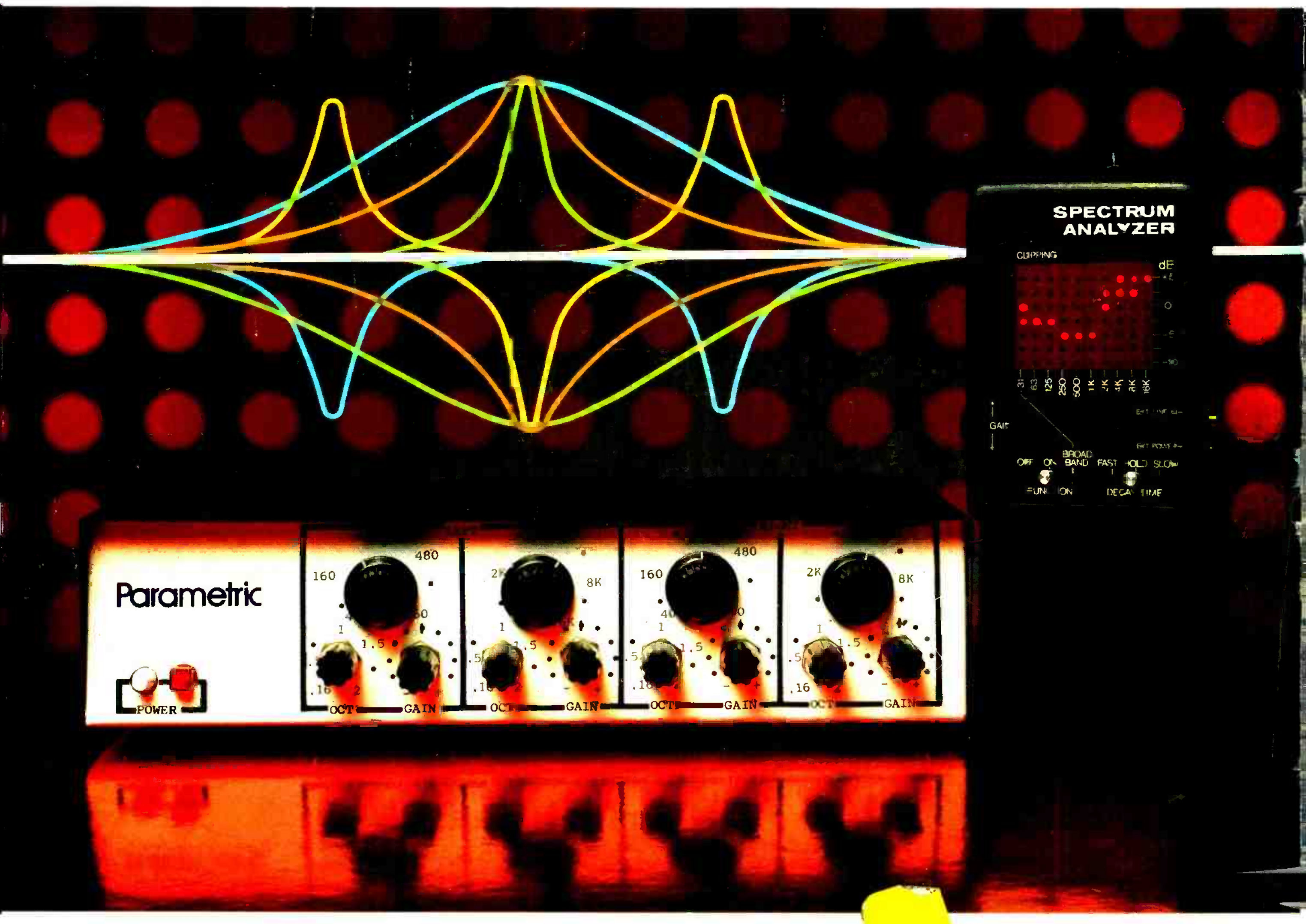
Popular Electronics®

WORLD'S LARGEST-SELLING ELECTRONICS MAGAZINE SEPTEMBER 1979/$1.25

A Monostable Catalog for Experimenters
Simple Computer Control Interfaces

Audio Focus:

- Digital Audio
- Parametric Equalizer & LED Spectrum Analyzer Construction Plans



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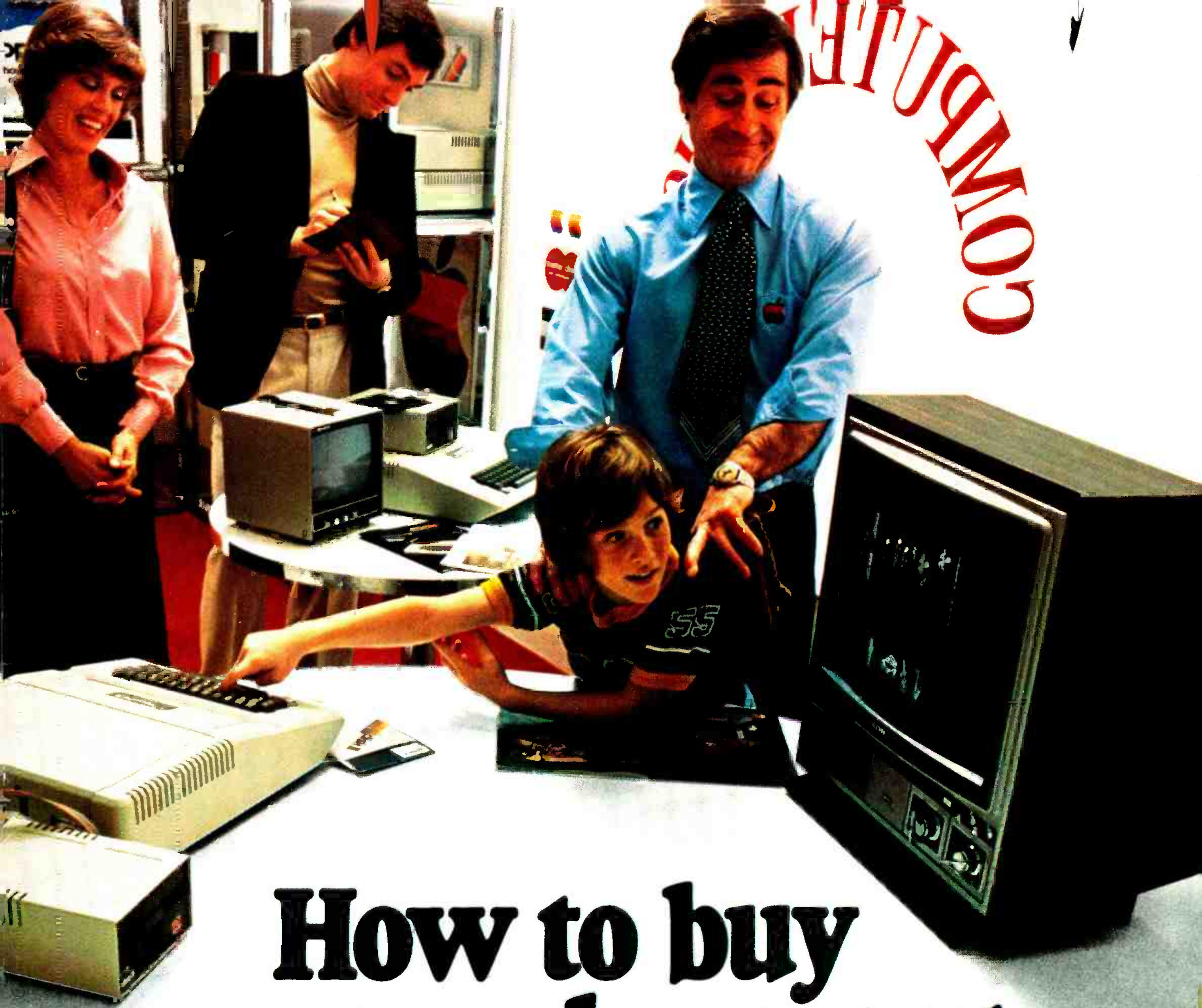
Optonica SA-5901 AM/ ereo Receiver
Aiwa AD-6900 Cassette Deck
Ohm I Speaker System



How to buy a personal computer.

In California, a store owner charts sales on his Apple Computer. On weekends though, he totes Apple home to help plan family finances with his wife. And for the kids to explore the new world of personal computers.

A hobbyist in Michigan starts a local Apple Computer Club, to challenge other members to computer games of skill and to trade programs.

Innovative folks everywhere have discovered that the era of the personal computer has already begun—with Apple.

Educators and students use Apple in the classroom. Businessmen trust Apple with the books. Parents are making Apple the newest family pastime. And kids of all ages are learning how much fun computers can be.

Visit your local computer store

The excitement starts in your local computer store. It's a friendly place, owned by one of your neighbors. He'll show you exactly what you can use a personal computer for.

What to look for

Your neighborhood computer store has several different brands to show you. Chances are the salesman will recommend an Apple Computer. Apple's the one you can program yourself. So there's no limit to the things you can do. The more you use your Apple the more uses you'll discover. So it's important that Apple is the computer with more expansion capability. You can't outgrow Apple.

It's your move

Grab a piece of the future for yourself—we'll give you the address of the Apple dealer nearest you when you call our toll-free number. Then drop by and sink your teeth into an Apple.
(800) 538-9696.
In California,
(800) 662-9238.

apple computer

CIRCLE NO. 8 ON FREE INFORMATION CARD

JS&A's new program will save consumers millions.

Micro TV Breakthrough

Remember the $400 Sinclair Micro TV? Here's the story on the greatest TV value ever.

That Sinclair TV shown above is small – the smallest TV in the world.

And when it was first introduced last year, it made history. So did its high price – $395.

Our company never sold the unit for two reasons: 1) It was being promoted as a pocket TV and we felt it would not fit in most pockets and 2) We felt $395 was too high a price for the unit regardless of its quality, size and features.

But we were wrong. Thousands of them were sold and it was selected as one of the most exciting new products of the year.

WE BOUGHT ONE

A few months ago we purchased a Sinclair TV and discovered another feature we didn't like. The unit included a 220-volt converter for European operation. This meant that every American who bought the set had to pay extra for the converter even though very few Americans would be taking their TV to Europe.

So we came up with an idea. We went to England and purchased thousands of sets directly from the factory without the converter. We were also able to save money by eliminating the normal mark ups by importers, wholesalers and distributors.

We can now offer you the unit for only $249.95 and if you want the 220-volt converter, your cost is only $19.95 extra.

LESS THAN WHOLESALE

JS&A would be offering the exact same Sinclair TV at a price less than Sinclair's actual wholesale price in the United States and we would still make enough profit to pay for the cost of this advertisement.

There is one feature we liked very much about the set. Its rechargeable batteries are built into the unit. Larger portable TV's offer $60 optional rechargeable battery packs that must be purchased separately. Ours is built in and included in the price.

The Sinclair TV comes complete with an American AC adapter and charger, ear phones, carrying case, rechargeable batteries and a built-in antenna for both VHF and UHF. It also comes with a cigarette lighter power converter, so you can watch all your favorite TV channels from your boat, plane, motor home or car without even using your batteries.

PHOTOGRAPHIC QUALITY

We were well aware of Sinclair's advanced electronics and quality features. But what we found particularly exciting was its picture tube. Even though the 2" (measured diagonally) tube is small, the TV's resolution resembles that of a clear sharp photograph. You can even read small telephone numbers when they're flashed on the screen.

The Sinclair unit is offered in this advertisement with the same accessories available in the $395 system with the exception of the 220-volt power converter.

The Sinclair is also convenient. You can take it on trips and entertain your children while you fly or drive. You can keep it on your desk at work and monitor the latest news or stock market reports. And you can view the soap operas as you work around the house. We even took ours to the ball game to watch those instant replays.

BIG POCKETS

But don't expect to carry it in your pocket – it won't fit unless you have big pockets. The unit measures 1⅝" x 4" x 6¼" and weighs just 28 ounces which includes the built-in batteries.

The TV is serviced in the United States by Sinclair's service-by-mail facility. If service is ever required during its one-year limited warranty, just slip it in its handy mailer and send it to them for repair. Your solid-state unit should operate for years without a problem, but if it ever needs repair, it's good to know that service is an important part of our program.

For $249.95, the Sinclair Micro TV is worth your test. Order one from JS&A. Take it with you on a trip, bring it to your office, or carry it with you around the house. See how clear and sharp the picture is and how closely it resembles a black and white photograph. Then decide if you want to keep it. If not, no problem. Simply return your TV within 30 days for a prompt and courteous refund. We just want you to prove to yourself, the miracle of space-age electronics before you decide.

AMERICA'S LARGEST

Sinclair Radionics is one of England's largest electronics manufacturers and JS&A is America's largest single source of space-age products – further assurance that your modest investment is well protected even though the unit is offered at such a bargain price.

To order your Sinclair Micro TV, simply send your check for **$249.95** plus $3.00 postage and handling (Illinois residents, please add 5% sales tax) to the address shown below or credit card buyers may call our toll-free number below. But please act quickly.

The Sinclair TV is an outstanding product that was priced too high. If you felt like we did and you waited, your timing is perfect. Order a Sinclair Micro TV at no obligation, today.

JS&A PRODUCTS THAT THINK

Dept. PE One JS&A Plaza
Northbrook, Ill. 60062 (312) 564-7000
Call TOLL-FREE 800 323-6400
In Illinois Call .... (312) 564-7000

WHEN THE GOING GETS TOUGH, BECKMAN'S NEW DIGITAL MULTIMETERS KEEP GOING.

Featuring new continuity function.

If you've ever been troubled by a faulty multimeter—or had to use one that wasn't quite up to the tougher jobs—your troubles are over. Now there's the Beckman line of digital multimeters. A new generation of 3½-digit models that combine superior reliability with highly versatile features.

Features like a unique continuity test function. With Beckman's new Insta-Ohms™ quick continuity indicator, you no longer need an analog VOM for fast, convenient continuity checks.

There's also 10-amp current ranges, in-circuit resistance measurement capability in all six-ohm ranges, a dedicated diode test function, and up to two years normal operation from a common 9V battery.

The Model TECH 310 with all these features, 7 functions, 29 ranges, and 0.25% Vdc accuracy is only $130.

The Model TECH 300 with 0.5% Vdc accuracy, but without the continuity function or the 10-amp current ranges, is just $100.

Whichever model you choose, you get a multimeter that won't let you down. There's exceptional overload and 6kV transient protection, plus ruggedness to take a 6-foot fall and to come up working.

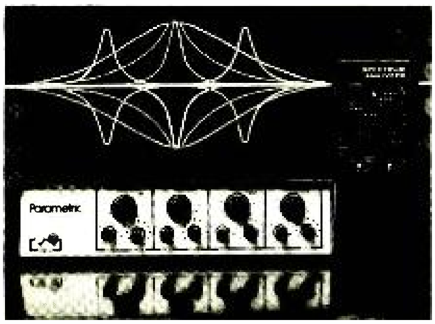
So get the Beckman digital multimeter that performs and keeps on performing. No matter how tough the going gets. For information on the complete line and accessories, write or call your local distributor or the Advanced Electro-Products Division, Beckman Instruments, Inc., 2500 Harbor Boulevard, Fullerton, CA 92634, (714) 871-4848, ext. 3651.

BECKMAN

SEPTEMBER 1979
VOLUME 16, NUMBER 3

Popular Electronics®

WORLD'S LARGEST-SELLING ELECTRONICS MAGAZINE



About the cover:

The parametric equalizer and the spectrum analyzer are both valuable audio tools in setting up your audio system and listening area.

Cover photo by Justin Kerr

Special Focus on Audio

Feature Articles

Construction Articles

Columns

Julian Hirsch Audio Reports

Electronic Product Test Report

Departments

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Editorial

EVERYTHING'S COMING UP COMPUTERS!

News about computers and computer applications continues to engulf us. Just this morning, for example, I saw a TV news program concerning an MIT graduate student who developed a computer system to analyze the cries of babies. According to the researcher, the computer can distinguish between sounds that point to serious problems and those that are simply normal baby outpourings.

A few weeks earlier, I read a news release on a commercial computerized portrait system that's said to be the first *full-color* one on the market for reproducing a person's face on a T-shirt, tote bag, etc. (It's from Computer Ideas Inc, Raynham, MA.) Then I read about a nationwide information utility for personal-computer owners. With a 300-words/minute telephone interface, anyone can gain access to the system, called SOURCE (from Telecomputing Corp. of America in McLean, VA), by paying a one-time $100 registration charge. Thereafter, the network can be used via a local phone call at $2.75/hour. There are said to be more than 2,000 programs and data bases, ranging from games such as Star Trek to world and local news, business applications packages, a major subset of the New York Times Information Bank, airline schedules, and more.

At general electronics trade shows, too, I continually bump into new personal computer offerings. Recently, for instance, Texas Instruments unveiled its new TI-99/4 home computer, which comes with a 13-inch color video monitor, and uses ROM plug-in modules for program input. Ohio Scientific demonstrated its new C8P-DF, featuring an "on line" home controller that turns lights and appliances on and off, dims and brighten lamps, interfaces with a home security system, and has optional voice I/O and telephone interface systems. Commodore displayed its CBM business computer; Atari its Models 400 and 800 personal computer systems; Exidy its word processing and education systems; APF its MP1000 "Imagination Machine," which has color graphics; and Interact its Model One Benchmark, a "no-frills" version of its regular model.

Other avenues are used to reach media, too. Radio Shack, for instance, introduced its TRS-80 Model II small-business system at a press meeting. Its video monitor has a built-in floppy. And Heath's latest catalog features a new all-in-one personal computer (kit and assembled versions) that also has a built-in floppy disk.

Added to the foregoing are press releases about books on computers, software, peripherals, and a host of products that tout the word "computer" owing to the use of a microprocessor.

Viewing all this action, it's no wonder that computer specialists make up the second largest group of scientists in the United States. Given the enormous interest and projected growth in computers, it will surely be the premier science group at a near-future time.

Art Salsberg

Don't take our word for it.

"We can heartily recommend the Superboard II computer system for the beginner who wants to get into microcomputers with a minimum of cost. Moreover, this is a 'real' computer with full expandability."

Popular Electronics March, 1979

"(Their) new Challenger 1P weighs in at $349 and provides a remarkable amount of computing for this incredible price."

Kilobaud Microcomputing February, 1979

"Over the past four years we have taken delivery on over 25 computer systems. Only two have worked totally glitch free and without adjustment as they came out of the carton: The Tektronic 4051 (at $7,000 the most expensive computer we tested) and the Ohio Scientific Superboard II (at $279 the least expensive) . . . The Superboard II and companion C1P deserve your serious consideration."

