65/C
6-32 1/2 SCREW	.75/C
8-32 3/8 SCREW	.90/C
8-32 5/8 SCREW	.99/C
2-56 HEX NUT	.55/C
4-40 HEX NUT	.55/C
6-32 HEX NUT	.60/C
8-32 HEX NUT	.60/C
NO 2 LOCKWASHER	.85/C
NO 4 LOCKWASHER	.45/C
NO 6 LOCKWASHER	.45/C
NO 8 LOCKWASHER	.45/C

FREE CATALOG

SILICON TRANSISTORS

MPS918	.16	1.55/10	13.60/C	130.00/M
MPS930	.16	1.55/10	13.60/C	130.00/M
MPS2222A	.16	1.55/10	13.60/C	130.00/M
MPS2369A	.16	1.55/10	13.60/C	130.00/M
MPS2907A	.16	1.55/10	13.60/C	130.00/M
MPS3393	.16	1.55/10	13.60/C	130.00/M
MPS3393	.16	1.55/10	13.60/C	130.00/M
MPS3394	.16	1.55/10	13.60/C	130.00/M
MPS3395	.16	1.55/10	13.60/C	130.00/M
MPS3563	.16	1.55/10	13.60/C	130.00/M
MPS3565	.16	1.55/10	13.60/C	130.00/M
MPS3638A	.16	1.55/10	13.60/C	130.00/M
MPS3640	.16	1.55/10	13.60/C	130.00/M
MPS3641	.16	1.55/10	13.60/C	130.00/M
MPS3643	.16	1.55/10	13.60/C	130.00/M
2N3904	.16	1.55/10	13.60/C	130.00/M
2N3906	.16	1.55/10	13.60/C	130.00/M
2N4124	.16	1.55/10	13.60/C	130.00/M
2N4126	.16	1.55/10	13.60/C	130.00/M
2N4401	.16	1.55/10	13.60/C	130.00/M
2N4403	.16	1.55/10	13.60/C	130.00/M
2N4410	.16	1.55/10	13.60/C	130.00/M
2N5087	.16	1.55/10	13.60/C	130.00/M
2N5089	.16	1.55/10	13.60/C	130.00/M
2N5210	.16	1.55/10	13.60/C	130.00/M
2N3055	.99	9.20/10	85.00/C	800.00/M
MPF102	.36	3.35/10	30.60/C	300.00/M
2N5457	.48	4.50/10	41.00/C	400.00/M
MPSA13	.28	2.60/10	24.00/C	230.00/M
MJ2955	.99	9.20/10	85.00/C	800.00/M
TIP120	.99	9.20/10	85.00/C	800.00/M

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8 PIN SOLDER	.17	1.60/10	14.50/C
14 PIN SOLDER	.20	1.90/10	17.00/C
16 PIN SOLDER	.22	2.10/10	18.75/C
18 PIN SOLDER	.29	2.75/10	24.50/C
20 PIN SOLDER	.30	2.85/10	25.25/C
22 PIN SOLDER	.33	3.15/10	27.75/C
24 PIN SOLDER	.38	3.60/10	32.25/C
28 PIN SOLDER	.45	4.25/10	38.25/C
40 PIN SOLDER	.63	6.00/10	53.50/C
8 PIN W-W	.24	2.30/10	20.50/C
14 PIN W-W	.26	2.50/10	22.00/C
16 PIN W-W	.30	2.85/10	25.50/C
18 PIN W-W	.60	5.70/10	51.00/C
20 PIN W-W	.70	6.65/10	59.50/C
22 PIN W-W	.84	8.00/10	71.50/C
24 PIN W-W	.96	9.10/10	81.50/C
28 PIN W-W	1.12	10.00/10	95.20/C
40 PIN W-W	1.36	12.50/10	115.00/C

SILICON DIODES

1N4001	.64/10	5.50/C
1N4002	.66/10	5.60/C
1N4003	.68/10	5.80/C
1N4004	.70/10	5.95/C
1N4005	.82/10	7.05/C
1N4006	.90/10	7.75/C
1N4007	.99/10	8.60/C
1N4148	.40/10	3.50/C

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SPDT	.19	1.70/10	13.00/C
DPDT	.23	2.00/10	19.00/C

STRANDED HOOK UP WIRE

20 ga PVC	2.50/100'	10.00/500
22 ga PVC	2.80/100'	11.25/500
24 ga PVC	2.10/100	8.50/500
26 ga PVC	2.10/100	8.50/500

50 VOLT DISCS

100 PF	.40/10	3.50/C
220 PF	.40/10	3.50/C
470 PF	.40/10	3.50/C
.001 UF	.40/10	3.50/C
.0022 UF	.40/10	3.50/C
.0047 UF	.40/10	3.50/C
.01 UF	.45/10	3.65/C
.022 UF	.50/10	4.00/C
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.1 UF	1.35/10	11.50/C

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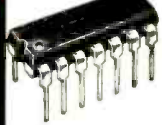

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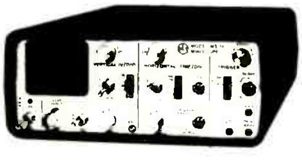
CIRCLE NO. 10 ON FREE INFORMATION CARD

NON-LINEAR SYSTEMS, INC.

PORTABLE 15 MHz OSCILLOSCOPE



The MS-15 miniscope is only 2.7" x 6.4" x 7.5", and weighs only 3 lbs. Vertical bandwidth is 15 MHz. The graticuled rectangular viewing area is four divisions high by five divisions wide. Division spacing is 0.25 inches. Internal and external triggering, automatic and line synchronization modes, and a horizontal input are provided. There are 12 vertical gain settings from 0.01 V to 50 V per division, and twenty one time base settings from 0.1 μs to 0.5 μs per division. An optional 10 to 1 probe and a carrying case are also available. Power is provided by batteries or the 115 V, 60 Hz line.

MS-15	MINISCOPE	$289.00
41-140	CARRYING CASE	30.00
41-141	10 TO 1 PROBE	24.50

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XR-2208CP	Four-Quadrant Operational Multiplier	$5.20
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XR-215	General Purpose Phase-Locked Loop	$6.56
XR-2211CP	FSK Demodulator/Tone Decoder	$6.88
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XR-205	Waveform Generator	$8.40
XR-2206CP	Monolithic Function Generator	$5.12
XR-2207CP	Current-Controlled Oscillator	$3.84
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XR-567CP	Tone Decoder	$1.68
XR-2567CP	Dual Tone Decoder	$5.18
VOLTAGE REGULATORS		
XR-1468CN	Dual ±15 Volt Tracking Regulator	$3.84
XR-4194CN	Adjustable Dual Tracking Voltage Regulator	$4.56
XR-4195CP	Dual ±15V Tracking Voltage Regulator	$3.38
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XR-4202P	Programmable Quad Operational Amplifier	$3.60
XR-4212 CP	Quad Operational Amplifier	$2.05
XR-4558CP	Dual Operational Amplifier	$0.86
XR-4739CP	Dual Low-Noise Operational Amplifier	$1.15
TIMING CIRCUITS		
XR-320P	Timing Circuit	$1.52
XR-555CP	Timing Circuit	$1.07
XR-556CP	Dual 555 Timing Circuit	$1.82
XR-2240CP	Programmable Timing Circuit	$3.44
XR-2556CP	Dual 555 Timing Circuit	$3.20
INTERFACE CIRCUITS		
XR-2200CP	Hammer Driver	$1.17
XR-2201CP/ -2202CP/ -2203CP/ -2204CP	High Voltage, High Current Darlington Transistor Arrays	$2.25 each
XR-2271CP	Flourescent Display Drivers	$1.15
OTHER CIRCUITS		
XR-1310P	FM Stereo Demodulator	$3.20
XR-2264CP	Proportional Servo IC	$4.24
XR-4151CP	Voltage-To-Frequency Converter	$7.50

5% CARBON FILM RESISTOR ASSORTMENTS

Each assortment contains 5 pcs each of 10 different values
Values included are shown in (Ohms)

¼Watt 5% assortments $1.75 ea. ½Watt 5% assortments $1.85 ea.

Asst.1:	10,	12,	15,	18,	22,	27,	33,	39,	47,	56
Asst.1A:	11,	13,	16,	20,	24,	30,	36,	43,	51,	62
Asst.2:	68,	82,	100,	120,	150,	180,	220,	270,	330,	390
Asst.2A:	75,	91,	110,	130,	160,	200,	240,	300,	360,	430
Asst.3:	470,	560,	680,	820,	1K,	1.2K,	1.5K,	1.8K,	2.2K,	2.7K
Asst.3A:	510,	620,	750,	910,	1.1K,	1.3K,	1.6K,	2K,	2.4K,	3K
Asst.4:	3.3K,	3.9K,	4.7K,	5.6K,	6.8K,	8.2K,	10K,	12K,	15K,	18K
Asst.4A:	3.6K,	4.3K,	5.1K,	6.2K,	7.5K,	9.1K,	11K,	13K,	16K,	20K
Asst.5:	22K,	27K,	33K,	39K,	47K,	56K,	68K,	82K,	100K,	120K
Asst.5A:	24K,	30K,	36K,	43K,	51K,	62K,	75K,	91K,	110K,	130K
Asst.6:	150K,	180K,	220K,	270K,	330K,	390K,	470K,	560K,	680K,	820K
Asst.6A:	160K,	200K,	240K,	300K,	360K,	430K,	510K,	620K,	750K,	910K
Asst.7:	1M,	1.2M,	1.5M,	1.8M,	2.2M,	2.7M,	3.3M,	3.9M,	4.7M,	5.6M
Asst.7A:	1.1M,	1.3M,	1.6M,	2M,	2.4M,	3M,	3.6M,	4.3M,	5.1M,	6.2M

(½Watt assortment No. 7 does not include 5.6M)
(½Watt assortment No. 7A does not include 5.1 or 6.2M)

Asst.8: (Consists of Asst's 1, 2, 3, 4, 5, 6 and 7)
Asst.8A: (Consists of Asst's 1A, 2A, 3A, 4A, 5A, 6A and 7A)