Creative Computing January, 1979

"The Superboard II and its fully dressed companion the Challenger 1P series incorporate all the fundamental necessities of a personal computer at a very attractive price. With the expansion capabilities provided, this series becomes a very formidable competitor in the home computer area."

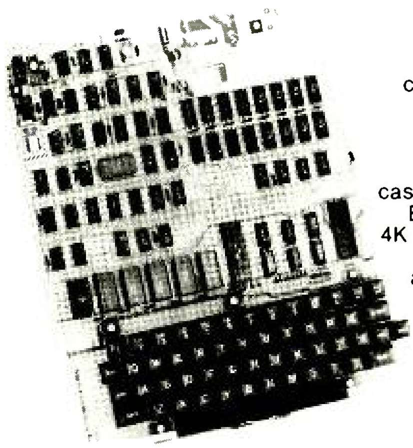
Interface Age April, 1979

"The graphics available permit some really dramatic effects and are relatively simple to program . . . The fact that the system can be easily expanded to include a floppy means that while you are starting out with a low-cost minimal system, you don't have to throw it away when you are ready to go on to more complex computer functions. Everything is there that you need; you simply build on to what you already have. You don't have to worry about trading off existing equipment to get the system that will really do what you want it to do. At $279, Superboard II is a tough act to follow."

Radio Electronics June, 1979

"The Superboard II is an excellent choice for the personal computer enthusiast on a budget."

Byte May, 1979



SUPERBOARD II
$279.00
The world's first complete computer system on a board including full keyboard, video display, audio cassette interface, 8K BASIC-in-ROM and 4K RAM. Expandable. Requires +5V at 3 amp power supply.

C1P $349.00
Complete with enclosure and power supply. All features of Superboard II. Easy to expand to more memory and floppy disk.

C1P MF $995.00
The first floppy disk based computer system the world has ever seen for under $1,000. 8K BASIC-in-ROM, 12K RAM. Expandable to 32K RAM.

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See your Ohio Scientific dealer for full details.

CIRCLE NO. 45 ON FREE INFORMATION CARD

Letters

555 DUTY CYCLES

I feel that Brian Walmann was slightly overenthusiastic in his criticism of 555 timer duty cycles (June 1979). While the formula given by TI is a misprint and clearly incorrect, Signetics' $R_B/(R_A + 2R_B)$ formula is actually correct. Unfortunately, a misprint in Mr. Walmann's article quotes Signetics incorrectly to further confuse the issue. The point is that duty cycle can be defined by either $R_B/(R_A + 2R_B)$ or $1 - R_B/(R_A + 2R_B)$, which is equal to $(R_A + R_B)/(R_A + 2R_B)$, so that both Signetics and Mr. Walmann are correct, depending on whether you define duty cycle as the high or low state.—*Barry Bodhaine, Boulder, CO.*

ON UNSUNG INVENTORS

Your Editorial on individual achievements in electronics in the July 1979 issue was tremendously uplifting to me. When we can say that a device is the product of the genius of a certain man working today, either alone or with resources granted to him by a modern corporation, we are making a very valuable statement about the true nature of Mankind. It is right to honor these real men.—*Zack T. Hinckley, Rockledge, FL.*

Thank you for your round of applause in your "Unsung Electronics Inventors" Editorial. However, I would like to set the record straight in that I have never been with National Semiconductor. Upon leaving Fairchild, I helped to found Intel Corporation, where I have been ever since and presently hold the position of Vice Chairman.

In response to your request to learn of new developers who are unrecognized, I submit the name of Ted Hoff, who invented the first microcomputer. We feel this invention has been a major contribution to the state of the art and would like to see Dr. Hoff receive some of the recognition he deserves.—*Robert N. Noyce, Intel Corp., Santa Clara, CA.*

Your Editorial on unsung inventors noted the wrong company affiliation for the inventor of the 555 timer, Hans Camenzind. Signetics Corp. contracted him for this work, not National Semiconductor.—*Robert Frostholm, Signetics Corp., Sunnyvale, CA.*

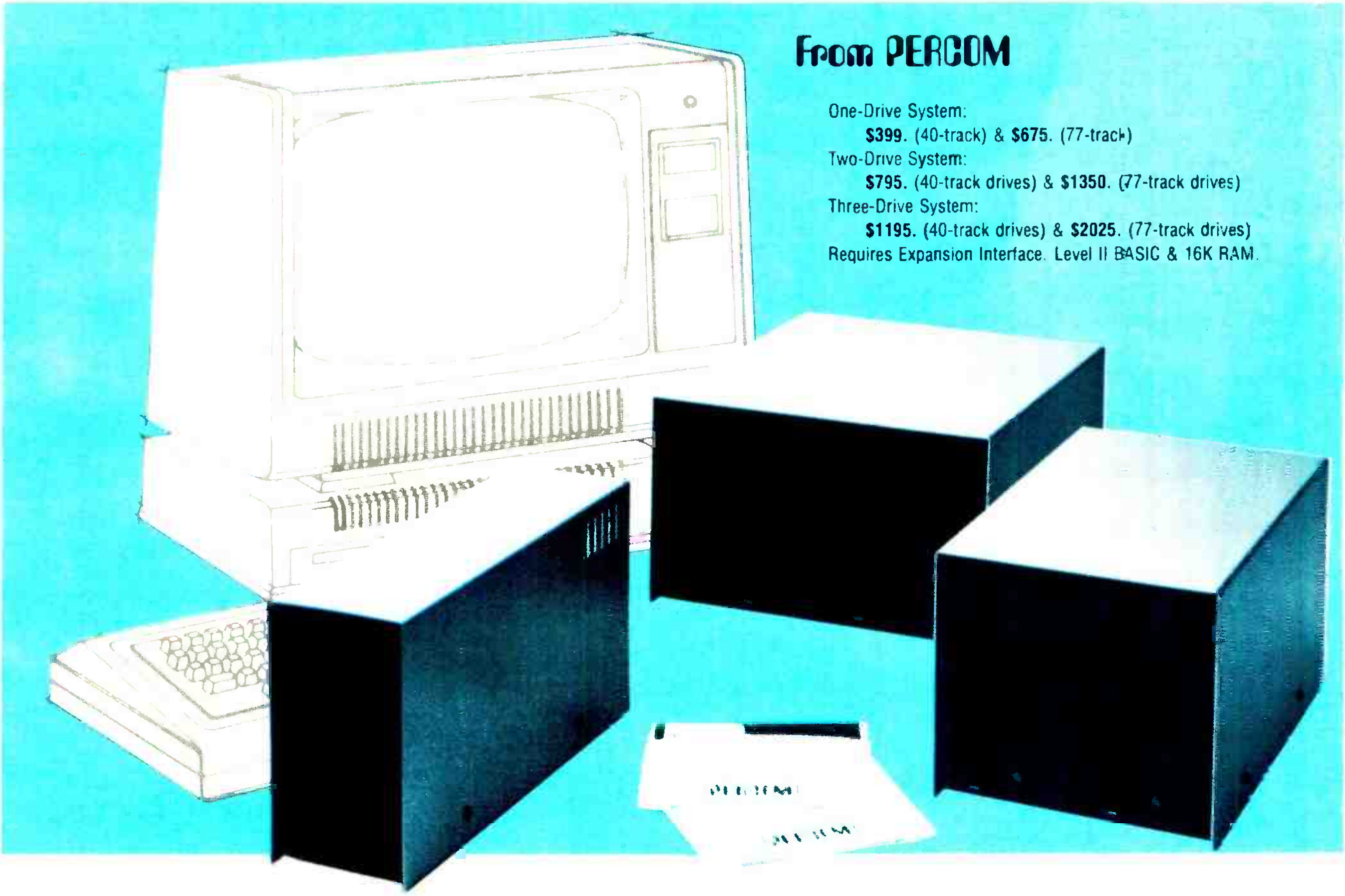
With reference to your July 1979 Editorial and the Bearcat scanner ads in the same issue, I think it is just great to be able to punch some buttons and have a radio receiver come up on frequency. Thanks to another unsung electronics inventor, James Murray (Radio Division, Naval Research Laboratory, Washington, DC), this is all possible. Mr. Murray invented the pushbutton frequency synthesizer in the early 1950s, and Hewlett-Packard developed it to make its Model 5100 synthesizer.—*L. C. Harlow, San Diego, CA.*

Out of Tune

"Controlling DC Power With Pulse-Width Modulation" (June 1979). In Fig. 2, a connection between pins 2 and 6 of *IC1* was omitted.

"Poor Man's Servant" (July 1979). While it appears in the schematic diagram, *C2* is not mentioned in the Parts List. Also, the project will draw as much as 500 mA (with the specified relay) when it is triggered, rather than the stated 100 mA. Therefore, a good choice of power supply would be one rated at 5 volts and 1 ampere. Finally, take note that some suppliers are using the term "sound trigger" to describe the VOX module.

"Build In-Circuit Transistor Tester for $10" (July 1979). A jumper between pin 12 of IC2 and the ground pad next to pin 9 was omitted from Fig. 2.



From PERCOM

One-Drive System:
$399. (40-track) & **$675.** (77-track)
Two-Drive System:
$795. (40-track drives) & **$1350.** (77-track drives)
Three-Drive System:
$1195. (40-track drives) & **$2025.** (77-track drives)
Requires Expansion Interface, Level II BASIC & 16K RAM.

Low Cost Add-On Storage for Your TRS-80*. In the Size You Want.

When you're ready for add-on disk storage, we're ready for you. Ready with six mini-disk storage systems — 102K bytes to 591K bytes of additional *on-line* storage for your TRS-80*.

- **Choose either 40-track TFD-100™ drives or 77-track TFD-200™ drives.**
- **One-, two- and three-drive systems immediately available.**
- **Systems include Percom PATCH PAK #1™, on disk, at no extra charge. PATCH PAK #1™ de-glitches and upgrades TRSDOS* for 40- and 77-track operation.**
- **TFD-100™ drives accommodate "flippy disks." Store 205K bytes per mini-disk.**
- **Low prices. A single-drive TFD-100™ costs just $399. Price includes PATCH PAK #1™ disk.**
- **Enclosures are finished in system-compatible "Tandy-silver" enamel.**

Whether you need a single, 40-track TFD-100™ add-on or a three-drive add-on with 77-track TFD-200™s, you get more data storage for less money from Percom.

Our TFD-100™ drive, for example, lets you store 102.4K bytes of data on one side of a disk — compared to 80K bytes on a TRS-80* mini-disk drive — and 102.4K bytes on the other side, too. Something you can't do with a TRS-80* drive. That's almost 205K bytes per mini-disk.

And the TFD-200™ drives provide 197K bytes of on-line storage per drive — 197K, 394K and 591K bytes for one-, two and three-drive systems.

PATCH PAK #1™, our upgrade program for your TRSDOS*, not only extends TRSDOS* to accommodate 40- and 77-track drives, it enhances TRSDOS* in other ways as well. PATCH PAK #1™ is supplied with each drive system at no additional charge.

The reason you get more for less from Percom is simple. Peripherals are not a sideline at Percom. Selling disk systems and other peripherals is our main business — the reason you get more engineering, more reliability and more back up support for less money.

In the Product Development Queue . . . a *printer interface* for using your TRS-80* with any serial printer, and . . . the *Electric Crayon*™ to map your computer memory onto your color TV screen — for games, animated shows, business displays, graphs, etc. Coming PDQ!

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To order add-on mini-disk storage for your TRS-80*, or request additional literature, call Percom's toll-free number: 1-800-527-1592. For detailed Technical information call (214) 272-3421.

Orders may be paid by check or money order, or charged to Visa or Master Charge credit accounts. Texas residents must add 5% sales tax.

Percom *'peripherals for personal computing'*

CIRCLE NO. 51 ON FREE INFORMATION CARD

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.

KLH Computer-Controlled Speaker

The KLH-1 loudspeaker from KLH Research & Development Corp. uses an analog computer to regulate the drive to its woofer section in order to prevent overdriving the system. According to the company, this permits the dual woofers to be optimized for maximum bass output from an enclosure of limited size. The floor-standing 1.25-cu-ft (35-liter) three-way system is said to be able to deliver a sound pressure level of 105 dB in a typical room, with a −3-dB point of 32 Hz and moderately high efficiency. $1000 per pair, with Analog Bass Computer module.

CIRCLE NO. 87 ON FREE INFORMATION CARD

12-Band Portable Receiver

The Trans-Oceanic R-7000 portable receiver from Zenith covers seven shortwave bands including all frequencies from 1.8 to 30 MHz, the AM and FM broadcast bands, the longwave FAA aviation weather band, the aircraft communications band for air traffic control, and the public service band for amateurs, police, weather, etc. Features include SSB capability, a squelch control, an ANL/AFC switch, fine and

coarse tuning controls, wide-narrow bandwidth switch. Two built-in antennas, 12 dial scales, a signal-strength meter, a tuning meter for FM, and a 5" speaker whose input runs through a bass-to-treble control are also provided. The radio can operate on 8 "D" cells, a 12-volt car battery, and 120 or 240 V ac. It measures 9.38" × 14.06" × 6.56" (238 × 357 × 167 mm) and weighs 13 lb 12 oz (6.25 kg) without batteries. $380.

CIRCLE NO. 88 ON FREE INFORMATION CARD

10–50-MHz Frequency Counter

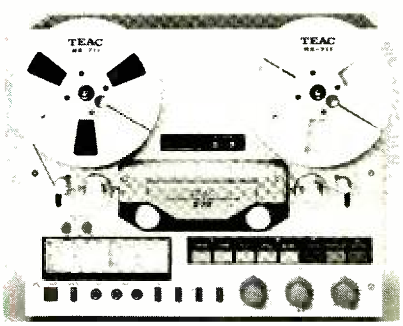
The FC-841 multifunction frequency counter from Soar is said to cover the range from 10 Hz to 50 MHz while maintaining a

time-base stability of 3 parts per million from 68°F (20°C) to 86°F (30°C). Gate time is 100 ms, and rated sensitivity is 30 mV rms up to 30 MHz, falling to 60 mV rms at 60 MHz. Readout is via a four-digit LED display 0.3 inches high. Kilohertz and megahertz ranges are selected by a switch. Powered by four AA cells, the counter can also be fed from an ac power line or a car's cigar lighter. $90.

CIRCLE NO. 89 ON FREE INFORMATION CARD

Teac Open-Reel Tape Deck

Closed-loop, dual-capstan tape drive and 7" reel capability are two of the features listed for the new X-7 open-reel deck from Teac. The two-speed (7½ and 3¾ ips) X-7 is equipped with three motors and three heads. The same machine is available as



the X-7R with six heads and bidirectional play-record. Wow and flutter is rated at 0.04% (WRMS) at 7½ ips, with frequency response of 30 Hz to 28 kHz and signal-to-noise ratio of 58 dB. Price: $750 for the X-7, $850 for the X-7R.

CIRCLE NO. 91 ON FREE INFORMATION CARD

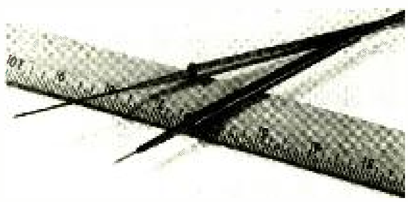
Speech Synthesizer

The Computalker CT-1A, designed to work with the Apple II microcomputer, is a completely self-contained speech synthesizer. The unit comes complete with its own chassis and power supply and contains all necessary interface circuitry as well as a 2-watt audio amplifier. Accompanying the unit is an interconnect cable, an Apple controller card, a detailed manual, and a software package. Phono jacks provide connection points for external speakers, headphones, or an amplifier. To operate the Speech Synthesizer, an Apple II must have a minimum of 16K RAM, with 32K recommended. $495.

CIRCLE NO. 92 ON FREE INFORMATION CARD

Ultrathin Test Probes

Telescoping test probes designed especially for microcircuitry and miniaturized components are available from Huntron Instruments, Inc. A retractable, tempered-steel electrode 2¾" (70 mm) in length and 0.048" (1.2 mm) in diameter extends from the handle of each probe, which is fitted



with a locking device to hold the electrode at the desired length. An insulating coating said to resist up to 1 kV covers each electrode down to its needle-sharp tip. Each probe comes with 5' (1.5 m) of PVC-coated Superflex leads fitted with standard banana plugs. All parts are said to be replaceable in case of damage.

CIRCLE NO. 93 ON FREE INFORMATION CARD

Data-Cable Line Monitor

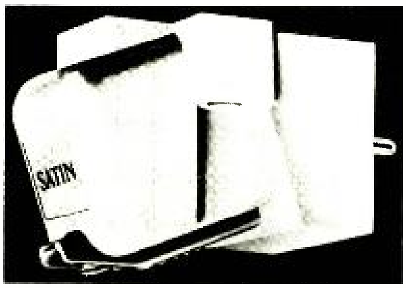
The Model 20 Line Monitor introduced by Remark International allows rapid and convenient access to all 25 signal paths of a standard communications data cable.

When connected in series with the cable, the monitor provides 25 clearly marked test points in the form of 0.025" square pins. Two standard data connectors, which

interface the cable and monitor, and all the pins are contained in an aluminum housing 3" × 2.5" × 1.5". Standard connector configuration is 1 male, 1 female; a 2-male or 2-female arrangement is available at extra cost. $32. Address: Remark International, 4 Sycamore Dr., Woodbury, NY 11797.

Satin 117S Moving-Coil Pickup

One of the latest of the Satin moving-coil cartridges introduced by Osawa is the Model 117S, distinguished by its special stylus shape. Like the earlier Model 117G,



the 117S is designed to feed a standard phono input with no transformer or head amp required. In addition, the new cartridge is said to have a fixed-point pivot for the stylus cantilever and a special formula lubricant instead of the less accurate rubber mechanisms often used to provide damping. $225.

CIRCLE NO. 94 ON FREE INFORMATION CARD

Speech Processor Mic

The new K-40 Speech Processor microphone from American Antenna is said to monitor speech and automatically adjust its gain so as to produce up to 400% more "talk" power than standard microphones. A two-position switch changes equalization to give high-pitch transmission for cutting through traffic noise or a mellow tone for quiet areas. An electronic storage sys-

tem that automatically provides a fresh electric charge each time the trigger is released eliminates the need for a battery. An internal magnet is provided to clamp the device to any steel surface. $42.50.

CIRCLE NO. 95 ON FREE INFORMATION CARD

LCD Designer's Kit

Beckman has introduced a kit that lets users experiment with large-area liquid crystal displays. Contains a 0.5", 4-digit LCD

display along with a connector/bezel assembly, printed circuit board, and complete specifications and applications information. $11.95. Address: Beckman Instruments, Inc., Display Systems Div., 2500 Harbor Blvd., Fullerton, CA 92634.