Asst's 8 or 8A— ¼Watt $10.95 ½Watt $11.55

COMPUTER INTERFACE CIRCUITS

	1–9	10 UP		1–9	10 UP		1–9	10 UP		1–9	10 UP
MH0026CN	$ 2.60	$ 2.20	SN7524N	$ 1.50	$ 1.35	DM8820N	$ 2.20	$ 1.75	AM8228PC	$ 8.20	$ 7.10
DS0056CN	5.85	4.70	SN7525N	1.40	1.25	DM8820AN	2.95	2.35	AM8238PC	8.20	7.10
DS3603N	4.10	3.30	SN75107BN	2.58	2.06	DM8830N	2.95	2.35	9600PC	1.65	1.50
AM1488PC	2.10	1.65	SN75108BN	2.58	2.06	DM8831N	3.25	2.80	9601PC	1.65	1.30
AM1489PC	2.10	1.65	SN75109N	2.58	2.06	DM8832N	3.25	2.80	9602PC	1.90	1.65
AM1489APC	2.10	1.65	SN75110N	2.58	2.06	DS8838N	2.95	2.35	9614PC	2.15	1.80
P3212	4.35	3.75	SN75234N	1.55	1.40	N8T268	3.10	2.70	9615PC	2.15	1.80
P3216	3.90	3.15	SN75235N	1.10	1.00	P8212	4.35	3.75	9616PC	3.15	2.60
DS3604N	6.65	5.35	SN75238N	1.95	1.60	P8216	3.90	3.15	9617PC	2.15	1.80
SN7521N	1.40	1.25	SN75239N	1.50	1.25	AM8224PC	6.50	5.40	9620PC	3.00	2.50
P3226	3.90	3.15	SN75325N	2.60	2.35	P8226	3.90	3.15	9621PC	3.00	2.50
2900 SERIES BI-POLAR MICROPROCESSOR AND SUPPORT CIRCUITS											
AM2901APC	$22.00	$17.40	AM2913PC	$ 4.10	$ 3.15	AM29700PC	$ 5.65	$ 4.50	AM29721PC	$ 5.00	$ 4.20
AM2901DC	29.40	22.05	AM2914DC	60.00	45.00	AM29701PC	5.65	4.50	AM29750DC	4.50	3.60
AM2902PC	3.82	3.18	AM2915APC	8.10	7.00	AM29702PC	5.65	4.50	AM29751DC	4.50	3.60
AM2905PC	8.10	7.00	AM2916APC	11.20	8.95	AM29703PC	5.65	4.50	AM29760DC	6.80	5.50
AM2906PC	11.20	8.95	AM2917APC	7.15	6.20	AM29704PC	15.75	12.60	AM29761DC	6.80	5.50
AM2907PC	7.15	6.20	AM2918PC	5.40	4.32	AM29705PC	15.75	12.60	AM29803DC	7.65	5.95
AM2909PC	8.95	7.15	AM2922PC	5.78	4.93	AM29720PC	5.00	4.20	AM29811DC	4.85	3.90
AM2911PC	5.95	4.75									
BI-POLAR MEMORY											
AM27LS00PC	$ 5.00	$ 4.20	AM27LS08DC	$ 4.50	$ 3.60	P3101	$ 4.40	$ 3.50	MM6561N	$ 4.40	$ 3.50
AM27LS01PC	5.00	4.20	AM27LS09DC	4.50	3.60	P3101A	4.75	3.70	DM8599N	3.30	2.60
AM27LS02PC	5.65	4.50	AM27LS10DC	6.80	5.50	IM5501CPE	4.40	3.50	82S25PC	4.75	4.20
AM27LS03PC	5.65	4.50	AM27LS11DC	6.80	5.50	MM6560N	4.40	3.50	93403PC	5.25	4.20
SILICON GATE MOS LSI											
MK1002L	$ 7.00	$ 6.00	P2111	$ 2.50	$ 2.00	AM2806HC	$ 7.00	$ 5.60	C4702A	$18.30	$13.85
P1101A	4.05	3.25	P2111-1	3.70	3.00	AM2807PC	2.92	2.34	MM5025N	40.80	33.60
1402APC	4.42	2.75	P2112	2.50	2.00	AM2808PC	5.02	4.02	MM5026D	44.00	35.20
1403APC	4.42	2.90	P2112-2	3.70	3.00	AM2809PC	3.52	2.82	MM5027N	40.80	33.60
1404APC	4.42	2.75	P2401	24.00	17.55	AM2857PC	7.15	5.75	MM5055N	7.15	5.75
1405A	5.80	4.25	P2405	10.85	7.90	AM2896PC	5.00	4.50	MM5056N	7.15	5.75
1406	10.20	8.40	2505K	3.70	3.56	TMS3114NC	9.96	7.32	MM5057N	7.15	5.75
1407	10.20	8.40	2512K	4.30	4.05	TMS3133NC	10.85	4.02	MM5058N	10.85	8.70
1506	4.05	3.24	2521V	2.65	2.55	3341APC	8.25	6.55	P8080A	18.60	15.85
1507	4.05	3.24	2524V	2.50	2.25	3347PC	6.40	5.10	AM9080APC	18.60	15.85
C1702A	18.30	13.85	2525V	3.65	3.55	MM4025D	73.00	58.40	P8101	2.95	2.40
P2101	2.95	2.40	2533V	4.90	4.02	MM4026D	73.00	58.40	P8102	2.30	1.80
P2101-1	4.20	3.40	2602B	4.10	3.85	MM4027D	75.00	60.00	P8111	2.50	2.00
P2101-2	4.20	3.40	AM2802PC	4.42	2.75	MM4055D	16.00	12.80	P8251	12.50	11.50
P2101A	4.74	3.85	AM2803PC	4.42	3.54	MM4056H	11.50	9.20	P8255	12.50	11.50
P2101A-2	5.50	4.50	AM2804PC	4.42	2.75	MM4057D	16.00	12.80	C8702A	18.30	13.85
P2102	2.30	1.80	AM2805HC	3.70	3.56	MK4102P	21.60	18.00	AM9401PC	16.88	13.50
P2102-1	3.45	2.80									

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				2N3694	.22	2N4037	.66	2N4922	1.00	2N5308	.40	2N5825	.26
2N508A	.80	2N2904A	.36	2N3702	.18	2N4058	.25	2N4923	.70	2N5309	.52	2N5826	.30
2N697	.26	2N2905	.34	2N3704	.18	2N4060	.20	2N4983	1.10	2N5321	.60	2N5827	.30
2N699	.80	2N2905A	.36	2N3705	.18	2N4061	.25	2N4984	1.50	2N5322	.70	2N5828	.34
2N706	.35	2N2906	.20	2N3706	.25	2N4093	1.10	2N4987	.75	2N5323	.70	2N5828A	.40
2N711	.49	2N2906A	.21	2N3707	.18	2N4123	.20	2N4988	1.20	2N5354	.34	2N6000	.50
2N718	.40	2N2907	.24	2N3708	.20	2N4124	.20	2N4989	1.60	2N5355	.38	2N6001	.52
2N718	.40	2N2907A	.28	2N3709	.20	2N4125	.20	2N4991	.75			2N6002	.54
2N918	.40	2N2924	.30	2N3710	.20	2N4126	.24	2N4993	1.80	2N5366	.50	2N6014	.66
2N929	.26	2N2925	.22	2N3711	.20	2N4142	.18	2N4994	.30	2N5367	.50	2N6015	.68
2N930	.28	2N2926	.15	2N3721	.20	2N4143	.18	2N5086	.30	2N5368	.25	2N6027	.50
2N1132	.35	2N3019	.90	2N3724	.50	2N4220A	1.00	2N5087	.30	2N5369	.26	2N6028	.60
2N1613	.32	2N3053	.36	2N3725	.52	2N4224	1.25	2N5088	.30	2N5370	.28	2N6034	.92
2N1711	.34	2N3054	.90	2N3731	3.60	2N4228	.40	2N5089	.40	2N5373	.28	2N6035	1.00
2N1893	.36	2N3055	1.00	2N3740	1.20	2N4235	1.80	2N5109	1.90	2N5375	.28	2N6037	.92
2N2102	.40	2N3375	6.30	2N3741	1.50	2N4237	1.20	2N5131	.20	2N5383	.58	2N6076	.20
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2N2218	.26	2N3392	.28	2N3772	2.50	2N4248	.22	2N5134	.20	2N5418	.30	2N6101	1.06
2N2218A	.26	2N3393	.22	2N3773	3.90	2N4249	.18	2N5172	.20	2N5419	.35	2N6103	1.10
2N2219	.26	2N3414	.20	2N3789	3.00	2N4250	.24	2N5179	.50	2N5420	.40	2N6121	.66
2N2219A	.36	2N3416	.22	2N3819	.40	2N4256	.20	2N5190	.80	2N5447	.30	2N6122	.68
2N2221	.20	2N3417	.22	2N3823	.70	2N4258	.32	2N5191	.80	2N5448	.30	2N6123	.88
2N2221A	.25	2N3440	1.00	2N3859	.22	2N4348	2.10	2N5194	.80	2N5449	.25	2N6124	.80
2N2222	.22	2N3442	1.80	2N3860	.20	2N4395	1.30	2N5210	.15	2N5450	.20	2N6125	.68
2N2224	.24	2N3553	1.80	2N3866	1.10	2N4400	.25	2N5219	.20	2N5451	.25	2N6126	.88
2N2368	.30	2N3563	.15	2N3877A	.29	2N4401	.25	2N5220	.20	2N5457	.60	2N6218	.64
2N2369	.24	2N3564	.16	2N3903	.20	2N4402	.30	2N5221	.20	2N5458	.45	2N6219	.60
2N2369A	.26	2N3565	.18	2N3904	.22	2N4403	.40	2N5223	.20	2N5484	.60	2N6220	.58
2N2475	.60	2N3567	.19	2N3905	.20	2N4409	.30	2N5225	.18	2N5490	.70	2N6222	.30
2N2484	.30	2N3568	.30	2N3906	.22	2N4416	.90	2N5227	.24	2N5777	.60	2N6223	.30
2N2605	.50	2N3569	.18	2N3955	2.70	2N4425	.44	2N5232	.32	2N5778	.55	2N6224	.32
2N2608	2.00	2N3638	.20	2N3957	1.50	2N4427	1.00	2N5232A	.25	2N5811	.40	2N6225	.34
2N2646	.70	2N3638A	.22	2N3958	1.60	2N4858	1.00	2N5249	.40	2N5817	.40		
2N2647	.95	2N3642	.20	2N3962	.35	2N4898	1.10	2N5294	.70	2N5818	.40		
2N2713	.25	2N3643	.20	2N3970	1.20	2N4918	.80	2N5296	.70	2N5819	.45		
2N2904	.35	2N3645	.20	2N4032	.60	2N4919	.60	2N5298	.70	2N5822	.58		

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74LS01N	.44	74LS90N	.84	74LS192N	1.20
74LS02N	.32	74LS92N	.86	74LS193N	1.21
74LS03N	.32	74LS93N	.86	74LS194N	1.32
74LS04N	.36	74LS95N	1.00	74LS195N	.99
74LS05N	.33	74LS96N	1.24	74LS196N	2.76
74LS08N	.36	74LS107N	.46	74LS197N	2.84
74LS09N	.44	74LS109N	.46	74LS221N	1.76
74LS10N	.32	74LS112N	.64	74LS241N	3.00
74LS11N	.32	74LS113N	.64	74LS251N	1.10
74LS15N	.44	74LS114N	.92	74LS253N	1.10
74LS20N	.32	74LS123N	1.10	74LS257N	.95
74LS21N	.44	74LS125N	.60	74LS258N	1.10
74LS22N	.44	74LS132N	1.44	74LS260N	.44
74LS26N	.33	74LS136N	.74	74LS261N	1.90
74LS27N	.44	74LS138N	.99	74LS266N	.72
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74LS30N	.32	74LS145N	1.64	74LS281N	7.60
74LS32N	.36	74LS148N	3.45	74LS283N	2.00
74LS33N	.56	74LS151N	.88	74LS290N	1.76
74LS37N	.50	74LS153N	.88	74LS293N	1.76
74LS38N	.58	74LS155N	1.50	74LS299N	6.14
74LS40N	.44	74LS157N	.88	74LS365N	.70
74LS42N	.92	74LS158N	.99	74LS367N	.70
74LS51N	.44	74LS160N	1.25	74LS374N	3.21
74LS54N	.44	74LS161N	1.25	74LS375N	.82
74LS55N	.44	74LS162N	1.25	74LS378N	1.60
74LS73N	.46	74LS163N	1.25	74LS381N	4.56
74LS74N	.46	74LS164N	1.50	74LS386N	.72
74LS75N	.70	74LS170N	3.20	74LS399N	2.15
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IN4005	10/1.10
IN4006	10/1.20
IN4007	10/1.20
2SB405	.85
2SC536	2/1.20
2SC828	2/1.50
2SC829	2/1.50
2SC929	2/1.40
2SC930	2/1.30
2SC933	1.00
2SC1226A	1.25
2SC1359	.90
2SC1973	1.30
2SC1974	3.00
2SC1975	3.10
2SC2034	3.40
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IN5224B	2.8	.22
IN5225B	3.0	.22
IN5226B	3.3	.22
IN5227B	3.6	.22
IN5228B	3.9	.22
IN5229B	4.3	.22
IN5230B	4.7	.22
IN5231B	5.1	.22
IN5232B	5.6	.22
IN5233B	6.0	.22
IN5234B	6.2	.22
IN5235B	6.8	.22
IN5236B	7.5	.22
IN5237B	8.2	.22
IN5238B	8.7	.22
IN5239B	9.1	.22
IN5240B	10	.22
IN5241B	11	.22
IN5242B	12	.22
IN5243B	13	.22
IN5244B	14	.22
IN5245B	15	.22
IN5246B	16	.22
IN5247B	17	.22
IN5248B	18	.22
IN5249B	19	.22
IN5250B	20	.22
IN5251B	22	.22
IN5252B	24	.22
IN5253B	25	.22
IN5254B	27	.22
IN5255B	28	.22
IN5256B	30	.22
IN5257B	33	.22
IN5258B	36	.22
IN5259B	39	.22
IN5260B	43	.22
IN5261B	47	.22
IN5262B	51	.22
IN5263B	56	.22
IN5264B	60	.22
IN5265B	62	.22
IN5266B	68	.22
IN5267B	75	.22

1 WATT	V	PRICE
IN4728A	3.3	.44
IN4729A	3.6	.44
IN4730A	3.9	.44
IN4731A	4.3	.44
IN4732A	4.7	.44
IN4733A	5.1	.44
IN4734A	5.6	.44
IN4735A	6.2	.44
IN4736A	6.8	.44
IN4737A	7.5	.44
IN4738A	8.2	.44
IN4739A	9.1	.44
IN4740A	10	.44
IN4741A	11	.44
IN4742A	12	.44
IN4743A	13	.44
IN4744A	15	.44
IN4745A	16	.44
IN4746A	18	.44
IN4747A	20	.44
IN4748A	22	.44
IN4749A	24	.44
IN4750A	27	.44
IN4751A	30	.44
IN4752A	33	.44
IN4753A	36	.44
IN4754A	39	.44
IN4755A	43	.44
IN4756A	47	.44
IN4757A	51	.44
IN4758A	56	.44
IN4758A	62	.44
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1,032 SOLDERLESS PLUG-IN TIE POINTS
CAPACITY: *UP TO 12* 14-PIN DIP's
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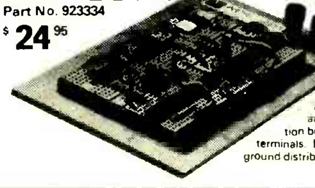

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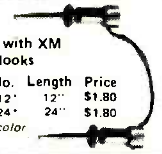

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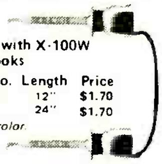

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Specify color.

Jumper with X-100W Mini Hook

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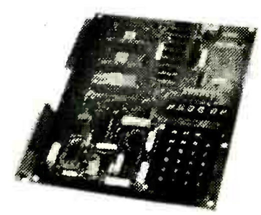

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WEIGHT 44 lbs

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RAM (user) 4K (8K OPT) exp to 32K
ROM (resident operating system) 14K
8K-BASIC interpreter
4K-Operating system
1K-Diagnostic routine
1K-Machine language monitor

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9" b&w high resolution CRT • 1000 char display 40 col by 25 lines • 8x8 dot matrix for characters and continuous graphics • Auto scrolling from bottom of screen • Winking cursor with full motion control • Reverse field on all characters • 64 standard ASCU char; 64 graphic char.

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9-1/2" wide x 3" deep, 73 keys • All 64 ASCU characters available without shift • Calculator style numeric key pad • All 64 graphic and reverse field characters accessible from keyboard (with shift) Screen: Control Clear and erase • Editing: Character insertion and deletion

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Fast redundant recording scheme assuring reliable data recovery • Modified drive for higher reliability of recording and record retention • High noise immunity, error detection and correction • Uses standard audio cassette tapes • Tape files named.

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Supports multiple languages • Machine language accessibility • File management in operating system • Cursor control, reverse field and graphics under simple BASIC control • Cassette file management from BASIC • True random number generation or pseudo random sequence

INPUT/OUTPUT

INPUT/OUTPUT

All other I/O supported through IEEE-488 instrument interface which allows for multiple intelligent peripherals • All I/O automatically managed by operating system software • Single character I/O with GET command • Easy screen line-edit capability • Flexible I/O structure allows for BASIC expansion with intelligent peripherals.

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25pf	9/pkg	390pf	7/pkg	.01mfd	9/pkg
27pf	9/pkg	470pf	7/pkg	.015mfd	8/pkg
47pf	8/pkg	560pf	7/pkg	.02mfd	8/pkg
68pf	8/pkg	680pf	7/pkg	.022mfd	8/pkg
100pf	8/pkg	.001mfd	9/pkg	.03mfd	8/pkg
150pf	8/pkg	.0015mfd	9/pkg	.039mfd	7/pkg
220pf	8/pkg	.0022mfd	9/pkg	.047mfd	7/pkg
270pf	7/pkg	.003mfd	9/pkg	.1mfd	6/pkg

PLESSEY POLYESTER MINI BOX

MF	V	$	MF	V	$	MF	V	$
001	1000	.14	.012	630	.14	.15	100	.20
.0012	1000	.14	.015	400	.15	.18	100	.21
.0015	1000	.14	.018	400	.15	.22	100	.23
.0018	1000	.14	.022	400	.15	.27	100	.26
.0022	1000	.14	.027	400	.15	.33	100	.30
.0027	1000	.14	.033	250	.15	.39	100	.33
.0033	1000	.14	.039	250	.15	.47	100	.36
.0039	630	.14	.047	250	.15	.56	100	.44
.0047	630	.14	.056	250	.15	.68	100	.47
.0056	630	.14	.068	250	.15	.82	100	.54
.0068	630	.14	.082	250	.17	1.0	100	.60
.0082	630	.14	.1	100	.17			
.01	630	.14	.12	100	.18			

MATSUO DIPPED TANTALUM

MF	V	$	MF	V	$	MF	V	$
.1	35	.33	2.2	20	.33	10.0	35	.90
.15	35	.33	2.2	35	.40	15.0	20	.45
.22	35	.33	3.3	35	.42	15.0	35	1.32
.33	35	.33	4.7	35	.45	22.0	16	.45
.47	35	.33	6.8	16	.40	33.0	20	1.32
.68	35	.33	6.8	35	.45	47.0	20	1.53
1.0	35	.33	10.0	16	.42	68.0	16	1.62
1.5	35	.40	10.0	25	.45			

1% MICA 500V

51 PF	.29	220 PF	.41	1500 PF	.60
62 PF	.29	240 PF	.46	2000 PF	.90
75 PF	.29	300 PF	.50	2200 PF	.94
82 PF	.29	390 PF	.50	4700 PF	1.80
100 PF	.30	470 PF	.50	5100 PF	1.80
120 PF	.32	620 PF	.52	10000 PF	3.60
150 PF	.35	820 PF	.53		
180 PF	.41	1000 PF	.60		

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LCD or LED KITS

BUILD A WORKING DPM IN 1/2 HOUR WITH THESE COMPLETE EVALUATION KITS

Test these new parts for yourself with Intersil's low cost prototyping kits, complete with A/D converter and LCD display (for the 7106) or LED display (for the 7107). Kits provide all materials, including PC board, for a functioning panel meter.

ICL7106EV (LCD) $29.95 **ICL7107 (LED) $24.95**

QUALITY PARTS

RESISTOR KITS 5% CARBON FILM RESISTORS

COMPLETE WITH STORAGE BIN

1/4 WATT KIT
42 Different Values
(68Ω to 4.7 MΩ)
20 Each Value

1/2 WATT KIT
42 Different Values
(68Ω to 4.7 MΩ)
20 Each Value

1/4W — $24.90 PER KIT
1/2W — $25.90 PER KIT

CARBON FILM RESISTORS (5%)

Only in Multiples of 100 pcs per value (ohms)

¼W . . . $1.69 per 100
½W . . . $1.79 per 100

10	100	1.0K	10K	100K	1.0M
11	110	1.1K	11K	110K	1.1M
12	120	1.2K	12K	120K	1.2M
13	130	1.3K	13K	130K	1.3M
15	150	1.5K	15K	150K	1.5M
16	160	1.6K	16K	160K	1.6M
18	180	1.8K	18K	180K	1.8M
20	200	2.0K	20K	200K	2.0M
22	220	2.2K	22K	220K	2.2M
24	240	2.4K	24K	240K	2.4M
27	270	2.7K	27K	270K	2.7M
30	300	3.0K	30K	300K	3.0M
33	330	3.3K	33K	330K	3.3M
36	360	3.6K	36K	360K	3.6M
39	390	3.9K	39K	390K	3.9M
43	430	4.3K	43K	430K	4.3M
47	470	4.7K	47K	470K	4.7M
51	510	5.1K	51K	510K	5.1M
56	560	5.6K	56K	560K	5.6M
62	620	6.2K	62K	620K	6.2M
68	680	6.8K	68K	680K	6.8M
75	750	7.5K	75K	750K	7.5M
82	820	8.2K	82K	820K	8.2M
91	910	9.1K	91K	910K	9.1M

SGS ATES — AUDIO POWER AMPLIFIER IC'S

TBA800	5 watt	$1.95
TBA810S	7 watt	2.10
TBA810AS	7 watt	2.10
TBA820	2 watt	1.35
TBA830S	4.2 watt	1.95
TCA940	10 watt	3.30
TDA2002	8 watt	4.20
TDA2010	12W Hi-Fi	5.25
TDA2020	20W Hi-Fi	6.00

MN6040 C-MOS PLL

MN6040 C-MOS PLL — a single-chip plase-locked loop intended for use as a frequency synthesizer in CB transceivers and other communications equipment.