30-MHz Dual-Trace Miniscope

Non-Linear Systems' Model MS-230 miniature oscilloscope is rated at 30 MHz and offers dual-trace operation. The battery-operated Miniscope measures 8.5"D × 6.4"W × 2.9"H (216 × 163 × 74 mm) and weighs 3.5 lb (1.6 kg), including battery. It features alternate, chopped, and separate sweep modes and internal and external triggering. There are 12 vertical-gain set-

tings for each channel from 0.01 to 50 volts/division. There are also 21 time-base settings from 0.05 μs to 0.2 s/division. Verniers are provided for time-base and vertical-amplifier adjustment. Included are a horizontal input channel, an internal calibrator, input cables and a battery charger that permits line operation. Accessories include a 10:1 10-megohm probe and leather carrying case with shoulder strap and belt loop. $559.00.

CIRCLE NO 96 ON FREE INFORMATION CARD

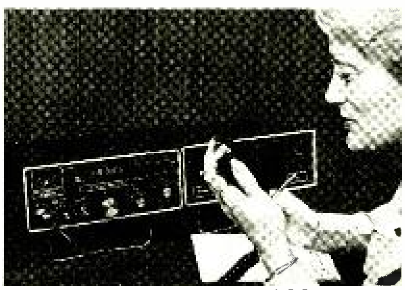
Phase Linear Power Amp

The Model 300 Series Two power amplifier from Phase Linear is rated to deliver a minimum of 120 watts per channel at no more than 0.009% total harmonic distortion, 20 Hz to 20 kHz with both channels driven into 8 ohms. Transient inter-modulation distortion (TIM) is said to be no more than 0.005%. Although the amplifier is a class AB design and therefore subject to crossover distortion, Phase Linear claims that all the spurious products from this source lie above 80 kHZ, where they are inaudible. $450.

CIRCLE NO 97 ON FREE INFORMATION CARD

Ham Transceiver with Microprocessor

Swan Electronics's new Astro 150 Amateur Radio transceiver features microprocessor control and memory. The all-solid-state transceiver is claimed to be the

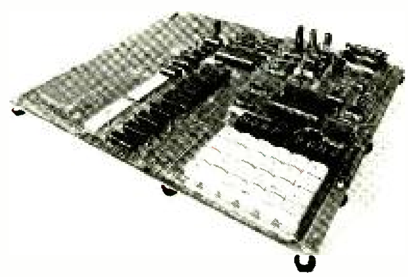


most advanced on today's hf SSB market. It offers more than 100,000 digitally-controlled frequencies and variable-rate scanning (VRS). With UP and DOWN pushbuttons on the microphone, the transceiver can be tuned for accurate 100-Hz steps or at a fixed scan rate. The VRS system is a supplement to conventional tuning knobs with electronic scanning. Features include: 235 watts of transmitter input power, full and semibreak-in CW, narrow-band CW filter, and expanded frequency coverage.

CIRCLE NO 98 ON FREE INFORMATION CARD

16-Bit μcomputer Kit

A complete 16-bit 8086 microcomputer kit is available from Intel. It includes an 8-digit



LED display, a 24-key hex keyboard, 8K ROM, 2K RAM, and all necessary components other than a power supply. Features of the SDK-86 include 48 parallel I/O lines, an RS232 or current loop serial I/O structure, a selectable data transfer rate from 110 to 4800 baud, and TTL-compatible bus signals. A complete design library accompanies the kit. $780.

CIRCLE NO 99 ON FREE INFORMATION CARD

Tunable FM Antenna Amp

Audio Marketing by Von introduces the FM Power Sleuth, a tunable FM amplifier designed to feed the antenna terminals of a tuner or receiver. It is designed mainly for fringe-area use, but is said to contribute to reception in urban and suburban installations where indoor or dipole antennas are used. Rated specifications for the device include: r-f gain 35 dB, ±5 dB; noise figure 7 dB maximum; spurious reject 90 dB or better; image rejection 85 dB or better. $150. Address: Audio Marketing by Von, 11 Royal Crest Drive, North Andover, MA 01845.

Rotating Organ "Speaker"

The new Schober Organ Model RT-151 Rotatone is an all-electronic device that provides the same kind of electronic-organ sound enhancement as rotating-baffle loudspeakers. It can be installed in most electronic organs, generally just before the power amp. Like a rotating speaker system, the Rotatone adds both vibrato (FM) and tremolo (AM) to the sound. In the FAST position of the control switch, the AM and FM are at vibrato rate of about 6 Hz. Set to SLOW, amplitude and frequency variations are much more subtle. The third switch position completely bypasses the Rotatone. The device is built on a 5½" (140-mm) square printed-circuit board that can be mounted anywhere. The switch is housed in a shallow walnut box that can be installed under the lower keyboard. The Rotatone is available in kit form for $87.50.

CIRCLE NO. 100 ON FREE INFORMATION CARD

New Literature

DX PROGRAM SCHEDULE

An hour-by-hour detailed schedule of DX programs throughout the week is published twice a year (such as in the July issue) in *Review of International Broadcasting*. Subscriptions are $12 per year from Glenn Hauser, University Radio WUOT, Knoxville, TN 37916.

TI MICROCOMPUTER GUIDE

The CL 377A 20-page product selection guide from Texas Instruments covers the TM990 Series of 16-bit microcomputer modules, including software, firmware, and hardware products. Descriptions contain key specifications and features of memory and I/O expansion modules, A/D and D/A interface modules, and others. Address: Texas Instruments Incorporated, Inquiry Answering Service, P.O. Box 1443, MS-6404, Houston, TX 77001.

AUDIO-TECHNICA DIRECT-DISC CATALOG

Perhaps the most extensive single listing of very-high-fidelity records, the StandarDisc catalog, is available from Audio-Technica. It includes such labels as Gale, Umbrella, RCA, and Toshiba EMI for direct-to-disc and Telarc for a new digitally mastered album. With 17 new discs, the catalog listing has been expanded to 46 recordings. Address: Audio-Technica U.S., Inc., 33 Shiawassee Ave., Fairlawn, OH 44313.

ALLIED ELECTRONICS CATALOG

Allied Electronics' 1979 Engineering Manual and Purchasing Guide is filled with a wide selection of industrial-type parts, supplies, and equipment. Its 260 pages contain illustrations, dimensions, technical data and specifications, descriptive explanation, and prices. Send $1.00 to cover postage to: Allied Electronics, Dept. C-79, 401 East 8 St., Fort Worth, TX 76102.

SHAKESPEARE MARINE ANTENNA CATALOG

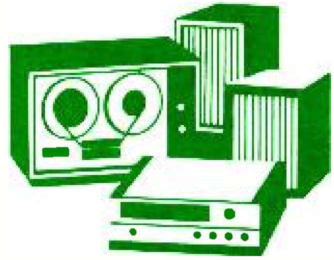
Shakespeare's 1979 Fiberglass Marine Antenna Catalog contains products and electronic data, as well as background information on the company's fiberglass process. The catalog also includes do's and don't's for choosing a marine antenna. Address: The Shakespeare Company, Electronics and Fiberglass Division, P.O. Box 246, Columbia, SC 29202.

NATIONAL SEMICONDUCTOR PERSONAL COMPUTER BROCHURE

A 24-page brochure from National Semiconductor Corporation details its range of components for personal computers. The brochure describes more than 100 components including microprocessors, memories, CRT controllers, LED displays, floppy disk interfaces, serial and parallel interfaces, sound synthesizers, analog interfaces, and printer interfaces. Address: National Semiconductor Corp., 2900 Semiconductor Drive, Santa Clara, CA 95051.

CSC 1979 CATALOG

Continental Specialties's 32-page catalog for 1979 highlights signal generators, test instruments, logic probes, frequency counters, solderless breadboards, IC test clips, and more. New products listed include four cases, etched and drilled printed-circuit boards, and printed worksheet pads, the last to complement CSC's Experimentor solderless breadboards. Address: Continental Specialties Corp., 70 Fulton Terr., New Haven, CT 06509.



Stereo Scene

By Harold A. Rodgers, Senior Editor

GIVING THE SYSTEM A FIGHTING CHANCE

NOT INFREQUENTLY, when visiting the homes of various friends and acquaintances, I find myself drawn into conversations about the ills that afflict their stereo systems. The opening remarks of these discussions typically run something like this: "My system just isn't sounding right anymore. I think I'll probably have to replace the. . . ." Or: "There is something very strange about this room. No matter what kind of speakers I try, the sound is muddy."

Now it may very well be that the owner of the first system has detected an ailing component or has attained such auditory sophistication that equipment that was once satisfactory is no longer so. And it is possible that the second complainer is unlucky enough to live in an acoustically disastrous environment. But in my experience this is rarely the case. Most often, the audio system is capable of sound that is presentable or even creditable—were it not called upon to struggle against impossible odds. Diagnosing the problem is very simple in most of these instances: The loudspeakers are badly positioned.

It is by now fairly common knowledge that to hear decent stereo, you will have to set up your speakers and then sit approximately halfway between them. Likewise, it seems to be generally understood that a speaker aimed at an overstuffed chair rather than toward the listening position will seem deficient in high-frequency output. Yet it is amazing how often even these simple principles are violated. Were such elementary oversights the total extent of the problem, the subject would hardly rate treatment in a column of a magazine with a technically oriented readership. But, strange as it may seem, I have seen errors only slightly more subtle made by knowledgable colleagues.

Giving Speakers the Best Possible Home. If you are intent upon getting the best performance that your stereo system can deliver, it will pay you to recognize immediately that loudspeakers—and the listening position—optimally placed will probably contradict all the conventional wisdom of interior decorating. (Murphy's Law insists that it be thus.) Making matters even more complicated, there are no hard and fast rules for correct placement. (A noted acoustician is said to have remarked: "We can calculate the behavior of a room quite exactly—as long as it is empty. But put a single chair in that room and we are not sure what we are doing.") There are, however, some general guidelines.

Loudspeakers, as a rule are ambivalent about walls (and floors and ceilings, too, for that matter). While close proximity of a speaker to a room boundary can increase its radiation loading (and thereby its efficiency), sound waves reflected from the assisting surface can create reinforcements and cancellations at various points in the audio spectrum and cause uneven frequency response.

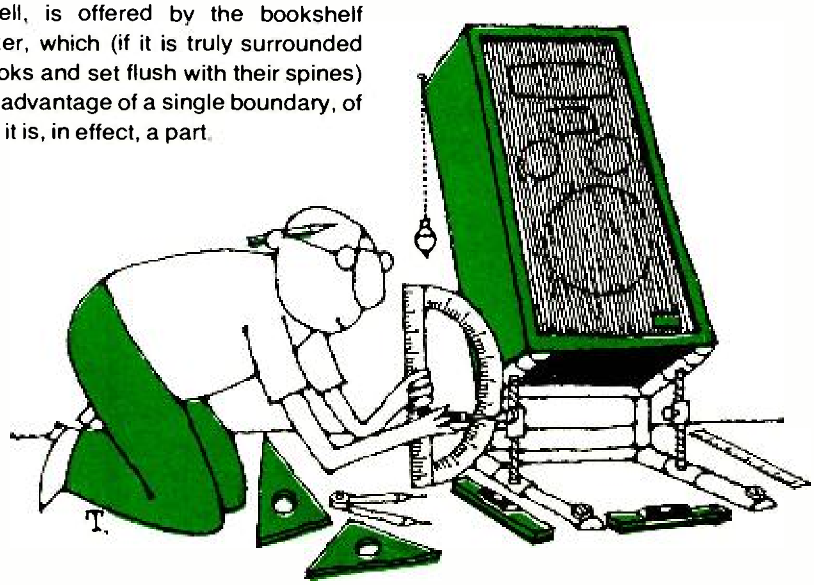
Some manufacturers have taken this into account and designed speakers to take advantage of the loading offered by two- and three-plane corners without incurring a frequency-response penalty. Another solution, with other advantages as well, is offered by the bookshelf speaker, which (if it is truly surrounded by books and set flush with their spines) takes advantage of a single boundary, of which it is, in effect, a part.

But room boundaries have another effect: they reflect sound back and forth between themselves, giving rise to *modes* or resonances at frequencies that depend on how far apart they are. The effect of room modes is to create peaks and dips in the frequency response of the room itself. In fact, in an ideally reflective room there would be frequencies at which no sound could propagate and other frequencies at which it would propagate for extended periods. These standing waves or room modes (different names for the same phenomenon) fall sufficiently close together at midbass frequencies and above that they cause no problems in most rooms. In the low bass, however, they can raise havoc.

The best defense against standing waves lies in the choice of room. First, the bigger the better. If the room is big enough, the modes overlap at low bass frequencies and are troublesome only at infrasonic frequencies. (Getting enough acoustic power out of your speakers might be a problem, though.) The second consideration is that, if possible, no two room dimensions should be equal. Nor should one be an exact multiple of another. A cubical listening room, in which all three sets of modes, one associated with each dimension, coincide, would be a disaster.

Since most of us have little control over the sizes and shapes of our rooms, let's look again at loudspeaker positioning and see if it can help us to tame room modes. Indeed, it can if the sound source is kept away from the room boundaries, whereby energy is transferred into the modes relatively slowly. Thus a transient, like a bass-drum pulse,

(Continued on page 20)



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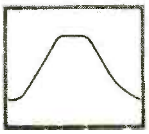
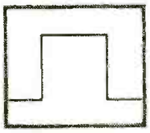


Distorted waveform response produced by conventional receiver.



Square waveform response of Hi-Speed receiver.

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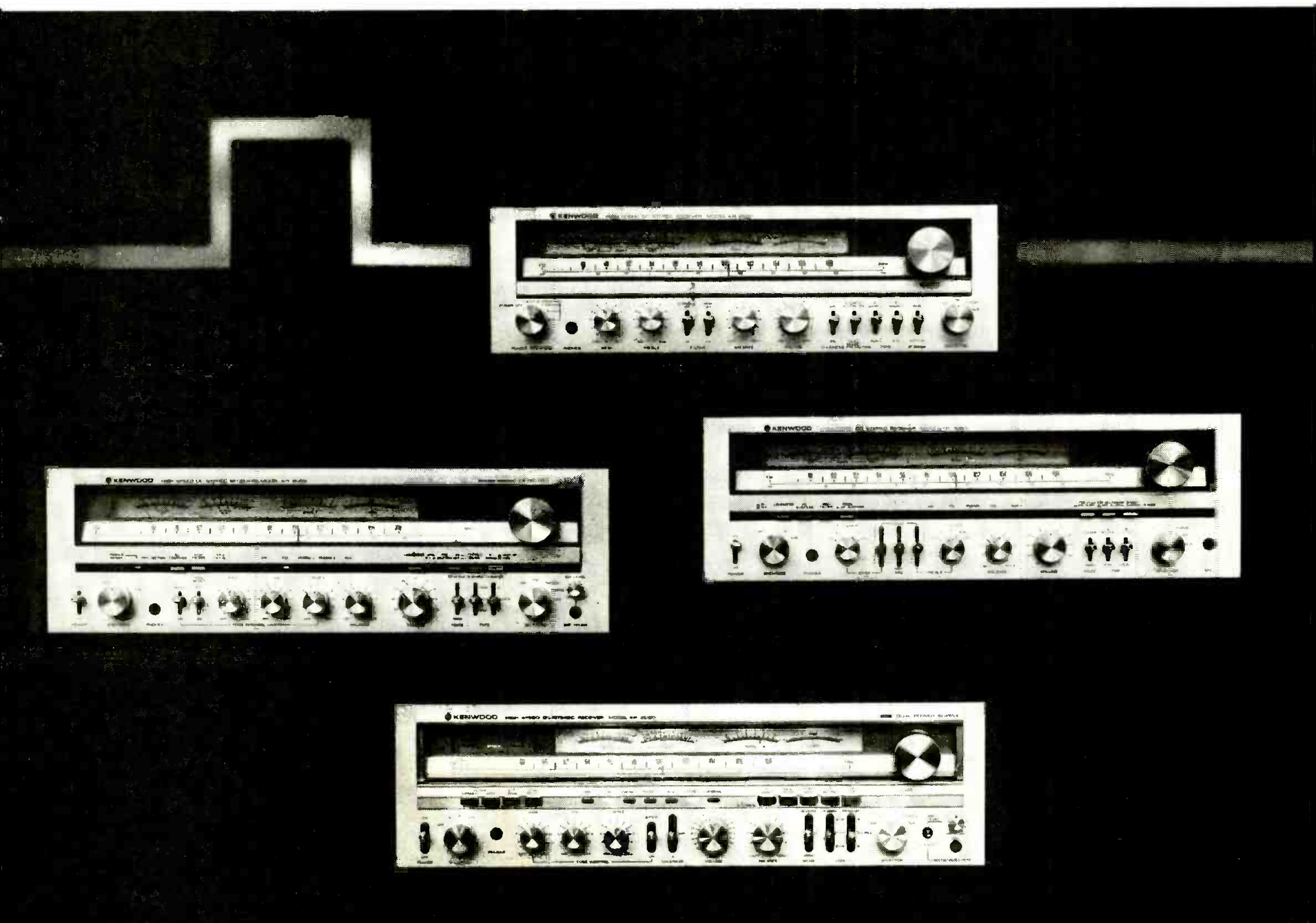

might actually die out before the room begins to color it. And even more sustained bass tones don't last all that long. Organ pedal points may still cause difficulties, but even these should be improved to some extent.

It would now seem that, in theory at least, we have a conflict between speakers designed for placement near room boundaries and the requirements for reducing standing waves. In practice, though, the contradiction almost never arises. The reason is that standing waves cause the most difficulty in small rooms, whose size already excludes devices such as corner horns that would excite modes most readily. Conversely, in a room large enough to welcome a corner horn, modes are already less of a problem.

If a dilemma exists, it is in the case of speakers designed to have their woofers placed at a wall/floor intersection. The designed-for location is often optimum in a reasonably large room; but where modes are a problem, better sound may be achieved by moving the speaker away from the wall. With the woofer still close to the floor, the loading situation becomes analogous to that of the bookshelf speaker. A small loss of bass, which can easily be equalized out, is the price of less prominent standing waves. Granted, you are violating the designer's intentions, but nothing is damaged by the experiment. If you dislike the result, go back to the orthodox arrangement.

And what is to be done with the ubiquitous "box with front-firing drivers"? This type is similar to the bookshelf speaker except that it is difficult to mount so that the drivers are flush with a room boundary. A reflected wave is thus allowed to perturb the frequency response. If the box is set with its back against a wall, the cancellation so induced tends to fall right in the midbass. The cancellation frequency is the one at which the distance from the driver to the wall is one-quarter wavelength. Thus, if we can increase the distance from the driver to the nearest boundary to about five feet, the cancellation will be at about 56 Hz.