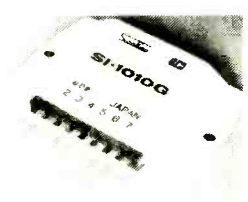
$7.90

TO 220 VOLTAGE REGULATOR FROM FAIRCHILD

7805C	5V	7815C	15V
7806C	6V	7818C	18V
7812C	12V	7824C	24V

2 for $1.20

Sanken HYBRID AUDIO POWER AMPLIFIERS



SOCKET FOR SANKEN AUDIO AMPLIFIERS

FOR 10 & 20 W. A-SI-8	$.95
FOR 30 & 50 W. A-SI-10	$.95

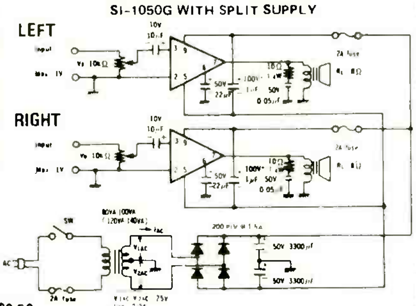
- Multi-purpose linear amplifiers for comercial and industrial applicacations.
- Less than 0.5% harmonic distortion at full power level.
- 1/2 dB response from 20 to 100,000 Hz.
- Single or split (dual) power supply.
- Rugged, compact and lightweight packages.
- Built-in current limiting for SI-1050G and efficient heat radiating construction.

SANKEN Series SI-1000G amplifiers are self-contained power hybrid amplifiers designed for Hi-Fi, stereo, musical instruments, public address systems and other audio applications. The amplifiers have quasi-complementary class B output. The circuit employs flip-chip transistors with high reliability and passivated chip power transistors with excellent secondary breakdown strength. Built-in current limiting is provided for SI-1050G and all devices can be operated from a single or split power supply.

SI-1010G (10W output) . . . $ 6.90
SI-1020G (20W output) . . . $13.95
SI-1030G (30W output) . . . $19.00
SI-1050G (50W output) . . . $27.80

TYPICAL CONNECTIONS

SI-1050G WITH SPLIT SUPPLY



Data Sheet with Application Notes — $0.50

DIP SOCKETS

LOW PROFILE SOLDER TIN

	1-24	25-49	50 UP
8 Pin	.16	.15	.14
14 Pin	.19	.18	.17
16 Pin	.21	.20	.19
40 Pin	.62	.61	.60

STANDARD SOLDER GOLD

8 Pin	.30	.27	.24
14 Pin	.35	.32	.29
16 Pin	.38	.35	.32
40 Pin	1.75	1.59	1.45

WIREWRAP GOLD (Level No. 3)

14 Pin	.39	.38	.37
16 Pin	.43	.42	.41

ANCRONA

Send Check or Money Order to: P.O. Box 2208P, Culver City, Calif. 90230. Calif. residents add 6% sales tax. Minimum Order $10.00. ADD $1.00 to cover postage and handling. Master Charge and Bankamericard welcomed (include your card number and exp. date).

TELEPHONE ORDERS: Call (213) 641-4064

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Tucson, AZ 85711
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OREGON ANCRONA
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Portland, OR 97220
(503) 254-5541

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Atlanta, GA 30305
(404) 261-7100

TEXAS ANCRONA
2649 Richmond
Houston, TX 77098
(713) 529-3489

BREAD BOARD JUMPER WIRE KIT

Each kit contains 350 wires cut to 14 different lengths from 0.1" to 5.0". Each wire is stripped and the leads are bent 90° for easy insertion. Wire length is classified by color coding. All wire is solid tinned 22 gauge with PVC insulation. The wires come packed in a convenient plastic box.

JK1 . . . .$10.00 / kit

SOCKET JUMPERS

Mates with two rows of .025" sq. or dia. posts on patterns of .100" centers and shielded receptacles. Probe access holes in back. Choice of 6" or 18" length.

Part No.	No. of Contacts	Length	Price
924003-18R	26	18"	$ 5.38 ea.
924003-06R	26	6"	4.78 ea.
924005-18R	40	18"	8.27 ea.
924005-06R	40	6"	7.33 ea.
924006-18R	50	18"	10.31 ea.
924006-06R	50	6"	9.15 ea.

JUMPER HEADERS

Solder to PC boards for instant plug-in access via socket-connector jumpers. .025" sq. posts. Choice of straight or right angle.

Part No.	No. of Posts	Angle	Price
923863-R	26	straight	$1.28 ea.
923873-R	26	right angle	1.52 ea.
923865-R	40	straight	1.94 ea.
923875-R	40	right angle	2.30 ea.
923866-R	50	straight	2.36 ea.
923876-R	50	right angle	2.82 ea.

INTRA-CONNECTOR

Provides both straight and right angle functions. Mates with standard .10" x .10" dual row connectors (i.e. 3m, Ainsley, etc.) Permits quick testing of inaccessible lines.

Part No.: 922576-26 **No. of contacts:** 26 **Price** $6.90 ea.

INTRA-SWITCH

Permits instant line-by-line switching for diagnostic or QA testing. Switches actuated with pencil or probe tip. Mates with standard .10" x .10" dual-row connectors. Low profile design. Switch buttons recessed to eliminate accidental switching.

Part No.: IS-26 **No. of contacts:** 26 **Price** $13.80 ea.

CRYSTALS

THESE FREQUENCIES ONLY

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

CONNECTORS

PRINTED CIRCUIT EDGE-CARD

156 Spacing-Tin-Double Read-Out

Bifurcated Contacts — Fits .054 to .070 P.C. Cards

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

25 PIN-D SUBMINATURE (RS232)

DB25P	PLUG	$3.25
DB25S	SOCKET	$4.95

205-CB HEAT SINKS 680-.75A

205-CB	Beryllium Copper w-black finish for TO-5	$ .25
291-.36H	Aluminum for TO-220 Transistors & Regulators	$ .25
680-.75A	Black Anodized Aluminum for TO-3	$1.60
Dude 4	Black Anodized Aluminum — predrilled mounting holes for TO-3 — 4¾ x 1¼ x 2"	$1.75

Etching Kits (cannot be shipped via air)

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

Plugboards

3662	6.5 X 4.5 X 1/16 Epoxy glass P Pattern 44 P.C. Tabs-spaced .156	$ 6.95 ea.
22/44	Mating connector for plugboard — 22 pin double readout	$ 2.95 ea.
8800V	Universal Microcomputer Processor plugboard — Epoxy Glass — complete with heatsink and mounting hardware 5.313 X 10 X 1/16 copper clad	$19.95 ea.

Vector

1/16 VECTOR BOARD

	0.1 Hole Spacing Part No.	P-Pattern L	P-Pattern W	Price 1-9	Price 10 up
PHENOLIC	64P44 062XXXP	4.50	6.50	1.72	1.54
	169P44 062XXXP	4.50	17.00	3.69	3.32
EPOXY	64P44 062WE	4.50	6.50	2.07	1.86
GLASS	84P44 062WE	4.50	8.50	2.56	2.31
	169P44 062WE	4.50	17.00	5.04	4.53
	169P84 062WE	8.50	17.00	9.23	8.26
EPOXY GLASS COPPER CLAD	169P44 062WEC1	4.50	17.00	6.80	6.12

63 KEY KEYBOARD $29.95

This keyboard features 63 unencoded SPST keys unattached to any kind of P.C.B. A very solid molded plastic 13" x 4" base suits most applications.

HD0165	Encoder Chip (encodes 16 Keys)	$7.95 ea.
AY-5-2376	Encoder Chip (encodes 88 Keys)	$14.95 ea.

MICROPROCESSOR COMPONENTS

8080A	CPU	$16.00	CDP1802	CPU	$19.95
8212	8 Bit Input/Output	4.95	MC6800	8 Bit MPU	24.95
8214	Priority Interrupt Control	15.95	MC6820	Periph. Interface Adapter	15.00
8216	Bi-Directional Bus Driver	6.95	MC6810AP1	128 x 8 Static RAM	6.00
8224	Clock Generator/Driver	9.95	MC6830L8	1024 x 8 Bit ROM	15.00
8228	System Controller Bus Driver	10.95	Z80	CPU	29.95

CPU'S

8080A	Super 8008	16.00
2650	8 BIT MPU	26.50
P8085	CPU	29.95

SR'S

2504	1024 Dynamic	$ 3.95
2518	Hex 32 BIT	7.00
2519	Hex 40 BIT	4.00
2522	Dual 132 Bit SSR	2.95
2524	512 Dynamic	1.95
2525	1024 Dynamic	3.00
2527	Dual 256 BIT	3.95
2529	Dual 512 BIT	4.00
2532	Quad 80 BIT	3.95
2533	1024 Static	5.95
3341	Fifo	6.95
74LS670	16 x 4 Reg	3.95

UART'S

AY-5-1013	30K Baud	$5.95

ROM'S

2513(2140)	Char. Gen.-upper case	$ 9.95
2513(3021)	Char. Gen.-lower case	9.95
2516	Char. Gen.	10.95
MM5230	2048 BIT (512 x 4 on 256 x 8)	1.95

RAM'S

1101	256 x 1	Static	$ 1.49
2101	256 x 4	Static	5.95
2102	1024 x 1	Static	1.75
2107 5280	4096 x 1	Dynamic	4.95
2111	256 x 4	Static	6.95
7489	16 x 4	Static	2.49
8101	256 x 4	Static	5.95
8111	256 x 4	Static	6.95
8599	16 x 4	Static	1.49
21L02/91L02	1024 x 1	Static	2.25
74200	256 x 1	Static	6.95
93421	256 x 1	Static	2.95
MMS262	2K x 1	Dynamic	2 for 1.00
UPD414(2104)	4K	Dynamic 16 Pin	5.95

PROMS

1702A	2048	Famos	$ 9.95
5203	2048	Famos	14.95
82S23	32 x 8	Open C	5.00
82S123	32 x 8	Trisate	5.00
74S287	1024	Static	7.95
3601	256 x 4	Fast	3.95
2708	8K	Eprom	19.95
2716	16K	Eprom	34.95
6301-1	1024	Tri State Bipolar	3.49
6330-1	256	Open Collector Bipolar	2.95

SPECIAL REQUESTED ITEMS

FCM3817	$5.00	11C90	19.95	7205	19.95	9368	3.95
AY-3-8500-1	8.95	4N33	3.95	ICM7045	24.95	LD110/111	25.00/set
AY-5-9100	17.50	8T20	7.50	ICM7207	7.50	95H90	11.95
AY-5-9200	14.95	8T97	2.00	ICM7208	22.00	MC3061P	3.50
AY-5-9500	4.95	HD0165	7.95	ICM7209	7.50	MC4016 (74416)	7.50
AY-5-2376	14.95	MCM6571	13.50	MK50240	17.50	MC1408L7	8.95
9374	1.95	MCM6574	13.50	DS0026CH	3.75	MC1408L8	9.95
82S115	25.00	MCM6575	13.50	TIL308	10.50		

CLOCK CHIPS

MM5309	$9.95
MM5311	4.95
MM5312	4.95
MM5314	4.95
MM5316	6.95
MM5318	9.95
MM5369	2.95
MM5841	9.95
CT7001	5.95

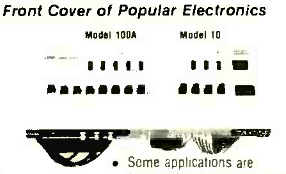
PARATRONICS

Featured on February's Front Cover of Popular Electronics

Logic Analyzer Kit Model 100A

$229.00/kit

Model 100A assembled $295.00



- Analyzes any type of digital system
- Checks data rates in excess of 8 million words per second
- Trouble shoot TTL, CMOS, DTL, RTL, Schottky and MOS families
- Displays 16 logic states up to 8 digits wide
- See ones and zeros displayed on your CRT, octal or hexadecimal format
- Tests circuits under actual operating conditions
- Easy to assemble — comes with step-by-step construction manual which includes 80 pages on logic analyzer operation.

(Model 100A Manual - $4.95)

- Some applications are
- — Troubleshooting microprocessor address, instruction, and data flow
- — Examine contents of ROMS
- — Tracing operation of control logic
- — Checking counter and shift register operation
- — Monitoring I/O sequences
- — Verifying proper system operations during testing

PARATRONICS TRIGGER EXPANDER - Model 10

Adds 16 additional bits. Provides digital delay and qualification of input clock and 24-bit trigger word. — Connects direct to Model 100A for integrated unit).

Model 10 Kit — $229.00
Model 10 Assembled — $295.00
Baseplate — $9.95
Model 10 Manual — $4.95

B&K PRECISION 3½-Digit Portable DMM

- Overload Protected
- .3" high LED Display
- Battery or AC operation
- Auto Zeroing
- 1mv, 1Va, 0.1 ohm resolution
- Overange reading
- 10 meg input impendence
- DC Accuracy 1% typical

Ranges: DC Voltage ±0-1000V
AC Voltage 0-1000V
Freq. Response 50-400 HZ
DC/AC Current 0-100mA
Resistance 0-10 meg ohm
Size 6.4" x 4.4" x 2"

Model 2800 $99.95

Comes with test leads, operating manual and spare fuse

Accessories:

AC Adapter BC-28	$9.00
Rechargeable Batteries BP-26	20.00
Carrying Case LC-28	7.50

CSC 100 MHz 8-Digit Counter

- 20 Hz-100 MHz Range
- .6" LED Display
- Crystal-controlled timebase
- Fully Automatic
- Portable — completely self-contained
- Size — 1.75" x 7.38" x 5.63"
- Four power souces, i.e. batteries, 110 or 220V with charger, 12V with auto lighter adapter and external 7.2-10V power supply

MAX-100 $134.95

ACCESSORIES FOR MAX 100:

Mobile Charger Eliminator use power from car battery — Model 100 — CLA $3.95

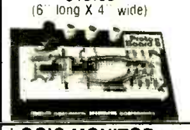
Charger/Eliminator use 110 V AC — Model 100 — CA1 $9.95

CONTINENTAL SPECIALTIES

PROTO BOARD 6

$15.95

(6" long X 4" wide)



Other CS Proto Boards

PB100 - 4.5" x 6"	$ 19.95
PB101 - 5.8" x 4.5"	29.95
PB102 - 7" x 4.5"	39.95
PB103 - 9" x 6"	59.95
PB104 - 9.5" x 8"	79.95
PB203 - 9.75 x 6½ x 2¾	80.00
PB203A - 9.75 x 6½ x 2¾ (includes power supply)	129.95

PROTO CLIPS

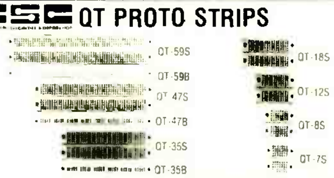
14 PIN	$4.50
16 PIN	4.75
24 PIN	8.50
40 PIN	13.75

DESIGN MATES

DM1 - Circuit Designer $69.95
DM2 - Function Generator $74.95
DM3 - RC Bridge $74.95

LOGIC MONITOR for DTL, HTL, TTL or CMOS Devices **$84.95**

CSC QT PROTO STRIPS



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

Experimentor 300	$ 9.95
Experimentor 600	$10.95

$5.00 Minimum Order — U.S. Funds Only
California Residents — Add 6% Sales Tax

Spec Sheets - 25¢ — Send 35¢ Stamp for 1978 Catalog
Dealer Information Available

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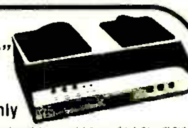
1978 CATALOG NOW AVAILABLE

1021-A HOWARD AVE., SAN CARLOS, CA. 94070
PHONE ORDERS WELCOME — (415) 592-8097
All Advertised Prices Good Thru January

The Incredible "Pennywhistle 103"



$129.95 Kit Only

The Pennywhistle 103 is capable of recording data to and from audio tape without critical speed requirements for the recorder and it is able to communicate directly with another modem and terminal for telephone "hamming" and communications for the deaf. In addition, it is free of critical adjustments and is built with non-precision, readily available parts.

Data Transmission Method	Frequency-Shift Keying, full-duplex (half-duplex selectable)
Maximum Data Rate	300 Baud.
Data Format	Asynchronous Serial (return to mark level required between each character)
Receive Channel Frequencies	2025 Hz for space, 2225 Hz for mark
Transmit Channel Frequencies	Switch selectable: Low (normal) = 1070 space, 1270 mark, High = 025 space, 2225 mark
Receive Sensitivity	-46 dbm accoustically coupled
Transmit Level	-15 dbm nominal. Adjustable from -6 dbm to -20 dbm
Receive Frequency Tolerance	Frequency reference automatically adjusts to allow for operation between 1800 Hz and 2400 Hz.
Digital Data Interface	EIA RS-232C or 20 mA current loop (receiver is optoisolated and non-polar)
Power Requirements	120 VAC, single phase, 10 Watts
Physical	All components mount on a single 5" by 9" printed circuit board. All components included

Requires a VOM, Audio Oscillator, Frequency Counter and/or Oscilloscope to align

ERC AM/FM 8-Track Stereo Receiver With BSR Changer

- PLL System
- BSR Record Changer
- Slide Controls
- Automatic AFC Control
- 4 Speaker Output
- Walnut finish vinyl covered wood veneer with smoke dust cover

Size: 20"W x 9⅜"H x 15¼"D

Model 8365 $149.95

DIGITAL STOPWATCH

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

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

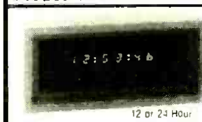
Stop Watch Chip Only (7205) $19.95

IMC 3½ DIGIT DPM KIT

- New Bipolar Unit
- Auto Zeroing
- .5" LED
- Auto Polarity
- Low Power
- Single IC Unit

Model KB500 DPM Kit	**$49.00**
Model 311D-5C-5V Power Kit	**$17.50**

JE700 CLOCK



12 or 24 Hour

115 VAC

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

KIT ONLY **$16.95**

HEXADECIMAL ENCODER 19-KEY PAD

- 1 - 0
- ABCDEF
- Shift Key
- 2 Optional Keys

$10.95 each

INSTRUMENT/CLOCK CASE

Injection molded unit. Complete with red bezel. 4½" x 4" x 1-9/16"

$3.95 ea.

JE803 PROBE

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

$9.95 Per Kit

printed circuit board

T²L 5V 1A Supply

This is a standard TTL power supply using the well known LM309K regulator IC to provide a solid 1 AMP of current at 5 volts. We try to make things easy for you by providing everything you need in one package, including the hardware, for only

$9.95 Per Kit

ELECTRONICS Market Place

CIRCLE NO. 24 ON FREE INFORMATION CARD

LOWEST PRICES ON PRIME TTL ICs

BASED ON OUR PLEDGE TO OFFER YOU THE LOWEST POSSIBLE PRICES ON PRIME TTL ICs, THIS MONTH WE HAVE REDUCED OUR ALREADY LOW PRICES. EVEN FURTHER, ON MANY ITEMS. HOWCOME? WE JUST NEGOTIATED A MULTI-MILLION UNIT CONTRACT FOR OUR INTERNATIONAL CUSTOMERS AND ARE HAPPY TO PASS ON THE SAVINGS TO YOU. AS ALWAYS, OF COURSE, WE GUARANTEE THAT EVERY IC PURCHASED FROM US TO BE OF PRIME QUALITY AND WITH ORIGINAL MANUFACTURER'S FULL MARKING AND BRAND SYMBOL. NO RETESTS, FUNCTIONAL ONLYS, OR FALLOUTS AT ICC. IN ADDITION, OUR VOLUME DISCOUNT SCHEDULE ALLOWS YOU TO MIX ALL YOUR REQUIREMENTS FOR EVEN GREATER SAVINGS.