There is some advantage to moving the disturbance to the lower part of the spectrum. Standing waves are beginning to roughen the response in this region anyway, and with perseverance (and some luck) the cancellation and a standing wave might be made to offset each other. To keep reinforcements and cancellations from piling up, it is very important that no speaker be located the same distance from two or more room boundaries.

And don't forget about the floor! It reflects sound much the way walls do. Speaker stands can be invaluable in adjusting the distance between a woofer and the floor. Sometimes, the way to place the woofer where you want it is to invert the box. This works as long as the tweeter (and midrange) can be kept approximately at ear level.

Compromises. Clearly, what I have outlined here will be entirely impractical in circumstances where the result is a room that's made unlivable, unattractive, or both. Fortunately, concessions can be made to practicality without too much adverse influence on the sound.

The first thing to remember is that the peaks and dips caused by reflections are limited to ± 3 dB—not terribly noticeable unless two or more of them coincide to cause double or triple the disturbance. Thus, if a speaker must be against or too close to a wall, try to keep it away from a second wall. Or, failing that, make the distances to the two walls unequal. In addition, although symmetrical placement of speakers generally benefits interchannel balance and stereo imaging, it is best if the symmetry is not quite exact. That way, you won't get ripples of ± 6 or ± 9 dB.

You can also make use of the distribution of standing waves in your room to adjust the bass/treble balance of the speakers. It can be demonstrated without too much trouble that antinodes (points of maximum amplitude in the standing-wave pattern) occur at the room boundaries. Therefore, a listener seated near a wall is likely to experience more bass response than one seated in the center of the room. After having located your speakers, you may find it advantageous to fine tune your listening position with this in mind.

If all of this suggests that installing your components in a listening room is an arduous task requiring many hours of experimentation, you can take some comfort in the fact that the effort expended will depend mainly on how fussy you are and how determined you are to get the most for the money you have invested in your system. The rewards can certainly justify the effort expended. A word to chronic "upgraders" who restlessly trade equipment for new models: If very similar problems occur with many different types of equipment, the problem you are chasing may well be in your room. ◇

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3550	99.95	50Hz-550MHz	TCXO 1 PPM 17° - 40°C	25MV	25MV	75MV	8	.5 Inch	*115 VAC or 8.2-14.5 VDC	2⅛" x 8" x 5"
500HH	$149.95	50Hz-550MHz	TCXO 1 PPM 17° - 40°C	25MV	20MV	75MV	8	.4 Inch	*115 VAC or 8.2-14.5 VDC or NICAD PAK.	1" x 3½" x 5¾"

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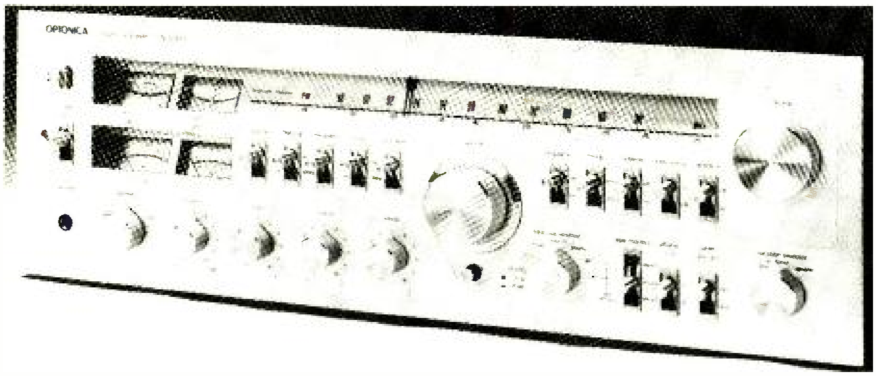
CIRCLE NO. 21 ON FREE INFORMATION CARD

Julian Hirsch Audio Reports



the high-powered Optonica Model SA-5901 AM/FM stereo receiver with "Opto Lock" tuning

each dc-coupled power amplifier has its own power supply

Optonica's Model SA-5901 flexible high-performance AM/FM-stereo receiver is rated to deliver 125 watts/channel into 8 ohms between 20 and 20,000 Hz, with THD at no more than 0.02%. Each of the receiver's dc-coupled power amplifiers has its own power supply, including separate power transformer; a third power supply operates the preamplifier and tuner sections.

An "Opto Lock" afc system that automatically disables when the TUNING knob is touched and locks the receiver to the tuned signal when released is featured in the FM tuner. A 400-Hz audio tone from a built-in oscillator (adjustable to match any FM modulation level from 20% to 80%) can be used to set the recording gain on a tape deck.

This is a large, heavy receiver, with a silver colored control panel and black markings (the Model SA-5905 is identical except that it has a black colored control panel with silver markings). Overall size is 21 5/8"W × 16"D × 7 3/16"H (550 × 406 × 183 mm) and weight is 46.2 lb (21 kg). Suggested retail price is $800.00.

General Description. In spite of its considerable size, the receiver's front panel is well filled with controls. Near the long slide-rule dial are two red LEDs that indicate when an FM STEREO signal is being received and when the OPTO LOCK system comes on. There are also separate tuning meters for center-channel tuning on FM only and relative signal strength on both AM and FM. The latter meter has a second scale, calibrated in FM modulation percentage, for use with a built-in "air check calibrator."

The large VOLUME control has 41 lightly detented positions. The BALANCE control is center-detented and the BASS, MID, and TREBLE tone controls each have 11 detented positions. When the MUTING switch is pressed in, the audio gain is reduced by 20 dB.

Operating the AIR CHECK CALIBRATOR switch replaces the tuner's audio with an internally generated 400-Hz tone, the level of which can be set by a knob on the rear apron of the receiver and is simultaneously indicated on the MOD% scale of the signal-strength meter. There is a green pilot light that comes on when power is applied and changes to red when the protection circuits are actuated. There are also two meters that indicate the left- and right-channel output levels, based on 8-ohm loads, on logarithmic scales calibrated from 0.01 to 300 watts.

The SPEAKER selector switch permits control over three sets of speaker outputs, energizing them singly or in two pairs of two. Another position on the switch silences the speaker outputs for headphone listening via a front-panel PHONES jack.

Separate program and recording-output selectors are provided. The REC OUT switch can be set to connect the normal SOURCE program to the recording outputs, as is the case with all receivers and amplifiers. In addition, this control also has settings for AUX, TUNER, and PHONO, which connect these sources to the tape outputs, regardless of the receiver's program selection. Hence, you can record one program while listening to another. Additional switch settings permit you to cross-connect two tape decks for dubbing from one to the other.

Program selection for listening is accomplished with a knob control and two toggle switches. The control allows selection of AUX, TUNER, or PHONO input. Selection between FM and AM is made with a TUNER switch. In the PHONO setting, a different switch permits either of two identical magnet-

one program can be recorded while listening to another

ic phono cartridges to be connected to the input. Finally, a three-position TAPE MONITOR switch is provided for connecting either the SOURCE or the playback from either of two tape decks to the audio amplifiers.

On the rear apron are insulated binding posts for three sets of speaker systems and the antenna inputs, a pivoted ferrite-rod AM antenna, the various source and tape jacks, and two accessory ac receptacles, one of which is switched.

Considerable use is made of integrated circuits in this receiver. The FM tuner's i-f amplifier employs two ICs, one of which includes the detector functions, and a PLL multiplex IC is used for stereo decoding. The audio output amplifiers of the tuner are ICs, as are the audio tone-control amplifiers, output-power meter drivers, and the rather elaborate protection circuits for the output transistors.

Laboratory Measurements. Beginning with this test, we are making a slight change in our distortion measuring procedure. Instead of measuring IM distortion, which conveys little information not included in a harmonic distortion measurement, we will measure the 1000-Hz THD versus power output into load impedances of 2,4,8, and 16 ohms. This will reveal the capabilities (and limitations) of an amplifier when subjected to the unusually low impedances sometimes presented by certain speaker systems. Although some amplifiers will not operate into a 2- or even a 4-ohm load and will shut down or blow a fuse, we will attempt to make these measurements to the fullest extent possible with each amplifier or receiver. In addition to the differences in maximum available power with different load impedances, this measurement will reveal how distortion increases at all power levels when driving very low load impedances. The tests will be made, as before, with both channels driven simultaneously, and immediately following

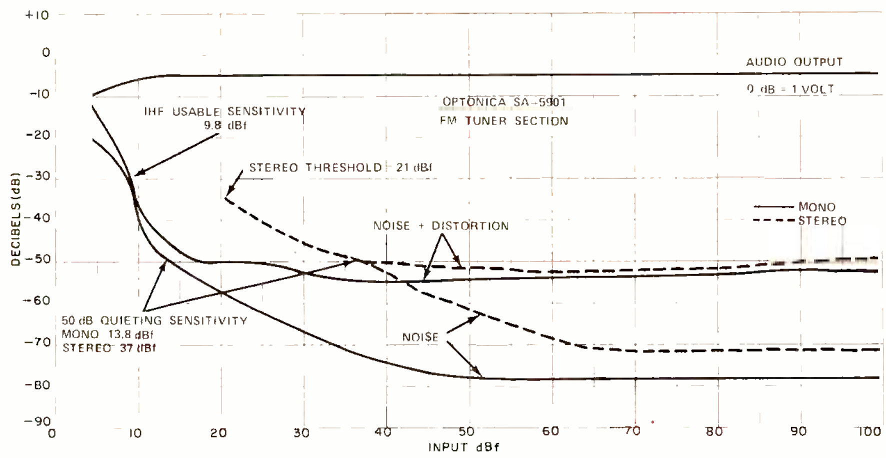
phono equalization was extremely accurate, within ±0.25 dB, 20-20,000 Hz

one hour of operation at one-third power and five minutes at full power.

Using the new test procedure, the SA-5901's clipping output was 150 watts/channel into 8 ohms, for an IHF clipping headroom of 0.8 dB. It was 100 and 113 watts into 4 and 16 ohms, respectively. The reduced power available into 4 ohms indicated that the amplifier's current capability would set an effective lower limit to its output into low-impedance loads. This was confirmed when we used 2-ohm loads. Although the protective circuit did not kick in, maximum output at 2 ohms was about 50 watts/channel, with a softly rounded waveform instead of the hard clipping that occurred with higher load impedances.

The 8-ohm IHF dynamic headroom was 2.36 dB, which corresponds to a short-term output of 215 watts.

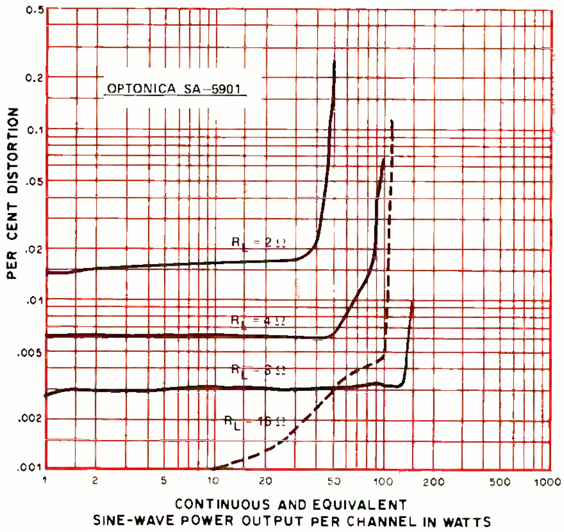
The 1000-Hz THD was very low and almost constant with power output. With 8-ohm loads, the THD was about 0.003% from 0.1 to 125 watts output and only 0.01% at 150 watts. Distortion with 4-ohm loads was



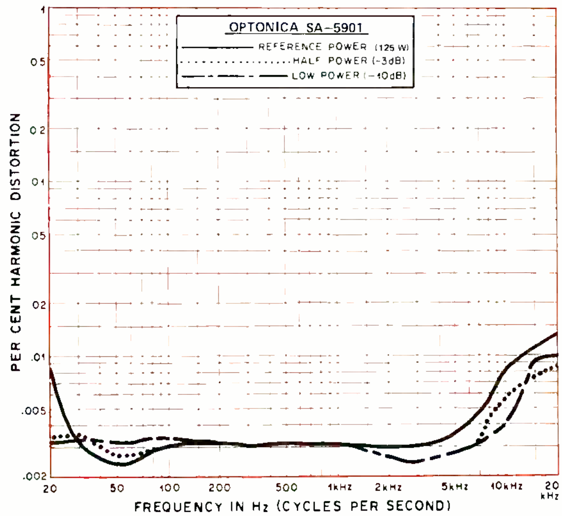
Noise and sensitivity curves for FM section of receiver.

Performance Specifications

Specification	Rating	Measured
Continuous output power (8 ohms, 20-20,000 Hz)	125 W/ch at 0.02% THD	Confirmed
S/N (A-wtd, shorted, Ref: 1 watt	59 dB phono 79 dB high level	77.4 dB phono 79.5 dB Aux (IHF std)
Input sensitivity (for 1 watt out)	0.22 mV phono 13.4 mV high level	0.21 mV phono 14 mV high level
Phono overload (1 kHz)	350 mV	420 mV
RIAA curve deviation	±0.2 dB, 20-20000 Hz	Confirmed
Low-cut filter	30 Hz, 12 dB/octave	30 Hz, slope does not exceed 6 dB/oct in audio range
High-cut filter	7000 Hz, 6 dB/octave	Confirmed
FM Sensitivity (IHF)	9.8 dBf (1.7 μV)	Confirmed
THD	0.1% mono 0.3% stereo	0.2% mono 0.22% stereo
Image rejection	95 dB	97 dB
AM suppression	60 dB	61 dB
Selectivity	80 dB	92 dB
S/N ratio	83 dB mono 75 dB stereo	78.5 dB mono 71.5 dB stereo
Capture ratio	1.2 dB	Not measurable (due to afc)
Stereo separation (1000 Hz)	45 dB	40.5 dB



1000-Hz THD, both channels driven, left measured.



Distortion with 8-ohm load for three power levels.

slightly greater, measuring 0.0063% or less up to 50 watts and 0.065% at 100 watts. Into 16 ohms, distortion was approximately the 0.001% residual of our test instruments up to 10 watts output and reached 0.0045% at 100 watts. As expected, a 2-ohm load resulted in a considerable increase in distortion, although it could hardly be called excessive. THD rose from 0.008% to 0.02% as the power increased from 0.1 to about 35 watts and reached 0.28% at 50 watts.

Distortion with 8-ohm loads was relatively independent of frequency as well as power output. It was typically about 0.003% from 20 to 5000 Hz and increased to 0.01% at 20,000 Hz. This occurred at all power levels from rated maximum down to one-tenth rated power, although at full power the 20-Hz distortion also rose slightly, to 0.008%. The IHF slew factor exceeded our measurement limit of 25.

The tone controls had a sliding bass turnover frequency and a hinged treble response. Together with the selectable turnover frequencies, the 11 settings for each control gave a nearly unlimited choice of response characteristics. The MID control had its greatest effect at about 1500 Hz, but its coverage was quite broad and at maximum or minimum settings it affected the response from 300 to 5000 Hz.

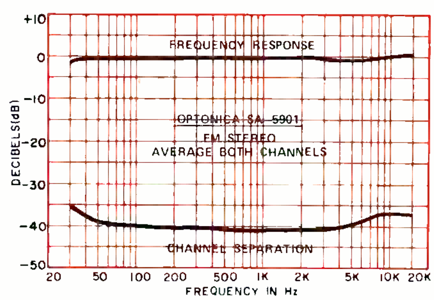
The loudness compensation boosted both low and high frequencies at low volume settings, but the amount of boost was moderate and the subjective effect was quite pleasing. The filters had gradual 6-dB/octave slopes and cut-off frequencies at about 30 and 6000 Hz. (The LOW filter is rated to have a 12-dB/octave slope, but this was not attained down to our lower measurement limit of 20 Hz.) The RIAA phono equalization was extremely accurate, within the ±0.25-dB resolution of our test equipment, from 20 to 20,000 Hz. When the response was measured through the inductance of typical phono cartridges, the output was increased slightly but by no more than 1 dB at frequencies above 4000 Hz.

A 14-mV signal was required at the AUX input for a reference output of 1 watt at maximum gain. PHONO sensitivity was 0.21 mV for 1 watt, and the phono preamplifier overloaded at an extremely high input of more than 400 mV. The A-weighted signal-to-noise ratio, referred to 1 watt output under standard IHF test conditions, was 79.5 dB through the AUX and 77.4 dB through the PHONO inputs. The measured phono preamplifier input termination was 46,000 ohms in parallel with 220 pF.

In many respects, the FM tuner section was as exceptional as the receiver's audio amplifiers. IHF usable sensitivity was 9.8 dBf (1.6 μV) in mono, and stereo sensitivity was set by the switching threshold at 21 dBf (6 μV). The 50-dB quieting sensitivity was 13.8 dBf (2.6 μV) in mono, with 0.5% THD, while in stereo, it was 37 dBf (39 μV), with 0.35% THD. The FM distortion at a 65 dBf (1000 μV) input was 0.2% in mono and 0.22% in stereo, and the respective S/N readings were 78.5 and 71.5 dB.

The FM stereo frequency response was ±0.7 dB from 30 to 15,000 Hz, and channel separation was about 40 dB over most of that range, reducing to 35 dB at 30 Hz and 37 dB at 15,000 Hz. The 19-kHz pilot carrier leakage into the audio was 68 dB below 100% modulation, and the tuner hum was −67 dB. The muting and stereo thresholds were approximately the same, at 21 dBf (6 μV).

Capture ratio could not be measured reliably because of the non-defeatable afc (except by holding the tuning knob, which was not practical during measurements). AM rejection was 61 dB at 45 dBf (100 μV) input, and 65 dB at 65 dBf. Image rejection was exceptional at 97 dB, and alternate channel selectivity of 92 dB was one of the highest figures we have measured on a receiver (the adjacent channel selectivity of 3.7 dB was much more typical of present-day receivers and tuners). The only measurement made on the AM tuner section was of its frequency response, which was restricted even by the reduced standards of AM reception. It



Averaged frequency response and crosstalk for both channels.