7400 TTL

Part	Price
7400	$ .14
7401	.15
7402	.15
7403	.15
7404	.16
7405	.16
7406	.24
7407	.24
7408	.17
7409	.17
7410	.15
7411	.18
7412	.20
7413	.25
7414	.55
7416	.22
7417	.22
7420	.15
7421	.17
7423	.25
7425	.25
7426	.22
7427	.19
7430	.15
7432	.23
7437	.21
7438	.21
7439	.25
7440	.15
7441	.70
7442	.38
7443	.55
7444	.55
7445	.55
7446	.62
7447	.57
7448	.60
7450	.15
7451	.15
7453	.15
7454	.15
7459	.15
7460	.15
7470	.27
7472	.24
7473	.24
7474	.24
7475	.45
7476	.29
7480	.31
7482	.50
7483	.54
7485	.80
7486	.27
7489	1.75
7490	.40
7491	.51
7492	.40
7493	.40
7494	.60
7495	.60
7496	.60
7497	2.45
74107	.29
74109	.32
74121	.29
74122	.35
74123	.39
74125	.37
74126	.38
74132	.65
74141	.70
74145	.65
74147	1.50
74148	1.15
74150	.79
74151	.59
74152	.59
74153	.60
74154	.95
74155	.65
74156	.65
74157	.59
74160	.79
74161	.79
74162	.79
74163	.79
74164	.79
74165	.90
74166	.95
74167	3.20
74170	1.85
74173	1.10
74174	.85
74175	.75
74176	.69
74177	.70
74178	1.20
74179	1.20
74180	.65
74181	1.75
74182	.75
74184	1.75
74185	1.75
74188	2.80
74190	.95
74191	.95
74192	.80
74193	.80
74194	.80
74195	.49
74196	.73
74197	.73
74198	1.30
74199	1.30
74251	1.00
74279	.49
74283	1.00
74290	.59
74293	.57
74298	.92
74365	.62
74366	.62
74367	.62
74368	.62

74LS00 TTL

Part	Price
74LS00	$ .21
74LS01	.27
74LS02	.21
74LS03	.21
74LS04	.24
74LS05	.24
74LS08	.23
74LS09	.23
74LS10	.21
74LS11	.21
74LS12	.27
74LS13	.40
74LS14	.85
74LS15	.26
74LS20	.23
74LS21	.23
74LS22	.23
74LS26	.31
74LS27	.26
74LS30	.23
74LS32	.30
74LS37	.31
74LS38	.31
74LS40	.26
74LS42	.60
74LS47	.75
74LS48	.72
74LS51	.25
74LS54	.25
74LS55	.25
74LS73	.35
74LS74	.35
74LS76	.37
74LS78	.36
74LS83	.75
74LS85	1.30
74LS86	.36
74LS90	.50
74LS92	.50
74LS93	.50
74LS95	.85
74LS107	.35
74LS109	.35
74LS112	.35
74LS113	.35
74LS114	.35
74LS123	.90
74LS125	.46
74LS126	.46
74LS132	.72
74LS133	.34
74LS136	.35
74LS138	.70
74LS139	.70
74LS151	.65
74LS152	.65
74LS153	.66
74LS154	1.00
74LS155	.62
74LS156	.62
74LS157	.62
74LS158	.70
74LS160	.82
74LS161	.82
74LS162	.82
74LS163	.82
74LS164	.98
74LS168	.83
74LS169	.83
74LS170	1.60
74LS173	1.00
74LS174	.75
74LS175	.79
74LS181	2.50
74LS190	.90
74LS191	.90
74LS192	.90
74LS193	.90
74LS194	.85
74LS195	.50
74LS196	.80
74LS197	.80
74LS221	1.05
74LS251	.80
74LS253	.80
74LS257	.70
74LS258	.70
74LS259	1.60
74LS260	.34
74LS266	.26
74LS279	.52
74LS283	.72
74LS290	.60
74LS295	.90
74LS298	.90
74LS365	.52
74LS366	.52
74LS367	.52
74LS368	.52
74LS386	.36
74LS390	1.65
74LS393	1.35
74LS490	1.10
74LS670	2.29

74S00 TTL

Part	Price
74S00	$ .35
74S02	.35
74S03	.35
74S04	.36
74S05	.36
74S10	.35
74S11	.38
74S15	.38
74S20	.35
74S22	.36
74S30	.27
74S32	.50
74S40	.35
74S51	.17
74S64	.38
74S65	.38
74S74	.58
74S112	.58
74S113	.58
74S114	.58
74S132	.75
74S133	.38
74S134	.38
74S135	.49
74S138	.77
74S139	1.50
74S140	.47
74S151	1.25
74S153	2.10
74S157	.75
74S158	1.25
74S174	1.50
74S175	1.45
74S189	2.75
74S194	1.75
74S200	3.25
74S206	3.75
74S253	.95
74S257	1.15
74S258	1.15
74S280	2.25
74S287	3.20
74S289	3.55
74S300	1.60
74S305	1.90
74S310	2.85
74S312	1.05
74S313	1.55
74S316	2.80
74S341	4.10
74S342	1.20
74S343	4.95
74S346	1.25
74S362	2.15
74S387	4.70

74C00 TTL

Part	Price
74C00	$ .27
74C02	.27
74C04	.29
74C08	.29
74C10	.27
74C14	1.50
74C20	.27
74C30	.27
74C32	.35
74C42	1.50
74C48	1.95
74C73	.75
74C74	.65
74C76	.95
74C83	1.50
74C85	1.20
74C86	1.45
74C89	3.95
74C90	1.10
74C93	1.10
74C95	1.30
74C107	.80
74C151	2.75
74C154	2.70
74C157	2.00
74C160	1.30
74C161	1.90
74C162	1.90
74C163	1.90
74C164	2.95
74C165	2.95
74C173	1.60
74C174	1.95
74C175	1.95
74C192	2.00
74C193	2.25
74C195	2.25
74C200	8.25
74C221	2.00
74C901	.96
74C902	.96
74C903	.96
74C904	.96
74C905	6.60
74C906	.96
74C907	.96
74C908	2.10
74C909	3.95
74C910	6.60
74C914	1.90
74C918	2.20
74C925	9.25
74C926	9.25
74C927	9.25
74C928	9.25

VOLUME DISCOUNT SCHEDULE

Merchandise Total	Discount
$ 0.00-$ 9.99	NET
$ 10.00-$ 24.99	LESS 5%
$ 25.00-$ 99.99	LESS 10%
$ 100.00-$499.99	LESS 15%
$ 500.00-$999.99	LESS 20%
$1000.00 and Up	LESS 25%

STANDARD SHIPPING CHARGES

If your merchandise total is between:

$ 0.00-$ 4.99	add $2.00
$ 5.00-$24.99	add $1.00
$ 25.00-$49.99	add $0.75
$ 50.00-$99.99	add $0.50
$100.00 and Up	NO CHARGE

The above charges include shipping via First Class Mail or UPS (your choice), and insurance on all domestic shipments.

SPECIAL SHIPPING CHARGES

COD	$1.00–additional
Air Mail	$1.00–additional
Postal Insurance	$1.00–additional
Special Delivery	$1.25–additional

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master charge

VISA

CIRCLE NO. 20 ON FREE INFORMATION CARD

UNIVERSAL 4Kx8 MEMORY BOARD KIT
$69.95

32-2102-1 fully buffered, 16 address lines, on board decoding for any 4 of 64 pages, standard 44 pin buss

EXPANDABLE F8 CPU BOARD KIT
$99.00

featuring Fairbug PSU 1K of static ram, RS 232 interface, documentation, 64 BYTE register

4K BASIC FOR FAIRBUG F8
on paper tape $25.00

C/MOS (DIODE CLAMPED)

74C10	.22	4012	.22	4023	.22	4046	2.25
74C193	1.50	4013	.40	4024	.75	4049	.40
4001	.22	4015	.95	4025	.22	4050	.40
4002	.22	4016	.40	4027	.40	4055	1.50
4006	1.20	4017	1.05	4028	.88	4066	.80
4007	.22	4018	1.00	4029	1.10	4071	.27
4009	.42	4019	.25	4030	.22	4076	1.05
4010	.42	4020	1.05	4035	1.10		
4011	.22	4022	.95	4042	.78		

WSU-30 Hand wire wrap tool used to wrap, unwrap & strip # 30 wire $5.30

#24, EIGHT CONDUCTOR SPECTRA FLAT CABLE 10'/$1.50 100'/$13.50

DIP SOCKETS

8 PIN	.22	24 PIN	.40
14 PIN	.25	28 PIN	.50
16 PIN	.28	40 PIN	.60
18 PIN	.30		

#30 WIRE WRAP WIRE SINGLE STRAND 100'/$1.40

2708 8K EPROM (450 ns)	$15.75
2512 STATIC SHIFT REG	$ 1.95
2513 CHARACTER GEN	$ 6.75
2518 HEX 32 BIT SR	$ 2.50
TMS4050NL-4K dyn RAM	$ 4.95
5203 2K EPROM	$ 4.50
2102-1 1024 BIT RAM (450 ns)	$ 1.19
21078	$ 3.50
MK4008P	$ 1.95
5280 4K DYNAMIC RAM	$ 4.75
1101A 256 BIT RAM	$ .75
MM5203 UV PROM	$ 6.95
1702A UV PROM	$ 4.95
5204 4K PROM	$10.95
82S23	$ 1.95
AY 5 1013 UART	$ 6.95

LIGHT ACTIVATED SCR's TO 18 200V 1A $ 1.10

SILICON SOLAR CELLS
2¼" diameter .4V at 500 ma $4.00

LED READOUTS

FND 359 C.C.	.4"	$ .50	DL 704 .3" C.C.		$ .95
FND 70 C.C.	.4"	$ .55	MAN-7 .3" C.A.		$ .95
FND 503 C.C.	.5"	$ .85	NS 33-3 dig. array		$ .75
FND 510 C.A.	.5"	$ .85	DL 747 C.A.	.6"	$1.95

PRINTED CIRCUIT BOARD

4-1/2"x6-1/2" SINGLE SIDED EPOXY BOARD 1/16" thick, unetched $ .60 ea. 5/$2.60

7 WATT LD-65 LASER DIODE IR $8.95

2N 3820 P FET	$ .45
2N 5457 N FET	$ .45
2N2646	$ .45
ER 900 TRIGGER DIODE	4/$1.00
2N 6028 PROG. UJT	$ .65

MINIATURE MULTI-TURN TRIM POTS 100, 500, 1K, 2K, 5K, 10K, 25K, 50K, 100K, 200K, 500K, 1 Meg $.75 each 3/$2.00

CCD202 100 x 100 charge coupled device image sensor $145.00

VERIPAX PC BOARD
This board is a 1/16" single sided paper epoxy board 4½"x6½" DRILLED and ETCHED which will hold up to 21 single 14 pin IC's or 8, 16 or LSI DIP IC's with busses for power supply connector $4.00

MV 5691 YELLOW GREEN BIPOLAR LED	$ .90
FE 5001 PHOTO TRANS	$ .50
RED, YELLOW, GREEN or AMBER LARGE LED's	6/$1.00
IL-5 (MCT-2)	$ .75
MOLEX PINS	100/$1.00
	1000/$8.00
10 WATT ZENERS 3.9, 4.7, 5.6, 8.2, 12, 18, 22, 100, 150 or 200V	ea. $ .60
1 WATT ZENERS 4.7, 5.6, 10, 12, 15, 18 or 22V	ea. $ .25
MC6860 MODEM CHIP	$9.95

Silicon Power Rectifiers

PRV	1A	3A	12A	50A	125A
100	.06	.14	.30	.80	3.70
200	.07	.20	.35	1.15	4.25
400	.09	.25	.50	1.40	6.50
600	.11	.30	.70	1.80	8.50
800	.15	.35	.90	2.30	10.50
1000	.20	.45	1.10	2.75	12.50

SAD 1024 a REDICON 1024 stage analog "Bucket Brigade" shift register. $18.95

1N 4148 (1N914) 15/$1.00

MCA 81 OPTICAL LIMIT SWITCH $1.50

REGULATORS

309K	$ .95	340K-5, 12, 15 or 24V	$ .85
723	$ .50	340T 5, 6, 8, 12, 15, 18 or 24V	$1.10
LM 376	$ .60	78 MG	$1.35
320K-5 or 15V	$1.40	79 MG	$1.35
320T-5, 15 or 24V	$1.15		

RS232 CONNECTORS DB 25P male $2.95 DB 25S female $3.50

TRANSISTOR SPECIALS

MRF 8004 a CB RF Transistor	$ 1.50
2N3772 NPN Si TO 3	$ 1.00
2N1546 PNP GE TO-3	$ .75
2N4908 PNP Si TO 3	$ 1.00
2N6056 NPN Si TO 3 Darlington	$ 1.70
2N5086 PNP Si TO-92	4/$ 1.00
2N4898 PNP TO 66	$ .60
2N404 PNP GE TO 5	5/$ 1.00
2N3919 NPN Si TO 3 RF	$ 1.50
MPSA 13 NPN Si TO 92	3/$ 1.00
2N3762 NPN Si TO 66	$ .70
2N2222 NPN Si TO 18	5/$ 1.00
2N3055 NPN Si TO 3	$ .60
2N3904 NPN Si TO 92	5/$ 1.00
2N3906 PNP Si TO 92	5/$ 1.00
2N5296 NPN Si TO 220	$ .50
2N6109 PNP Si TO 220	$ .55
2N3638 PNP Si TO 5	5/$ 1.00

TTL IC SERIES

7400	.16	7445	.65	74151	.65
7401	.16	7446	.70	74153	.65
7402	.16	7447	.65	74154	1.00
7403	.16	7448	.70	74155	.70
7404	.20	7450	.15	74157	.65
7405	.20	7472	.32	74161	.85
7406	.25	7473	.32	74163	.80
7407	.25	7474	.32	74164	.95
7408	.20	7475	.45	74165	1.05
7409	.20	7476	.30	74170	2.25
7410	.16	7480	.45	74173	1.35
7411	.20	7483	.70	74174	.95
7412	.20	7485	.87	74175	.90
7413	.39	7486	.30	74176	.75
7414	.85	7490	.45	74177	.75
7416	.25	7491	.65	74180	.65
7417	.25	7492	.43	74181	2.00
7420	.16	7493	.45	74190	1.20
7425	.25	7494	.70	74191	1.20
7426	.25	7495	.65	74192	.83
7427	.25	7496	.65	74193	.83
7430	.16	74107	.28	74194	.85
7432	.25	74121	.33	74195	.85
7437	.24	74122	.38	74196	.86
7438	.24	74123	.40	74279	.87
7440	.16	74125	.40	75491	.50
7441	.70	74126	.40		
7442	.52	74150	1.10		

DIGITAL CASSETTES 1/2 hr. TAPE AND ERASABLE $1.25

MM5387AA with FCS8024 readouts. This new National clock chip will directly drive LED displays. Four .8" high readouts supplied $10.95

MCM 6571A 7 x 9 upper & lower case character gen. $10.75

CTS 206-8 eight position dip switch	$2.20
CTS-206-4 four position dip switch	$1.75

ALCO MINIATURE TOGGLE SWITCHES

MTA 106 SPDT	$1.20
MTA 206 DPDT	$1.70

Full Wave Bridges

PRV	2A	6A	25A
100			1.30
200	.75	1.25	2.00
400	.95	1.50	3.00
600	1.20	1.75	4.00

SANKEN AUDIO POWER AMPS

Si 1010 G 10 WATTS	$ 7.95
Si 1020 G 20 WATTS	$15.95
Si 1050 G 50 WATTS	$27.95

TANTULUM CAPACITORS

22UF 35V	5/$1.00	6.8UF 35V	4/$1.00
47UF 35V	5/$1.00	10UF 10V	$ .25
68UF 35V	5/$1.00	22UF 25V	$ .40
1UF 35V	5/$1.00	15UF 35V	3/$1.00
2.2UF 20V	5/$1.00	30UF 6V	5/$1.00
3.3UF 35V	4/$1.00	47UF 20V	$ .35
4.7UF 15V	5/$1.00	68 UF 15V	$ .50

74LS SERIES				LINEAR CIRCUITS	
		74LS125	.65		
74LS00	.26	74LS126	.65	LM 101	.75
74LS02	.26	74LS132	.80	LM 301/748	.29
74LS03	.26	74LS136	.39	LM307	.30
74LS04	.28	74LS138	.72	LM 308	.75
74LS05	.28	74LS139	.72	LM 311	.75
74LS08	.28	74LS151	.98	LM 318	1.20
74LS09	.28	74LS153	.93	LM 319	.95
74LS10	.26	74LS155	2.00	LM 324	1.05
74LS11	.26	74LS156	.95	LM 339	1.10
74LS13	.50	74LS157	.98	LM 358	1.40
74LS15	.28	74LS160	1.02	LM 370	1.15
74LS20	.26	74LS161	1.02	LM 377	2.50
74LS21	.26	74LS162	1.02	LM 380	.95
74LS22	.26	74LS163	1.02	LM 381	1.25
74LS26	.33	74LS168	1.10	LM 382	1.25
74LS27	.33	74LS169	1.10	LM 537	2.50
74LS30	.26	74LS170	1.72	LM 553	2.50
74LS32	.33	74LS173	1.39	LM 555	.39
74LS37	.37	74LS174	1.05	LM556	.85
74LS38	.37	74LS175	1.22	NE540L	2.75
74LS40	.27	74LS190	1.50	560	2.00
74LS42	.88	74LS191	1.50	565	.95
74LS47	.79	74LS192	1.75	566	1.25
74LS51	.26	74LS193	1.75	567	1.30
74LS54	.26	74LS195	1.25	703	.90
74LS90	.95	74LS196	.99	709	.25
74LS73	.40	74LS197	.99	710	.35
74LS74	.40	74LS221	1.25	741C or V	.31
74LS76	.40	74LS257	1.35	747	.65
74LS90	.89	74LS258	1.38	LM 1310	2.50
74LS92	.85	74LS279	.75	1456	.95
74LS93	.85	74LS365	.66	1458	.50
74LS109	.43	74LS366	.66	CA3046	.75
74LS112	.43	74LS368	.66	3900	.49
74LS113	.43	74LS390	1.95	8038CC	3.90
74LS114	.43			UA791P5	1.95

	TRIACS			SCR'S		
PRV	1A	10A	25A	1.5A	6A	35A
100	.40	.70	1.30	.40	.50	1.20
200	.70	1.10	1.75	.60	.70	1.60
400	1.10	1.60	2.60	1.00	1.20	2.20
600	1.70	2.30	3.60		1.50	3.00

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CIRCLE NO. 45 ON FREE INFORMATION CARD

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MICROPROCESSOR's

F-8	19.95
Z-80	25.00
Z-80A	35.00
CDP1802CD	24.95
AM2901	22.95
6502	12.95
6800	19.95
8008-1	8.75
8080A	15.95
TMS-9900TL	89.95

6800 SUPPORT

6810P	4.95
6820P	8.00
6828P	11.25
6834P	16.95
6850P	9.95
6852P	11.95
6860P	14.95
6862P	17.95
6880P	2.70

Z80 SUPPORT DEVICES

3881	12.95
3882	12.95

F-8 SUPPORT DEVICES

3851	14.95
3853	14.95

DYNAMIC RAMS

1103	1.50
2104	4.50
2107A	3.75
2107B	4.50
2107B-4	4.00
TMS4050	4.50
TMS4060	4.50
4096	4.50
4116	42.00
MM5270	5.00
MM5280	6.00
MCM6605	6.00

CHARACTER GENERATORS

2513 UP	6.75
2513 DOWN	6.75
2513 UP (5v)	9.95
2513 DOWN(5v)	10.95
MCM6571	10.80
MCM6571A	10.80
MCM6572	10.80
MCM6574	14.75
MCM6575	14.75

PROM'S

1702A	5.00
2704	15.00
2708	20.00
2716	38.00
3601	4.50
5203AQ	4.00
5204AQ	6.00
6834	16.95
6834-1	14.95
82S23B	4.00
82S129B	4.25
8223B	2.70

8080A SUPPORT DEVICES

8212	3.95
8214	9.95
8216	4.50
8224	4.95
8228	8.75
8238	8.00
8251	12.00
8253	28.00
8255	12.00
8257	25.00
8259	25.00

STATIC RAMS	1-24	25-99	100
21L02 (450)	1.50	1.40	1.25
21L02 (250)	1.95	1.80	1.50
21L11	4.25	4.10	3.95
1101A	1.49	1.29	1.10
2101-1	2.95	2.75	2.60
2102	1.25	1.15	1.00
2102-1	1.50	1.30	1.15
2111-1	4.00	3.50	3.25
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2114	17.95	16.95	16.50
31L01	2.50	2.35	2.00
3107	3.95	3.70	3.25
4200A	12.95	12.50	11.95
4804/2114	17.95	16.95	16.50
5101C-E	11.95	11.25	10.25
74C89	3.25	3.05	2.85
74S201	4.50	4.30	4.25
7489	2.25	2.10	1.90
8599	1.88	1.75	1.60
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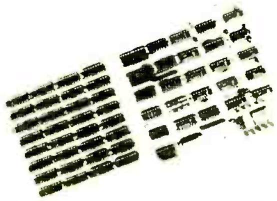

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on board regulation is provided. On board (invisible) refresh is provided with no wait states or cycle stealing required.

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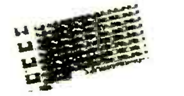
Fully assembled and tested. Not a kit. Imsai — Altair — S-100 Buss compatible, uses low power static 21L02-500ns fully buffered on board regulated, quality plated through PC board, including solder mask. 8 pos. dip switches for address select.



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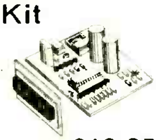

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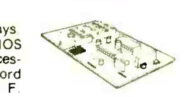

6 DIGIT ALARM CLOCK KIT

Features: Litronix dual 1/2" displays, Mostek 50250 super clock chip, single I.C. segment driver, SCR digit drivers. Kit includes all necessary parts (except case). Xfmr optional. Eliminate the hassle.

AC XFMR — **$1.50 Case $3.50**

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Features: Large LED 1/2" displays oper. from 0.1 sec. to 59 min. 59.99 sec. 5A-115V. Relay included to control appliances. Operates on 115V AC. Displays can be turned off for total darkness while counting. All necessary parts included.

Special design case $3.75.