(Continued on page 28)

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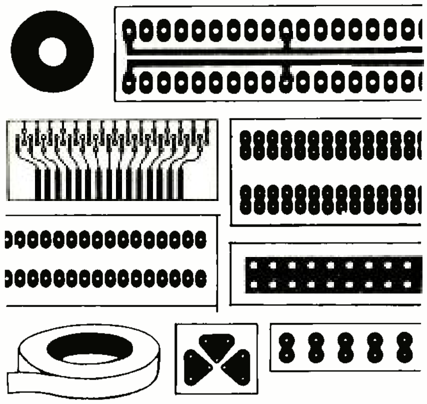

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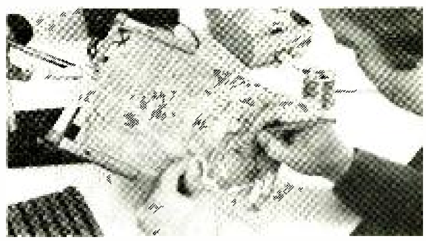

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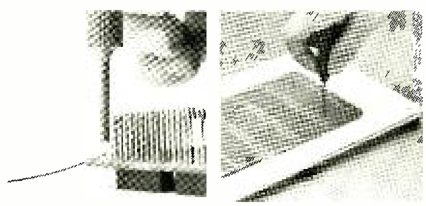

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was flat from 20 to 1000 Hz, but dropped to −6 dB at 2200 Hz.

The modulation percentage meter for the AIR CHECK CALIBRATOR was accurate, indicating 50% when the internal 400-Hz signal was set to equal the output from a 50% modulated FM signal. The audio power meters were acceptably accurate for their purpose, although they were calibrated at only 10-dB intervals. At most output levels, the meters indicated within 25% to 40% of the actual power, but there was not sufficient power available to produce a 100-watt indication on the meters. Meter response was rapid, with slow decay, so that the meters tended to follow dynamic program variations quite well.

User Comment. This impressive receiver manages to stand out from a field of generally very similar competitive products. Its audio-amplifier distortion levels are low by the most exacting standards. In fact, distortion cannot even be measured except with the most sophisticated laboratory instruments. Noise levels are very low, and phono overload is perhaps the highest of any receiver we have tested. Use of three entirely separate power supplies, regardless of audible benefits (about which we have reservations), certainly indicates a "no holds barred" approach to design.

FM tuner performance ranged from

a distinctive product inside and out as well as in performance quality

good to outstanding. Alternate-channel selectivity and image rejection, in particular, were far better than the norm, even for top-end receivers. Stereo channel separation was exceptionally uniform across the entire audio range. Separation was comfortably greater than that of any program source or the FM station. Unfortunately, the AM tuner sounded even more muffled than most.

It is in its operating controls and overall versatility that the SA-5901 really excels. All controls operated with an ideal tactile quality and a feeling of precision. We also appreciate the thought that went into the control layout, including designing the switches so that with all toggles up, the receiver is in a more or less "normal" or neutral operating condition. (With some fourteen switches that is not an insignificant accomplishment.)

An interesting sidelight is the use of relays to switch the speaker systems so that the front panel switch merely operates a low-level circuit. (The click of the relays is muted to the point where one might not be aware of their presence when this switch is operated.) The separate recording and listening program selectors, though not unique to Optonica, are still rare among receivers and amplifiers. In our view this is a highly desirable feature. The AIR CHECK CALIBRATION feature is also a worthwhile convenience for anyone who makes cassette recordings from FM broadcasts, since the recording level can be preset with assurance that no program peaks will exceed the recorder's dynamic range.

The Opto Lock afc system worked well. It removed the last trace of critical tuning from the handling of the receiver. From our experience with the SA-5901, we would say that there is no way one can tune in an FM station with it and get less than the full performance of which the receiver is capable. Exactly the opposite is true of most receivers we have used; there is almost no way one can achieve the same results we obtain in the laboratory in normal use.

All in all, we found the Optonica Model SA-5901 to be one of the more interesting receivers we have used. Although most receivers in a given price range tend to be more alike than different, the SA-5901 remains a distinctive product, inside and out, as well as in performance quality.

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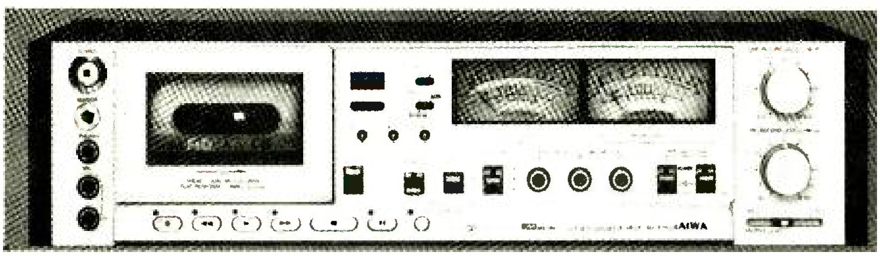


Aiwa Model AD-6900 cassette deck with variable bias

HIRSCH-HOUCK LAB REPORT

The premier feature of Aiwa's deluxe new Model AD-6900 cassette deck is a simple, effective means for optimizing bias and recording levels for virtually any tape formulation without external instruments or technical skills. Operation of the front-loading, three-head deck is controlled by solenoids through a sophisticated logic system. An optional remote-control accessory duplicates the functions of the front-panel control buttons. Recorder operation can also be controlled by certain Aiwa record players to make the deck go into record mode when a disc is being played and pause when the disc stops.

The deck measures 17¾"W × 13"D × 4¾"H (451 × 330 × 121 mm) and weighs 20.9 lb (9.5 kg). Optional wooden side panels and rack-mounting handles are available. Suggested retail price is $850.00.

General Description. Most of the deck's controls are conventional, but there are a couple of departures from usual practice. For example, the rewind and fast-forward buttons are labelled REW/REVIEW and F.FWD/CUE, respectively. Touching either button while the tape is at normal play will move the tape rapidly (at half the usual fast speed) in the indicated direction for as long as the button is pressed. Releasing the button instantly restores normal operation. During "cueing," the tape is close enough to the playback head that a high-pitched sound is heard when a recorded section of tape passes.

For normal rewind and fast-forward operation, the STOP button must be pressed first. After this, the rewind or fast forward button need be touched only momentarily to place the tape into high speed motion, with no sound heard from the outputs. If either cueing button is touched while the deck is recording, operation automatically goes to PLAY and continues in that mode when the button is released. LEDs indicate the selected mode.

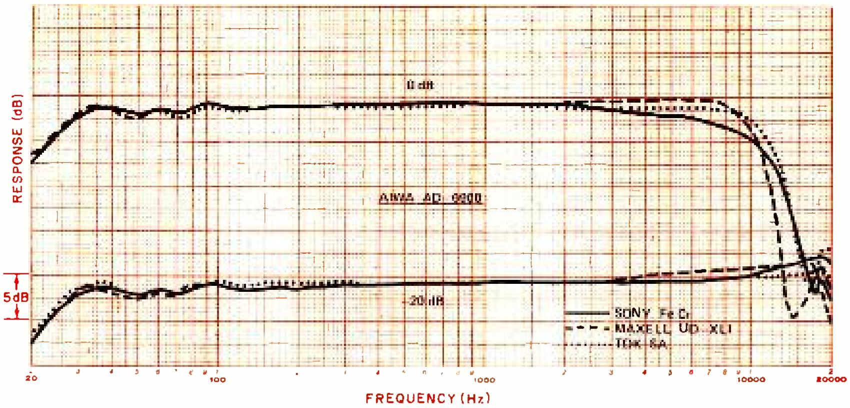
"peak hold" causes meter pointers to remain at highest levels

Another unconventional control is the REC MUTE/MUTING TIME COUNTER. Pressing and holding this button causes the deck to operate in the record mode, but the incoming signal is silenced and a red LED near the button blinks once per second. This facilitates timing an editing deletion while making a recording.

Standard phone jacks are provided on the front panel for microphones, headphone, and a LINE IN connection. Plugging a source into the last replaces the rear LINE IN signals with that from the front panel. This simplifies dubbing from another tape deck or high-level source, without disturbing normal system wiring.

The deck has a MEMORY rewind function that can be set to either stop the tape or to automatically put it into PLAY when the counter reaches 000 in rewind. The recorder can also be controlled by an external timer switch in its power-line circuit; a switch enables it to go into playback or record mode automatically when power is applied.

The front panel is dominated by two large illuminated meters. Each is actually two meters, with dual movements, pointers, and scales. The shorter black pointer gives conventional VU levels. The longer red pointer shows PEAK levels of as little as 10 ms duration and has a slower decay time of 1.5 seconds. The VU scale range is from −20 to +5 dB, while the PEAK range is from −50 to +10 dB. The two types of meter indications can be switched on separately. A button labelled PEAK HOLD freezes the PEAK meter pointers at their highest attained levels for at least 30 minutes.



Frequency responses at 0 and −20 dB for three different tape types.

Bias and equalization for the three basic tape types are selected separately by two small lever switches. The switches are labelled LH (normal ferric-oxide tapes), FeCr (for ferrichrome tapes), and CrO_2 (for either CrO_2 or high-performance ferric tapes that require high bias and 70-microsecond playback equalization.) Since individual tape brands within each category differ somewhat in their exact bias requirements and output levels, vernier controls are provided for each setting of the BIAS switch. Concentric with each control is a screw-driver-adjust control for setting recording level for that particular type of tape to give a standard Dolby-level output from the built-in oscillator.

Other front-panel controls provide for monitoring from either the SOURCE or the TAPE playback signal and control the Dolby system. The latter contains the usual filter to prevent FM pilot carrier leakage from affecting the frequency-sensing circuits.

The tape transport of the AD-6900

Performance Specifications

Specification	Rating	Measured
Frequency response		
LH (Maxwell UD-XL I)	25-14,000 Hz (+2/−3 dB)	25-19,000 Hz ±3 dB
FeCr (Sony FeCr)	25-18,000 Hz (+2/−3 dB)	25-20,000 Hz ±3 dB
CrO_2 (TDK SA)	25-17,000 Hz (+2/−3 dB)	25-20,000 Hz +1/−3 dB
S/N ratio	68 dB (FeCr, Dolby)	63.5 dB LH 63.5 dB CrO_2 62 dB FeCr
Distortion	0.9% (FeCr, 400 Hz)	0.56% (CrO_2, 1 kHz) 0.71% (LH, 1 kHz) 1.3% (FeCr, 1 kHz)
Wow & flutter	0.04% (wrms)	0.04% (wrms) ±0.07% (CCIR)
Rewind/fast forward time (C-60)	65 seconds	62 seconds
Input sensitivity	Mic: 0.25 mV Line: 75 mV	0.18 mV 50 mV
Input impedance	Mic: 200-10,000 ohms Line: over 50 kilohms	Not checked Not checked
Line output	0.41 V/0 VU	0.38-0.48 V/0 VU (depends on tape)
Bias/erase frequency	105 kHz	

uses separate motors for driving the capstan and tape hubs, with the hub drive operating at normal tape speeds to provide the correct tape tension and winding torque. In the fast speeds, it alone moves the tape. The goal of this tape transport design was to provide the low flutter of a closed-

playback head minimizes head-contour effects

loop dual-capstan drive in a lower-cost mechanism. The capstan is driven by a frequency-generator-feedback-stabilized dc motor.

Laboratory Measurements. According to Aiwa, the AD-6900 had been set at the factory for Maxell UD-XL I (LH), Sony Ferrichrome (FeCr), and TDK SA (CrO_2) tapes, which we used for our measurements. We also checked the record/playback frequency response with several other tapes to verify the effectiveness of the bias adjustment system.

Playback equalization was first checked with TDK AC-337 (120-μs) and Teac 116SP (70-μs) test tapes. The output at 120 μs (ferric EQ) varied only +1/−1.5 dB from 40 to 12,500 Hz. The response at 70 μs (chrome EQ) was +0.5/−1.5 dB from 40 to 8,000 Hz, but fell off to −5 dB at 10,000 Hz.

Overall record/playback frequency response with UD-XL I was flat within ±3 dB from 25 to 19,000 Hz at a −20-dB level. Response at a 0-dB recording level was within ±1.5 dB from 28 to 9500 Hz, which is unusually good for a cassette recorder. It fell below the −20-dB curve above 13,000 Hz. Sony FeCr tape gave a similar response but with a slightly more extended high-frequency output, varying ±3 dB from 25 to beyond 20,000 Hz. Its 0-dB recording level crossed the −20-dB curve at 15,500 Hz. Flattest overall response was measured with TDK SA tape—within +1/−3 dB from 25 to 20,000 Hz, also with a 15,500-Hz intersection of the 0-dB and −20-dB response curves. Almost identical results were obtained with Memorex High Bias and Maxell UD-XL II (CrO_2) and with TDK AD (LH). The TDK AD had noticeably less high frequency peaking, with a +1/−2-dB response from 27 to 17,000 Hz.

The Dolby circuits tracked well at all signal levels, probably due in part to the matching of the output level of each tape to Dolby requirements. There was never more than a 2-dB change in response at any frequency up to 16,000 Hz at levels from −20 to −40 dB when the Dolby system was switched in and out. The multiplex filter cut in sharply above 16,000 Hz, reducing the response at 19 kHz by at least 20 dB. The playback head is specially designed to minimize low-frequency-response irregularities, and our tests revealed relatively little response fluctuation due to head-contour effects.

For a 0-dB recording level, the line inputs required a 50-mV signal at 1000 Hz at maximum sensitivity, and the microphone inputs required 0.18 mV. The microphone preamplifier stage overloaded at 50 mV, a fairly safe figure. Playback output from a 0-dB recorded signal was about 0.4 volt with TDK SA and Sony FeCr and 0.48 volt with UD-XL I. Third-harmonic distortion in a 0-dB playback signal was 0.56% with SA, 0.71% with UD-XL I, and 1.3% with FeCr. Respective input levels required for 3% playback distortion were +7, +7, and + 4.5 dB.

Unweighted signal-to-noise (S/N) ratios, referred to the 3% distortion levels, were not outstanding. They ranged from 42 to 39.5 dB. With A-weighting, these figures improved considerably, to about 57 dB for SA and UD-XL I tapes and 54.7 dB for FeCr tape. With the Dolby system in use and CCIR/ARM weighting, S/N was 63.5 dB from the first two tapes and 62 dB with FeCr tape. At maximum gain through the microphone input, the noise level increased by 11.7 dB; but at normal gain settings, the increase was much less.

Calibration of the Dolby levels on the meters was exact. When set to the VU operating mode, the meters were much more heavily damped than true VU meters, which should indicate 99% to 101% of a steady-state signal level when driven by 0.3-second tone bursts of 1000 Hz at a 1-Hz repetition rate. Aiwa's meters indicated about 60% of steady-state values in this test. However, the PEAK meters gave exactly the same indications for continuous and burst signals.

Flutter was measured with TDK AC-342 and Aiwa test tapes, which gave similar results and confirmed the impressive claims made for the transport mechanism. JIS (weighted rms) flutter was 0.038% to 0.04%, and CCIR (weighted peak) flutter was +0.07% at the beginning of the test cassette. At the end of the cassette, JIS flutter had gone up slightly to 0.045%. Tape speed was 0.1% to 0.2% slow at the beginning of these tapes and 0.4% slow at the end. On a combined record/playback flutter measurement, readings were higher, as would be expected. They were 0.07% JIS and ±0.12% CCIR. In the fast speeds, the deck wound through a C-60 cassette in 62 seconds.

User Comment. The deck operated with a smooth, positive action and freedom from "bugs" or idiosyncrasies. There was a slight "clunk" from the solenoids as they operated, but the buttons themselves required almost no activating pressure, and the control logic appeared to be as foolproof as claimed. The EJECT lever, for example, can safely be pressed while the tape is in any mode, including fast winding.

The dual meters are certainly an effective means of setting up a cassette deck for full-fidelity recording. Using the PEAK HOLD feature, one can determine the maximum input level of the loudest passage of a program.

The tape adjustment system worked as claimed, in less time than it takes to describe it, and made frequency response essentially independent of the tape used. The small remaining response differences between tapes are mostly at frequencies beyond 10,000 Hz and are relatively

frequency response is essentially independent of tape type

subtle in their audible effects. Actually, the audible differences between tapes are more likely to result from differences in noise and distortion levels and in high-frequency saturation characteristics. This was demonstrated when we recorded white noise (FM hiss) and compared the source and playback signals. With any of the tapes used, it was possible to make a nearly perfect recording of the noise at some level between - 20 and 0 dB. However, reducing the level increased the extreme high-frequency response slightly while increasing the level reduced the highs slightly.

Our conclusion from these tests was that the AD-6900, used with any good-quality tape, can make recordings from FM radio or records without any audible difference between source and playback signals. This is about all one can expect from any cassette deck. The flutter in particular—as low as we have ever measured on a cassette deck—speaks eloquently for the construction of the AD-6900, as well as its design.

CIRCLE NO. 102 ON FREE INFORMATION CARD

Omnidirectional floor-standing Ohm I speaker system

THE Ohm I is a four-way speaker system that employs five drivers to give nearly omnidirectional radiation in the horizontal plane. This moderately large floor-standing unit has a slightly tapered cross section. Most of its audible output is radiated by three top-mounted upward-facing drivers that cover the entire range from 100 Hz to the limit of audibility.

On the front of the system are a "subwoofer" that operates at frequencies below 100 Hz and a "supertweeter" that is identical to the one on the top and effective principally above 10,000 Hz. The subwoofer and woofer are in separate vented enclosures, whose ducted ports open to the front of the cabinet.

Rated impedance is 4 to 8 ohms. The walnut cabinet has removable black cloth grilles on top and front. Size is 34½" H × 15½" square (876 × 394 × 394 mm) at the base, tapering to 13" square (330 × 330 mm) at the top. Weight is about 80 lb (36.4 kg). Suggested retail price is $650.

General Description. The Ohm I drivers were specifically designed for this system and, except for the subwoofer, have magnetic fluid cooling for their voice coils. The 12" (305-mm) subwoofer, whose enclosure occupies much of the cabinet volume, is vented through a 5" (127-mm) diameter ducted port. The woofer, which operates from 100 to 2000 Hz, is an upward facing 8" (203-mm) cone driver, with its separate enclosure volume also vented forward through a 4½" (114-mm) diameter ducted port.

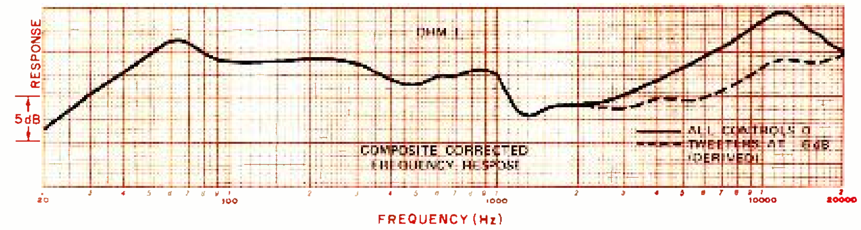
means are provided to drive the subwoofer alone for biamplification

On the top surface, near the woofer, is a 1½" (38-mm) cloth dome tweeter that radiates upward for maximum dispersion in its frequency range of 2000 to 10,000 Hz. A 1" (25.8-mm) cloth dome supertweeter near it operates above 10,000 Hz. To help overcome the increased absorption of the very high frequencies by ceilings and room furnishings, the super-tweeter is augmented by an identical front-radiating driver.