$44.95

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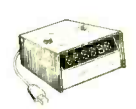

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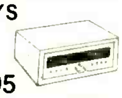

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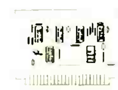

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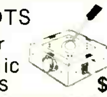

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7416	.43	7482	1.75	74154	1.54
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4016AE	.65	4040AE	2.40
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1N60	.25	2N1544	.80	2N2894	.40	2N3414	.17	2N3866	1.25	2N4403	20
1N270	25	2N1554	1.25	2N2903	3.30	2N3415	.18	2N3903	.16	2N4409	.20
1N914	.10	2N1560	2.80	2N2904	.25	2N3416	.19	2N3904	.16	2N4410	.16
1N4148	.25	2N1605	1.75	2N2904A	.30	2N3417	.20	2N3905	.16	2N4416	75
1S1555	.35	2N1613	.50	2N2905	.25	2N3442	1.85	2N3906	.16	2N4441	1.00
		2N1711	.50	2N2905A	.30	2N3553	1.50	2N3954A	3.75	2N4442	1 15
2N173	1.75	2N1907	4.10	2N2906	.25	2N3563	.20	2N3955	2.45	2N4443	1 35
2N338A	1.05	2N2102	.70	2N2906A	30	2N3565	.20	2N3957	1.25	2N4852	.55
2N404	.75	2N2160	.70	2N2907	.25	2N3638	.20	2N3958	1.20	2N5061	.30
2N443	2.50	2N2218	.25	2N2907A	.30	2N3642	.20	2N4037	.60	2N5064	.50
2N508A	.45	2N2218A	.30	2N2913	.75	2N3643	.20	2N4093	.85	2N5130	.20
2N706	.25	2N2219	.25	2N2914	1.20	2N3645	.20	2N4124	.16	2N5133	.15
2N718	.25	2N2219A	.30	2N3019	1.00	2N3646	.14	2N4126	16	2N5138	.15
2N718A	.30	2N2221	.25	2N3053	.30	2N3731	3.75	2N4141	20	2N5294	.50
2N918	.60	2N2221A	.30	2N3054	.70	2N3740	1.00	2N4142	.20	2N5296	.50
2N930	.25	2N2222	.25	2N3055	.75	2N3771	1.75	2N4143	.20	2N5306	.20
2N956	.30	2N2222A	.30	2N3227	1.00	2N3772	1.90	2N4220A	.45	2N5400	.40
2N1302	1.25	2N2270	.40	2N3247	3.40	2N3773	3.00	2N4234	.95	2N5401	.50
2N1305	.75	2N2369	.25	2N3250	.50	2N3819	.40	2N4400	.16	2N5457	.35
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Aluminum Knob - Solid machined aluminum knob with fluted sides made for Bose. Black front-face insert, black pointer line. Fits flat ¼" shaft, does not require set screws. .8 high, .7 diam. Easily worth $1.50 **NT540 $.82 2 for $1.50**

BOSE SPEAKERS

Bose has discontinued their original 301 System. New-Tone purchased the speakers remaining in inventory when the 301 was discontinued, and is offering them at prices that seem impossible. The speakers have been tested with the Bose "Tone Standard" as a reference and have been subjected to the Bose power-handling test which includes both fixed and sweep-frequency testing. **8-Inch Woofer** (Bose Part No. 102606) has a free-air resonant frequency of 25-35 Hz., and has a 1.5", 8.5-ounce magnet. The upper tested-frequency is 4000 Hz. **3-Inch Tweeter** (Bose Part No. 107376) has a free-air resonant frequency of 1200-1500 Hz., and has an upper tested-frequency of 16.5 kHz. **Supplies are limited.** We urge you to take advantage of these prices and stock up for your future needs.
Sorry, we have no information about the Bose enclosures or the crossover networks, nor do we have more specs. Bose says these data are proprietary information.

8" Woofer NT541 $10.95
3" Tweeter NT542 $ 3.95

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SPECIFICATIONS

Sensitivity: less than 25MV
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Accuracy: 10 ppm, .001 ppm with TV time base!
Input: BNC, 1 meg ohm direct, 50 ohm with prescale option
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TH3216 Kit $149.95
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741 MINI DIP, house marked .... 10/$2.00

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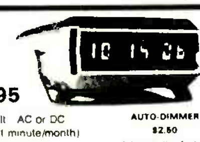

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SN7443N	.68	SN74116N	1.50	SN74177N	.76	SN74366N	.65
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SN7445N	.65	SN74121N	.34	SN74179N	1.49	SN74368N	.65
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CD4026BE	1.39	CD4514BE	2.50		
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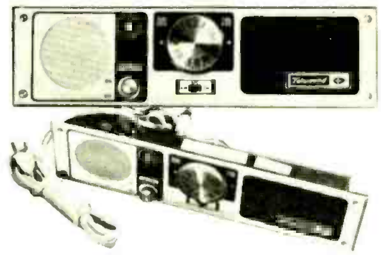

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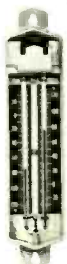

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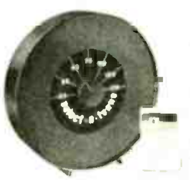

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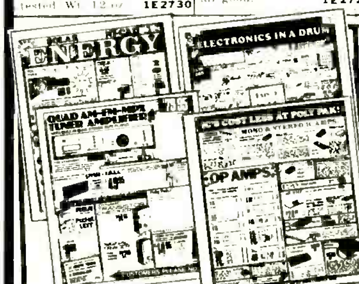

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B&K TV Analyst Model 1075. Manual and/or schematic. Harry Matosian, 14035 Hartsook St., Sherman Oaks, CA 91423.

Hallicrafter S-38C shortwave receiver. Schematic or any available information. Mark Stefanik, 20 Old Farm Rd., Cedar Knolls, NJ 07927.

REK-o-KUT Model R-34 manual turntable. Need drive belt. Arthur C. McReynolds, 1841 Isabella Ave., Monterey Park, CA 91754.

Novus Scientist PR calculator. Need Programs. E.C. Fante, 3085 Adams Way, Santa Clara, CA 95051.

Jefferson-Travis Radio Model 350-A-1. Schematics and any other information. Richard Harris, Box 518, Chase City, VA 23924.

Philco Standard shortwave radio Model 19A, Code 121. Schematic. R. Mills, 46 Harts Lane, Guelph, Ontario, CAN.

Sherwood SA-5200 tube-type stereo amplifier. Schematic. Fred Avery, Box 5883, Raleigh, NC 27607.

Pioneer Model SX-82 stereo receiver. Schematic and service manual. Eric Archer, 3402 Community Ave., Glendale, CA 91214.

Masco Commercial PA amplifier Model MA60. Operator's manual and schematic. Van Lynn Floyd, R.R. #1, Box 94, Johnson, KS 67855.

Hallicrafter Model S40A. Prints and documentation. Richard Furnari, 33 Highland Ave., Yonkers, NY 10705.

International 100D Executive CB transceiver and external speakers meter. Schematics and service manual. Larry R. Jewell, 223 Cedar Springs Rd., Spartanburg, SC 29302.

Hammarlund Super-Pro Model ASP 779 shortwave receiver. Schematic, parts list, service and operator's manual. Nelson Allan, Box 164, New Hartford, NY 13413.

Friden (Singer) Model EC1114, 14 digit desk calculator. Schematic or service manual. Robert Miller, Rt. 1, Anadarke, OK 73005.

Dumont Model 208 oscilloscope. Schematic and service manual. Alex P. Cameron, Rt. 3 Box 93, Samson, AL 36477.

Tektonix, Inc. Model S-32 Serviscope oscilloscope. Otto R. Jans, 400 Grove St., Ridgewood, NJ 07450.

Heathkit Oscilloscope IO-21. Schematic. R.L. Conhaim, 1329 Stanley Ave., Dayton, OH 45404.

Feranti 3 Band, 220-V ac-dc, 6-tube receiver. Model # unknown. Schematic, company address. Stephen Ostrom, 2167 Beaumont Rd., Ottowa, Ontario, CAN KIH 5V2.

Seeburg Select-o-matic 100 Model M 100-B, Ser. 5830. **Seeburg** Wall-o-matic 100 Model 3W-1, Ser. 10203. Service manuals and sources. Rod Stebelton, 6155 Coonpath Rd, Carroll, OH 43122.

Harvey Wells Model TBS-50 Amateur Transmitter. Owner's manual and schematic. Patrick W. Keogh, 1404 So. 87th St., West Allis, WI 53214.

Grand 5-Brand Radio, Model FP-1211-G. Dial string instruction and diagram. Bernard Grupe, 3012 Highland Dr., Gary, IL 60013.

Gonset Communicator 2, 2-meter VFO, VHF Amp Model 3063. Manuals. Richard Dawson, 1308 F. St., The Dalles, OR 97058.

Vernon 47/26 Tape Recorder. Schematic. James L. Negron, Box 162, Sandy Spring, MD 20860.

General Electric sweep generator Model ST-4A, **General Electric** marker generator St-5A. Schematic, operating

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manuals. Richard Roggeveen, 5569 Dunsburry Ct., San Jose, CA 95123.

Knight Model 150 transmitter and R-99 receiver. Operating manual and schematic. Mike Libonati, 100 Sullivan St., New York, NY 10012.

Heathkit Model W-2 power amplifier. Need output transformer. John Million, 1115 Barkley Rd., Charlotte, NC 28109.

Paco Model S-55 oscilloscope. Schematic and operating manual. Ed Palmer, #26–67 Angus Rd., Regina, Sask, CAN S4R 3L1.

Military oscilloscope Model OS-4B/AP, # N383-46496A. Schematic and instruction manual. Carl G. Kramer, 2525 Midpine Dr., York, PA 17404.

Schuttig & Co. Diversity Receiving TTY converter serial #61 made for U.S. Army Signal Corps. Information and schematics. Richard Dawson, 1308 F. St., The Dalles, OR 97058.

Philco Model 40–95 Code 122 console battery radio. Schematic, parts list, and source. Robert Michael, R.D. 3442, Fleetwood, PA 19522. ◇

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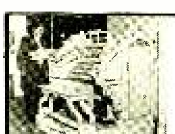

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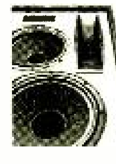

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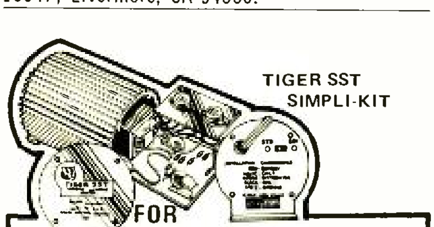

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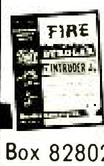

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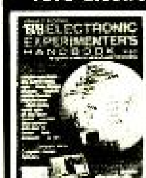

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