Also, on the system's top surface are four three-position switches for separately adjusting the levels of the midbass driver, tweeter, and each supertweeter. Each switch can reduce the level of its driver by either 3 or 6 dB. Means are provided for driving the subwoofer separately, should biamplified operation be desired.

Laboratory Measurements. The close-miked response of the two bass drivers was flat within ±2.5 dB from 35 to 1000 Hz, but the reverberent field measurement of the middle- and high-frequency response of the system revealed an apparent discontinuity in level between 1000 and 1500 Hz. The output dropped about 5 dB at that point and then rose smoothly with increasing frequency to a maximum at about 12,000 Hz before it fell off slightly at higher frequencies. These measurements were made with all level switches set to 0 dB (maximum output).

The MID-BASS switch affected the response between 200 and 2000 Hz, with a maximum reduction of 4 to 5 dB over much of that range. The LOW TWEETER switch had very little apparent effect, but the HIGH TWEETER switch reduced the output by as much as 6 dB at most frequencies above 4500 Hz.



Composite corrected frequency response.

When we spliced our two sets of data to form a composite frequency response, the resulting curve was ±6 dB from 24 to 20,000 Hz. By setting the tweeter level switches to −6 dB,

distortion was typically 1% or less from 45 to 100 Hz

the overall response variation could be reduced to ±4 dB over the same frequency range. System impedance reached its minimum of 3 ohms in the octave between 10,000 and 20,000 Hz, but was above 4 ohms below 5000 Hz. The maximum impedance was about 22 ohms at 52 Hz.

Despite its ported woofer and subwoofer systems, the Ohm I is relatively inefficient. With 2.83 volts of random noise in the 1000-Hz octave applied to it, the sound pressure level (SPL) was 84 dB at a distance of 1 meter from the upper front edge of the cabinet. This is comparable to typical acoustic-suspension speaker systems. If the tweeter levels are reduced to yield a flatter response curve, the efficiency goes lower still.

Tone-burst response of the system was good. Bass distortion, measured close to the cones of the woofer and subwoofer and to their port openings, was typically about 1% or less from 45 to 100 Hz. This was true whether we drove the system at 1- or 10-watt levels. (Our figures are based on an 8-ohm impedance, which is roughly correct for that frequency range.) At 1 watt, distortion rose to about 4% at 30 Hz and 5% at 25 Hz. At 10 watts the 30-Hz distortion was about 6%.

User Comment. For most practical purposes, the Ohm I can be considered omnidirectional in the horizontal plane. The front firing supertweeter contributes little to its audible sound, and the subwoofer is essentially omnidirectional. "Omni" speakers are dependent on room characteristics for their sound quality, and the level switches offer dozens of possibilities for altering system response. These factors make it especially difficult to generalize about the performance of the Ohm I, just on the basis of tests and use in a single environment.

Position in the room makes little or no difference in the sonic balance of the Ohm I. Although the system certainly delivers a full frequency range response, we usually found the sound rather dry and lacking in "warmth." At times we found it to be almost clinical in detail and often preferred to listen with the tweeter switches set to −3 or even −6 dB. At other times, and with different programs, we preferred to keep all switches at maximum. The

position in the room makes little difference in sonic balance

measured midrange response irregularity was not readily identifiable in the sound.

Summing up, the wide-range, omnidirectional Ohm I speaker system is capable of producing a smooth, clean sound throughout typical listening rooms, especially if one is willing to devote the time and effort to adjust its levels carefully. Rugged and relatively inefficient, it requires (and can handle) large amounts of power (from an amplifier than can handle the 3-ohm impedance of its topmost octave) if its qualities are to be fully enjoyed. On a wide variety of music, the system gave a fine sense of detail and better than adequate dynamic range.

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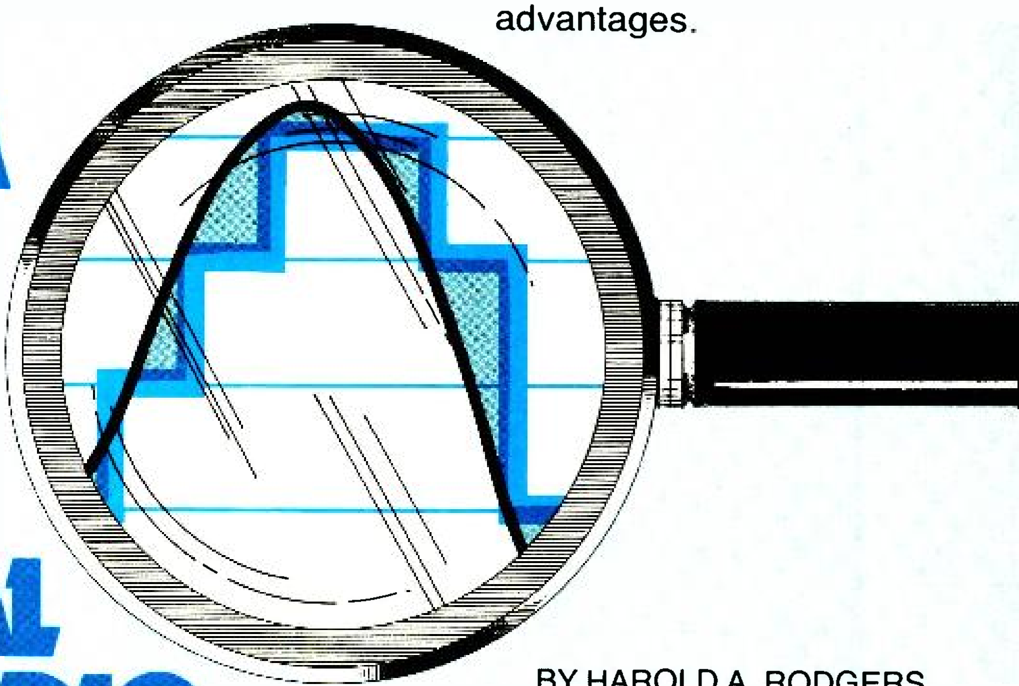
Popular Electronics®

SEPTEMBER 1979

Digital technology can offer a substantial improvement in audio reproduction. PE editors weigh its advantages.

A CLOSE LOOK AT DIGITAL AUDIO



BY HAROLD A. RODGERS
Senior Editor

with LESLIE SOLOMON
Technical Director

THE TELEGRAPH embodies many of the advantages to be found in digital transmission of information. Since all telegraph information is transmitted as a series of pulses, the linearity and signal-to-noise ratio of the system need only be good enough to allow the receiver to determine the presence or absence of a pulse. As payment for these advantages, we must accept the necessity of translating messages that do not in general originate in digital form (and cannot be used that way) at the input and output of the communications channel. Bandwidth of the channel is a key factor too, for it determines how fast the information can be sent.

Application of digital pulses to the high-fidelity reproduction of music is a fairly new development, largely because it is only recently that hardware with the capability of handling in real time the prodigious amounts of digital data necessary to represent a music signal have become reasonable in price. A large part of the technological development necessary to accomplish this was won through solving problems involved in remote telemetry from spacecraft. Probably the earliest samples of digital audio to be widely heard were the voices of Apollo astronauts as relayed back from space.

How Does It Work? Basically, a digital data-handling system must consist of at least three modules: an input section that handles analog data and translates it to digital code, a transmission channel (with or without a storage device), and an output section that reconverts the data to analog form and routes it to its destination. When dealing with sound, the original data is a continuous waveform that represents variations of air pressure as a function of time. Since it seems, at first glance, that a continuous signal can be chopped into infinitesimally fine segments, it is not clear how digital code limited to a finite number of elements might represent it.

Modern communication theory has shown that if the analog channel is band-limited to some maximum frequency, f, and sampled at a rate of 2f samples per second or more, the original signal can be reconstructed with no loss whatever. The band limitation is severe, however, and therefore places rigorous demands on whatever filter is used to realize it. This is particularly true when, in order to minimize cost, the sampling frequency barely exceeds twice the highest audio frequency. It is rare that a digital system intended to accommodate a 20-kHz bandwidth uses a sampling rate of more than 50 kHz.

Unfortunately, if signal energy is present in significant amounts at frequencies over half the sampling rate, the result is not just a loss of information, but a serious form of distortion (called *alias distortion*). What happens in effect is that the signal frequency beats with the sampling frequency to form products not present in the original. If a 35-kHz tone were allowed to interact with a 50-kHz sampling frequency, for example, a spurious 15-kHz tone would appear in the output. To combat this, filters used prior to sampling exhibit roll-off at extremely fast rates. Some critics complain that the phase shift resulting from such extreme slopes has audible effects, but there does not seem to be any objective evidence that strongly supports this claim.

To change our 40,000 to 50,000 analog samples to a digital signal, we will have to express each one as a number. The difficulty associated with this step is that, while values of the samples may fall anywhere between positive and negative extremes, size of the interval between two adjacent numbers in the set that must represent these values is fixed (depending on number of digits used to express the numbers). If, for example, decimal notation were employed, we would find that when using three-digit numbers the resolution between values could be no finer than one part in 10^3 or 1000. Using binary digits (bits), as is done in practice, we find resolution limited to one part in 2^n, *where n* is the number of bits.

Thus, there is an error *(quantization error)* between the original signal and the output of the analog-to-digital (A/D) conversion module. Analysis of this error shows that it is equivalent to noise. Since increasing the number of bits in the numbers representing the value of the samples makes the quantization steps smaller, it seems logical that by this action the quantization error and the noise it generates can be made as small as desired. This is, in fact, the case; each additional bit increases the S/N ratio by 6 dB.

Although signal conditions that limit the effects of quantization error to an increase in noise are met most of the time, there are circumstances under which it causes distortion. For example, a low-frequency sine wave whose amplitude is small enough to allow it to cross only a single quantization level would be converted to the digital equivalent of a square wave. This process introduces the same distortion products as does amplifier clipping, except that its confinement to low-level signals makes the effect more akin to crossover distortion. An additional penalty is exacted in the form of alias distortion when any of the false harmonics exceed one half the sampling frequency.

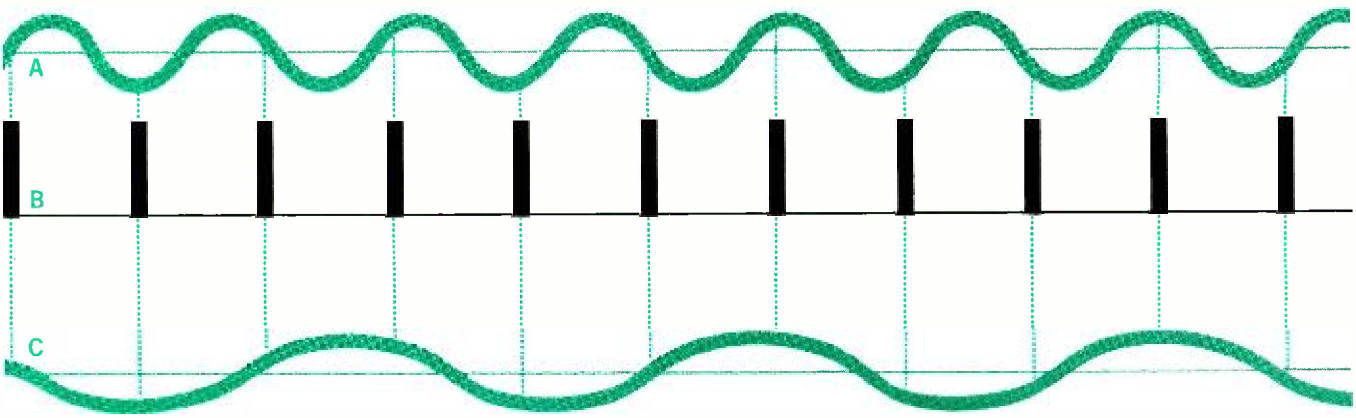
To offset this, a low-level signal with the correct spectral properties (white noise works very well) is added to the input audio signal to ensure that quantization error shows up as noise rather than distortion. Perceptually, the effect on the system from quantization error is now no worse than a small loss in S/N ratio.

Error Correction. While the immunity of digital information to disturbances in communication channels or storage media is high, it is not absolute. There is an appreciable likelihood that tape dropouts and interfering signals will cause digital data to be lost or altered. Since such losses can seriously degrade recovered audio, it is imperative that the system be able to cope with them.

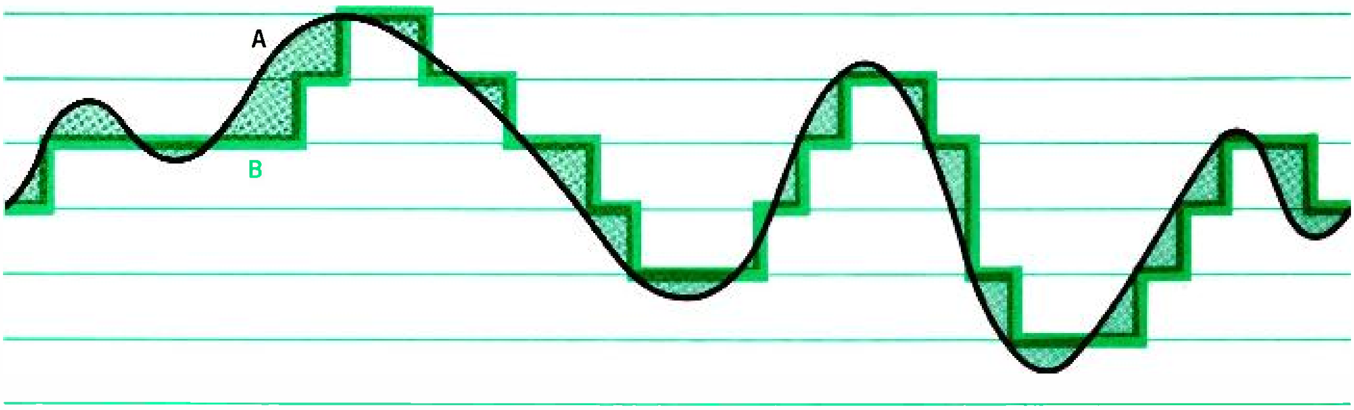
Error-correcting codes are, of course, nothing new to communication theory, although manufacturers of digital hardware indicate that some work has been necessary to find optimum codes for this application. The more elaborate codes allow the system to identify erroneous bits and correct them. A Sony spokesman estimated that the company's professional digital system will pass no more than one uncorrectable error per 100 hours of recording. The 3M Company states flatly that no uncorrectable errors have yet turned up in any of the recordings done on its machines.

Such prowess in error correction leads to the somewhat surprising result that, no matter how many generations of copies separate a particular dub from a master tape, the overwhelming probability is that the dub is *just as good as the master*. This turns out to be one of the most important properties of digital recording. Consumer systems, it should be pointed out, usually content themselves with error concealment, a technique in which erroneous digital words are identified and discarded, and the correct values estimated from digital words immediately before and after. This effectively hides the errors. Repeated copying will, in this case, produce cumulative errors. However, there is no reason why a consumer should expect assistance in dubbing copyrighted software. Error concealment is also applied to any uncorrectable errors that occur in professional systems.

Playback. The playback section of a digital audio signal chain is relatively straightforward. The data stream is read from the tape (or whatever storage medium is used), run through error correction (or detection) and loaded into a buffer memory. Like the A/D conversion performed in recording, the D/A conversion performed on playback is synchronized by a crystal-controlled clock. Time-base errors are thus limited to tolerances of the clock oscillators, making wow and flutter virtually a thing of the past. Since D/A converters can deliver false outputs in moving from one value to another, a sample-and-hold circuit is customarily used following this stage to prevent feedthrough of erroneous signals. An output low-pass filter normally protects outboard equipment following the digital system from the switching fre-



Alias distortion: sine wave A (top) has a higher frequency than pulse train B, the sampling waveform. Sine wave C, of lower frequency than A, gives same series of samples and appears in output when samples are reassembled.



Square cornered wave B is a quantization of smooth wave A across seven equally-spaced levels. Shaded area representing quantization error could be reduced by introducing more level with closer spacing.

quency and other ultrasonic components that might cause problems.

Controlling Costs. One of the major drawbacks of digital recording systems is cost. Systems using 16-bit resolution and a 50-kHz sampling represent just about the current limit of the state of the art—and they have price tags to match! Fortunately, the 90-odd dB of S/N ratio typical of these systems appears to be sufficient for professional applications.

Since consumer systems can dispense with some of the headroom required of professional systems, it would seem possible to reduce the number of bits they use. The critical question is, by how much? Barry Blesser, writing in the *Journal of the Audio Engineering Society*, points out that reducing the number of bits from 16 to 12 can drop system costs by a factor of as much as 100.

The simplest way to accomplish this is to simply design a system with fewer bits. The Phillips Digital Disc System, currently slated for introduction some time in 1981, will use a 14-bit code and accept as adequate the resulting 84-dB S/N ratio. Another approach, used in the Sony PCM-1 described elsewhere in these pages and in prototype disc systems developed in Japan, is floating-point or nonlinear encoding.

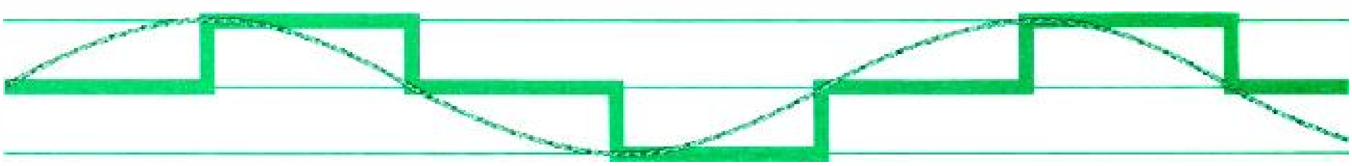
In floating-point encoding, the A/D converter at the input contains what is effectively a compressor that subtracts a constant from any voltages falling above a given threshold before encoding them. An extra bit appended to the digital word notifies the output D/A converter that this has been done and causes it to perform a complementary expansion on playback. The peak S/N ratio at any instant is still that which can be predicted by the bit resolution, but the dynamic range (the difference between the weakest and strongest signals the system can accept) is increased by the amount of compression/expansion.

Another technique used to minimize auditory effects of system noise is high-frequency pre-emphasis/de-emphasis. As in conventional tape recording, this trades high-frequency headroom for better noise performance. This could be disadvantageous in a system intended for recording live sources, but it is useful in systems biased heavily for playback use.

Miscellaneous Problems. Just as basic hardware of digital audio systems tends to be high in cost, so are ancillary items. Thus, a studio that wished to do not only its recording but its mixing and signal processing in the digital domain would require some fairly complex, specialized equipment. Mixing, for example, can no longer be performed by simple analog summation; a digital adder is required. Similarly, any change in system gain requires that each digital word be multiplied by a constant. Furthermore, equalization requires use of digital filters, which are usually programmed in software. Offsetting these fairly formidable requirements is the fact that digital hardware tends to be generalized. The equipment necessary for one kind of signal processing will usually perform other types as well. Such flexibility may foster development of new types of signal processing.

Editing is another problem area. The trusty razor blades that served so well during the era of analog recording must now be consigned to the recycling dump in favor of electronic methods. Equipment currently available is capable of letting the engineer analyze waveforms to be joined for both amplitude and slope and pick the junction point accordingly. Splices, which in a typical multi-track environment can be made at different points in the various channels, can be audibly perfect when this technique is applied.

Standards. At the present time, despite some efforts to the contrary, competing digital systems vary considerably in format. Sampling frequencies vary between about 44 and 50 kHz, and coding schemes range from 12-bit nonlinear to 16-bit linear. Lack of cross-compatibility between these various systems could eventually cause problems. Computer



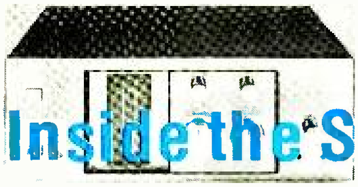
Low-frequency sine wave amplitude equal to plus-or-minus one least significant bit is converted to a quasi-square wave by quantization. The effect resembles amplifier clipping and introduces gross distortion.

routines have recently been developed to translate the digital code generated by one system into that of any other. Some degradation does occur in this process, but it is small enough to be acceptable provided several such conversions are not carried out in tandem.

Politics. The nature of the digital domain is such that format decisions are binding on performance. Thus, once a certain bit resolution is adopted, the S/N ratio is fixed with no possibility of improvement. Also, the choice of sampling rate places an absolute limitation on system bandwidth. This is in contrast to analog formats such as, for instance, the compact cassette, where successive improvements in tape and hardware have transformed a system originally designed for speech only into one that handles music with competence.

Such a state of affairs poses no conundrums when economics permit systems to be made much better than they need to be. But digital audio, on the contrary, almost demands that all reasonable compromises that might reduce costs be made. Since the effects of such compromises (and their irrevocable limits on performance) could persist in the marketplace for some time, caution would suggest that they be made only after the industry has sufficient experience to know what can be profitably traded away. In that sense, digital audio looks not like the final perfection of musical recording, but like the beginning of a new era.

Prospects for the Future. As might be expected, digital audio is already beginning to affect the established recording industry. London Records has released digitally mastered discs, and it seems likely some of the other major labels will do the same before too long. As



Inside the Sony PCM-1

BY LEWIS NANASSY
Sony Industries

Every digital recorder needs a high-speed, wide-band data-storage system. Professional tape machines tend to use high-speed transports operating at 30 ips or more for this purpose. To keep system cost down for consumer applications, the task can be assigned to a video tape recorder. To do this, some form of interface is necessary between the analog input signal and the video machine. The Sony PCM-1 is the first product of this type to reach the market (for about $4000). Here's how it works.

The PCM-1 converts two channels of audio information into a digital equivalent and arranges it in an appropriate format for recording on the VTR. It also includes means to change recorded digital signals from the VTR back into two channels of analog audio that could be fed to a conventional stereo system. The signal processor fits between the stereo audio system and the VTR (in this case a video cassette Betamax).

Signal Format. The digital data is recorded on the VCR as a series of magnetic pulses equivalent to zeros and ones. The digital audio information and error-checking elements (to be discussed later) are inserted within a conventional TV horizontal line as shown in Fig. 1.

The 94 bits are divided into 78 bits shared by the right and left audio information with the remaining 16 bits used for the CRC. Since a TV horizontal interval can support up to 110 bits, and there are 525 lines and 30 frames per second, it is possible for the TV signal to support up to 1.7 million bits per second. It is because of this that a VTR is used as a storage medium for digital audio.

Circuit Operation. As shown in Fig. 2, the

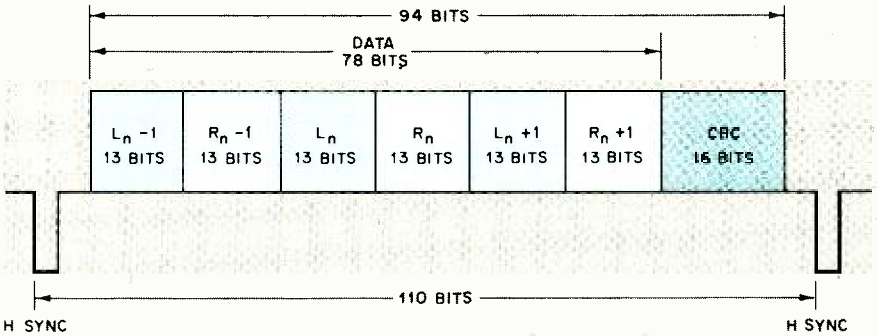


Fig. 1. Instead of video, each horizontal line contains digital information and error-correcting code.

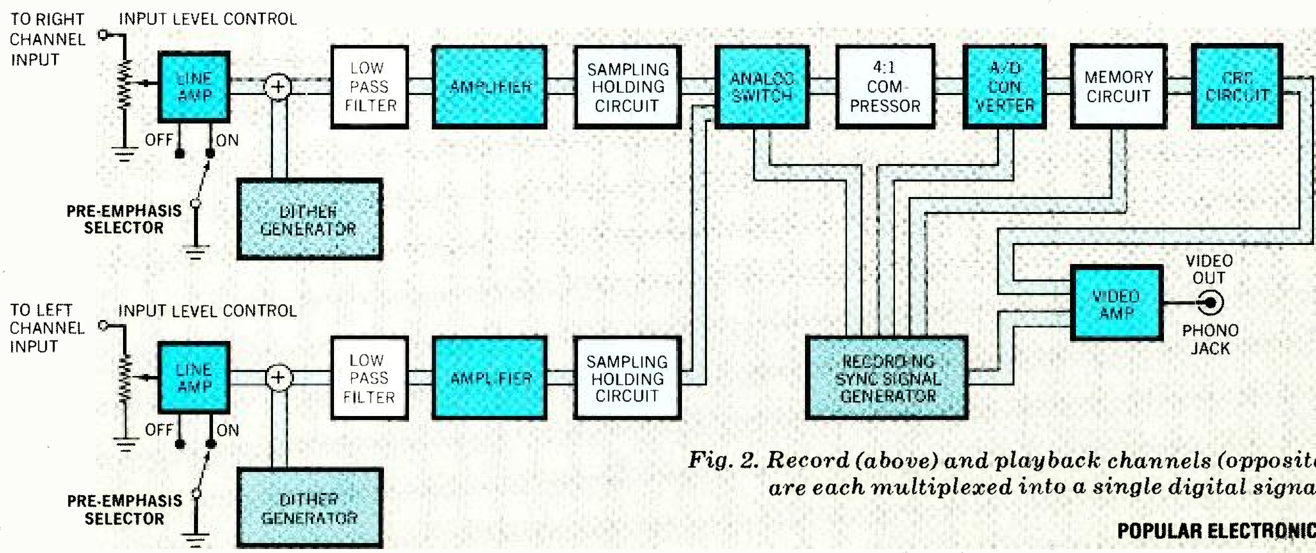


Fig. 2. Record (above) and playback channels (opposite) are each multiplexed into a single digital signal.

Soundstream's Dr. Tom Stockham pointed out at the 1979 Midwest Acoustics Conference, one of the tremendous advantages that digital audio offers to an institution that must store large numbers of master tapes is that of archival permanence. Once a performance is committed to a digital master tape, there is no reason why it should deteriorate at all with the passage of time. If a copy starts to age, a functionally identical dub can be made. It would be surprising, therefore, if record companies did not eventually phase in digital storage of their existing libraries.

Specialty recording companies have been using digital mastering for some time now, Nippon Columbia (Denon) being one of the first. The idea has since spread to the U.S., where it has been employed with apparent success by Telarc, Orinda, and Studio 80.

Generally, these discs have shown appreciably better sound quality than conventionally mastered discs. Unfortunately, the dynamic range of digital sources is so wide that making the transfer to disc without resorting to compression requires great care and, perhaps, prestidigitation as well. And some signal processing—diameter equalization and some means to prevent stylus lift due to excessive vertical (out of phase between the two channels) modulation at low frequencies—defies circumvention. For these reasons, there are many who believe that consumers will not enjoy the undiluted benefits of digital audio until digitally encoded software and the special players designed for it become widely available. (Note that while tape and discs seem to be front-runners among the storage media vying for hegemony in the digital marketplace, other media such as magnetic cards or highly miniaturized read-only memories could win out in the long run.)

The analog establishment is just not ready to roll over and die quite yet, however. For one thing, metal-particle tape

(Continued on page 46)

PCM-1 has separate record and playback sections. In the record mode, the analog audio input signals are amplified and applied to the line amplifier that sets up the desired signal levels and applies high-frequency pre-emphasis. To avoid problems with quantizing noise, a "dither" signal, generated from white noise developed across a zener diode, is added to the audio. It is this noise that fixes the final signal-to-noise ratio and that the pre-emphasis is designed to minimize. An improvement of about 7 dB is realized.

The audio is now sampled at a rate of 44,056 samples per second. The sample-and-hold circuits for the two channels are timed from a crystal oscillator and both are processed by the same A/D (analog-to-digital) converter, with a high-speed analog switch alternating the samples (Fig. 2). The output of the A/D circuit is digital code corresponding to the quantized value of the samples. To keep costs down, a 12-bit A/D converter is used. However, 12-bit resolution gives a dynamic range of only 72 dB, comparable to that of the best analog tape systems. A 4:1 compression applied before A/D conversion, yields another 12 dB of dynamic range when the signal exceeds the 0.93-volt reference level. In the playback mode, a 1-bit "flag" signal added to the 12-bit word is used to trigger a complementary 1:4 expander. This technique produces the equivalent dynamic range of over 84 dB, similar to that of a 14-bit system, although the instantaneous S/N ratio remains at 71 dB.

In operation, the comparator squares off the analog audio, with the output of the comparator feeding a digital counter formed from a series of flip-flops timed from the system clock. The flip-flops are coupled to a D/A converter that reconverts the digital signals into analog form. The new analog signal is fed to the other input of the comparator—when the two input signals are equal, the conversion is complete.

The digital word at the output of the A/D converter is fed to an 8K RAM that provides buffer storage and data interleaving. This allows for time compression required because the digital data signal cannot be recorded during the VTR sync pulses. Compression is achieved by clocking the digital data out of the memory intermittently at a faster rate than it was clocked in. All of the required clock signals, as well as the video sync signals are derived from a crystal-controlled oscillator. Next the digital data has its CRC (error-checking) elements inserted and is passed to the video output amplifiers, where it is mixed with the necessary video/sync signals. The composite output fed to the VTR input jack is 1-volt peak-to-peak NTSC video at 75 ohms output impedance.

In the playback mode, the amplified video signal is fed to a sync separator. The sync signals are used as a reference to allow the playback sync generator to compensate for slow drift and low-frequency time-base errors coming from the VTR. It is possible that (due to tape dropouts, for example) some of the pulses may be lost between recording and playback. Since a single false bit can drastically alter the digital word (a functional grouping of bits) of which it is a part, the system must include a check for such errors.

A special code, called CRC (cyclic redundance check) is central to the error-checking scheme. Each digital "word" (here a number representing the amplitude of a single sample of the audio signal) is divided by a standard number. The remainder from this division is appended to the digital word.

During playback, the digital word is divided

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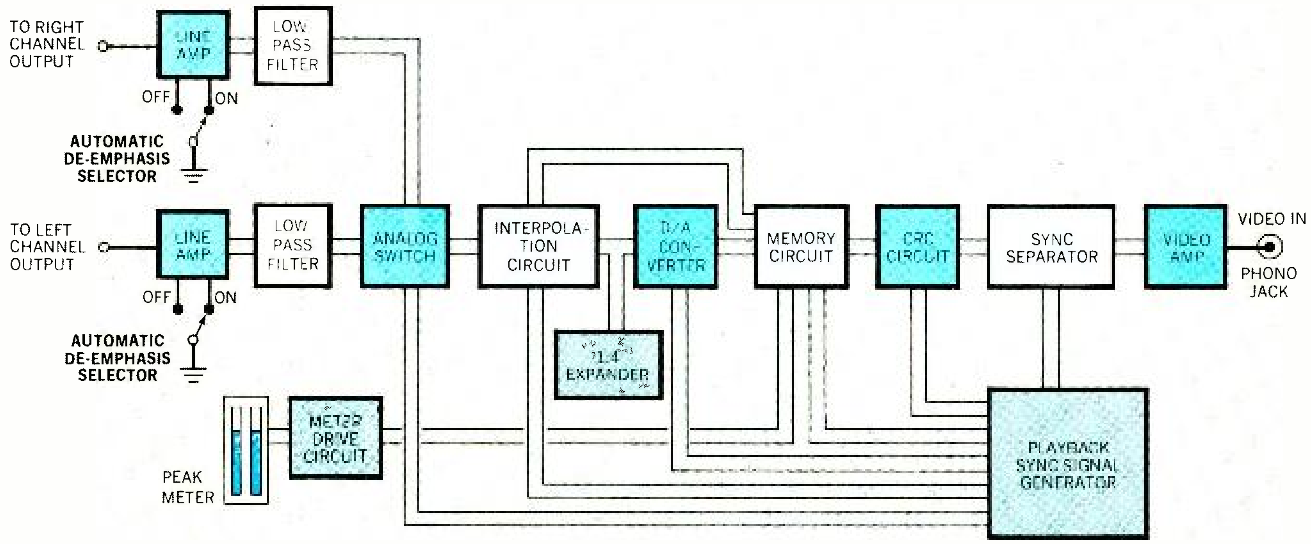

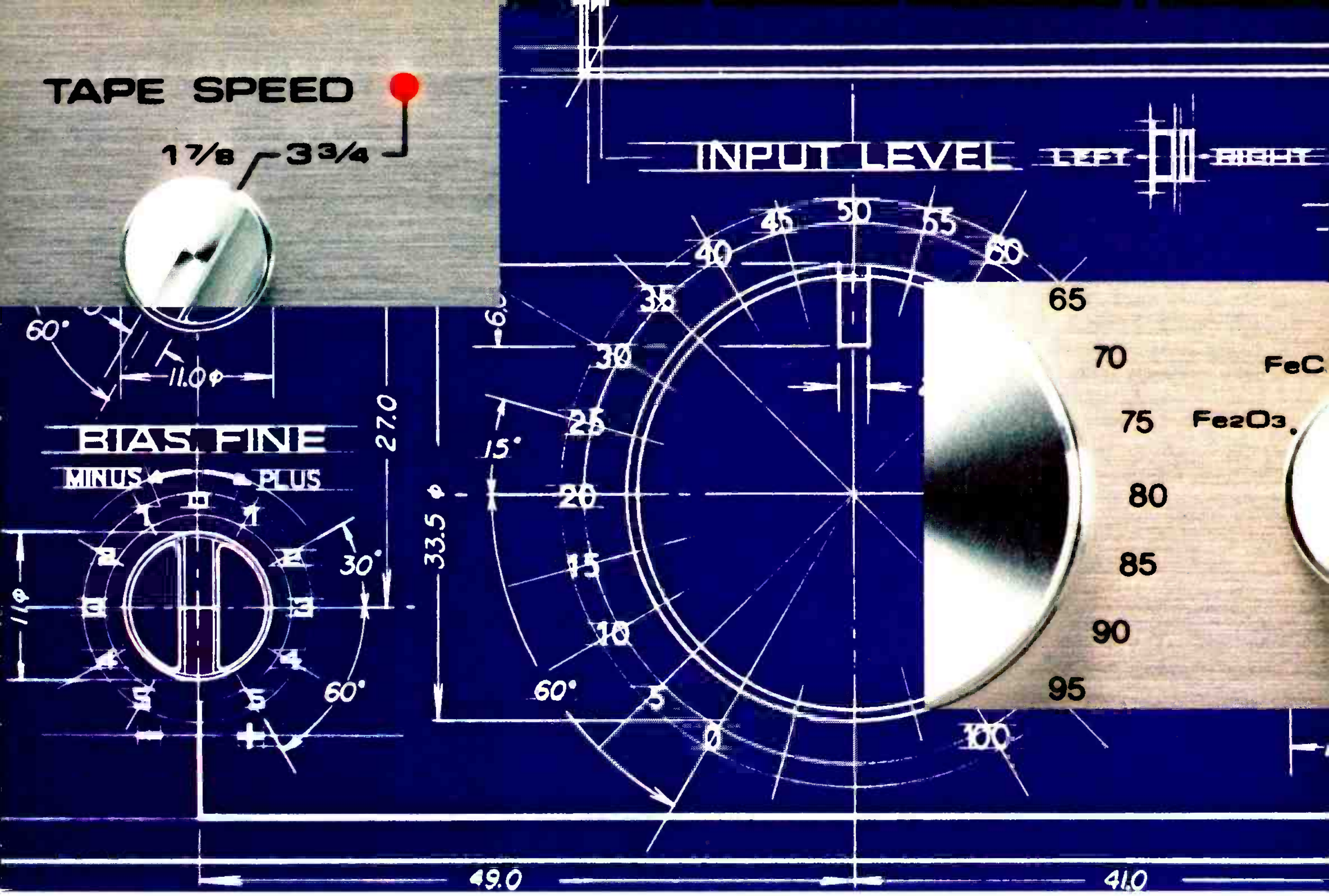

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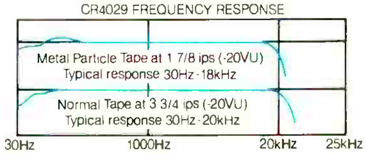

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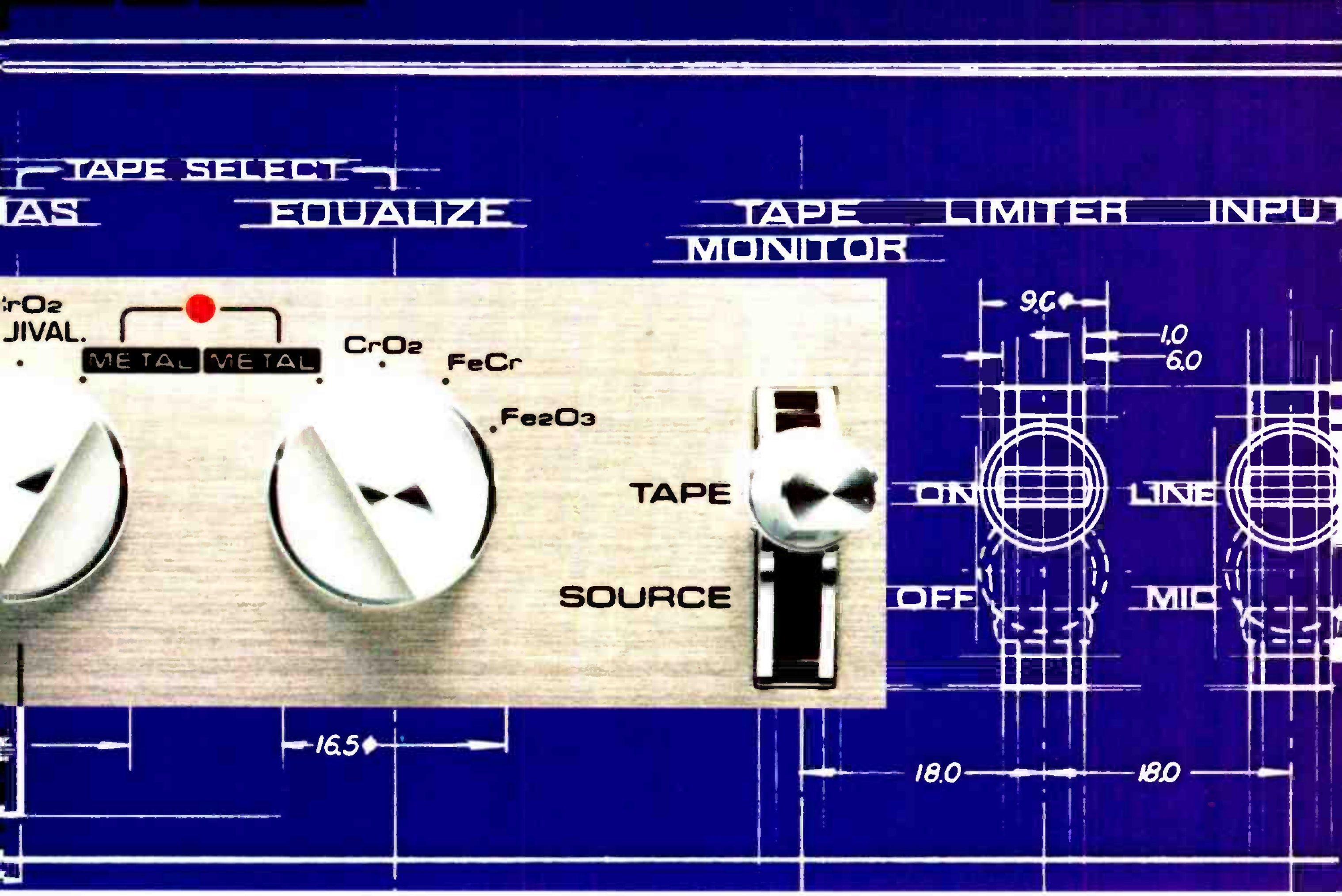
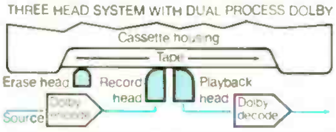
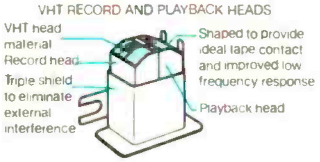




The separate playback head lets you listen to the actual recording already on the tape — as you record

CR4029 is a three-head design, each head can be optimized for a specific function. There's a wide 4 μm gap VHT record head for the best possible signal-to-noise ratio. A narrow 1 μm gap VHT playback head improves frequency response. And a Sendust alloy erase head overcomes the problem of hard-to-erase metal tape. The separate record and playback heads allow you to monitor as you record—an absolute must for serious recording.



ing. And Dual Process Dolby gives you the advantage of Dolby noise reduction in both the record/playback and off-the-tape monitoring mode.

THE CR4029 HAS ALL THE OPTIONS. Why have only part of the new tape technology when you can have all of it? Using the CR4029 three head system you can use metal tape at the standard 1⅞ ips speed, combining high performance with long play. Or use normal tape at the new 3¾ ips speed for both economy and superior performance. Or choose the ultimate: metal tape at high speed 3¾ ips, and exceed the expectations of the most critical enthusiasts.

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New guide for buying high fidelity equipment. Send $2.00 with name and address for Fisher Handbook to: Fisher Corporation, Department H, 21314 Lassen Street, Chatsworth, California 91311

SPECIFICATIONS:

Motor	(1) DC-Servo
Drive System	(1) Capstan
Number of Heads	3
Head Material	VHT/Sendust
Wow and Flutter	
1⅞ ips	0.06% WRMS
3¾ ips	0.05% WRMS
Signal-to-Noise Ratio (CCIR Weighted)	
(Dolby Off)	52dB
(Dolby On)	62dB
Frequency Response 1⅞ ips	
Normal Tape (± 3dB)	30Hz-14kHz
CrO₂ Tape (± 3dB)	30Hz-16kHz
FeCr Tape (± 3dB)	30Hz-16kHz
Metal Tape (± 3dB)	30Hz-18kHz
Frequency Response 3¾ ips	
Normal Tape (± 3dB)	30Hz-20kHz
CrO₂ Tape (± 3dB)	30Hz-22kHz
FeCr Tape (± 3dB)	30Hz-22kHz
Metal Tape (± 3dB)	30Hz-25kHz
Total Harmonic Distortion at OVU	
1⅞ ips	1.5%
3¾ ips	1.2%
Tape Selector Switch	Norm., CrO₂, FeCr, Metal
Bias Fine Adjustment	± 20%

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Digital Audio □ □ □

used on professional open-reel recorders offers increased dynamic range. Aided by advanced noise-reduction systems, such as Telefunken's c4d, these tapes could offer signal-to-noise ratios approaching the 90-odd dB available from digital systems. Granted, there will still be wow and flutter and modulation noise, but smaller recording studios, lacking the budget to go digital, might well tolerate these minor disadvantages in return for the wide dynamic range.

Noise reduction may help the conventional phono disc, too. The idea of applying dbx noise reduction to phono discs and playing them back through a decoder, which had little success in its first incarnation, has been reintroduced. In the transformed signal environment and sonic marketplace that now exist, partly due to the influence of digital recording, the dbx system should have far better prospects.

One of the telltale effects that tends to betray the action of a compander like the dbx is that any noise present in the original master tape will vary in level, often quite audibly, on playback. This was often exacerbated by the fact that mastering engineers, not foreseeing such demanding use of their product, are often content with master tapes whose signal-to-noise ratios are just a little better than that of the final disc. Indeed, most of us have probably heard discs on which the hiss from the master tape is clearly audible, which means that the tape S/N ratio can actually be a little worse than that of the disc.

With a digital master tape, the situation is vastly different. Here, the noise is usually so far below the level of the music that, even when the compander action makes it fluctuate, it remains, for practical purposes, inaudible. More to the point, the dbx system can accommodate the wide-ranging digitally reproduced signal without being backed up onto its remotest margins, as is a conventionally made disc. It would be foolhardy to predict how dbx will fare once digital disc systems are widely available to consumers, but for the foreseeable future digital mastering and compansion of analog discs seem to make a happy combination.

Whatever the long-term prospects of digital audio may be, it seems safe to say that it will materially influence the sound of reproduced music—and for the better. Its effects are already beginning to show and are certain to become greater with passing time. ◇

the Sony PCM-1

continued

by the same number. If the remainder is the same, the check bit is stripped off and the remainder of the digital word (the actual digitized audio) passes along for further processing. If the remainder is incorrect, the word is discarded and its value ultimately interpolated from the words immediately adjoining.

After error detection, the digital data stream is fed to a 16K random-access memory that acts as a buffer to take up any short-term time-base errors and to re-establish the original timing. Speed variations such as wow and flutter are thereby eliminated.

The digital signal is then coupled to a D/A converter to produce the equivalent analog signal. Each digital input line is wired to an electronic switch that, when closed, allows a constant current to flow into a scaled resistor network. The output voltage is dependent on how many switches are closed at that instant. The more active bits, the more switches and the higher the output voltage. Thus, each incoming digital word produces its instantaneous analog equivalent.

Now the signal goes to the 1:4 expander that re-establishes the original dynamic range. This is followed by an interpolation circuit that "patches" errors detected by the CRC. A high-speed electronic analog switch, toggled by the timing signal from the playback sync generator, separates the right and left channels. After passing through a low-pass filter that removes the sampling frequency and other undesirable high-frequency components, the two independent analog channels pass through line amplifiers where de-emphasis is applied. The resulting audio can then be routed to any good stereo amplifier/speaker combination.

Figure 3 compares the performance of the PCM-1 with that of a high-quality, 2-track, 38-cm/s tape recorder. ◇

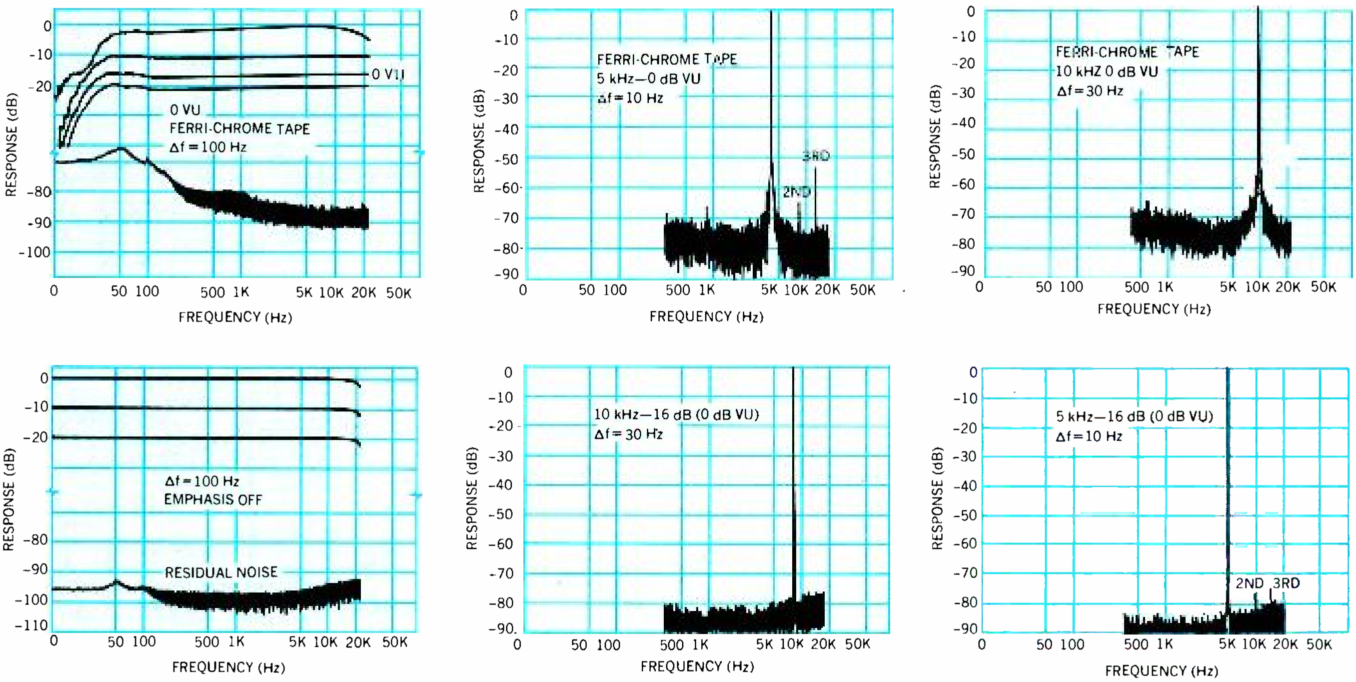
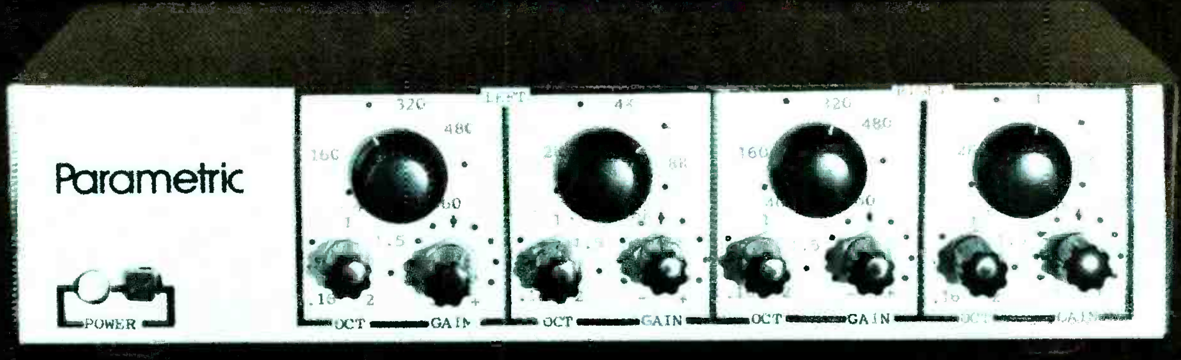


Fig. 3. Performance comparisons of a professional 2-track tape deck running at 38 cm/s (A, B, and C at top) with PCM-1 (D, E, and F) for (left to right) dynamic range, modulation noise, and distortion at 5 kilohertz.

BY JOHN H. ROBERTS



TAILOR THE SOUND OF YOUR AUDIO SYSTEM WITH THIS STEREO PARAMETRIC EQUALIZER

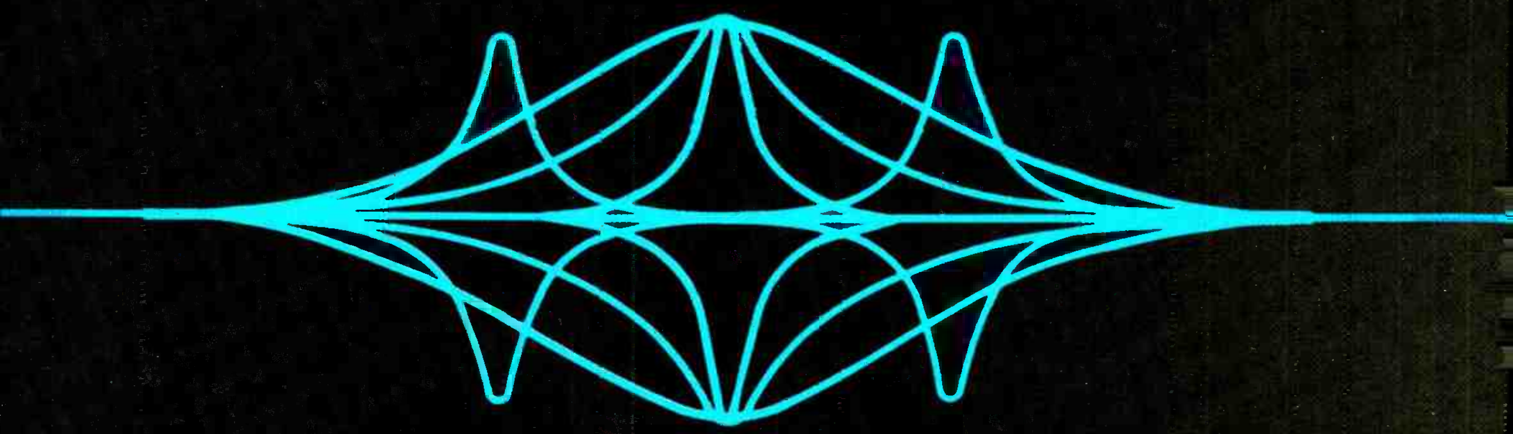
Low-cost, high-performance component employs BIFET operational amplifiers, can be powered by dc or ac sources.

AS THE state of the audio art has matured, whole new families of sophisticated components generically known as *signal processors* have become available for use in sound systems. Among the most popular category of signal processors is the equalizer. And the subcategory that has generated the most excitement among serious audio enthusiasts and sound professionals is the parametric equalizer.

As its name implies, each of the parametric equalizer's key parameters—its center frequency, filter bandwidth or Q, and amount of boost or cut introduced—can be independently adjusted. This provides extraordinary flexibility, allowing the user to tailor equalization to the precise needs for a particular program or room/system combination.

Presented here is a two-band parametric stereo equalizer with several features that commend it to the audiophile. It has been designed so that the Q and BOOST/CUT controls interact to compensate for the perceived change in loudness as filter bandwith increases or decreases. Furthermore, the circuit employs high-performance BIFET op amps, which combine the best of both junction-field-effect and bipolar-junction transistors in each amplifier. It can be powered by either the ac line or a 12-to-30-volt dc supply, making it equally "at home" in fixed, mobile, or portable applications. Finally, the Parametric Equalizer is relatively inexpensive—a line-powered stereo kit costs $99.00.

A Short Course in Equalization. Although last month's POPULAR ELECTRONICS contained a comprehensive



Audio Project □ □ □

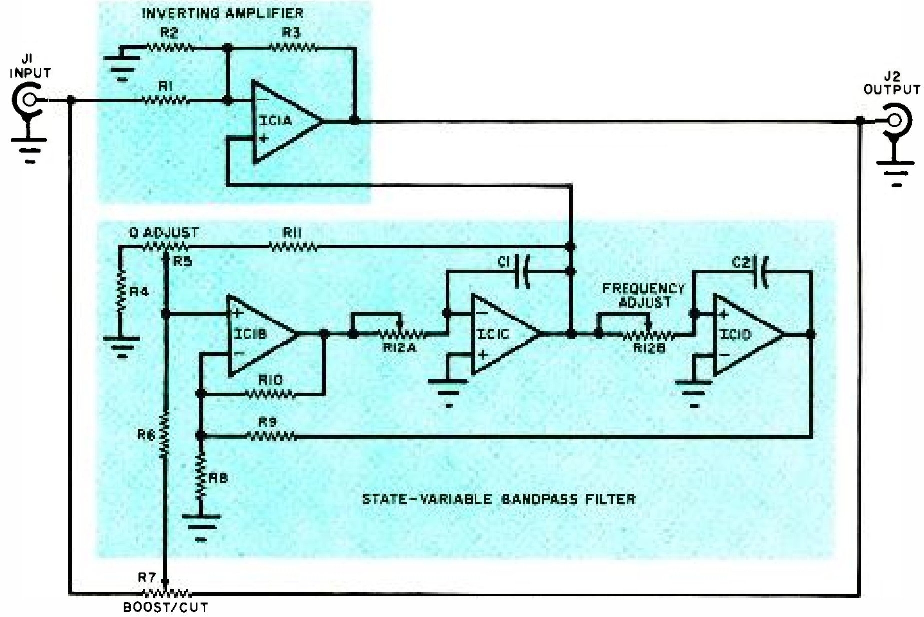
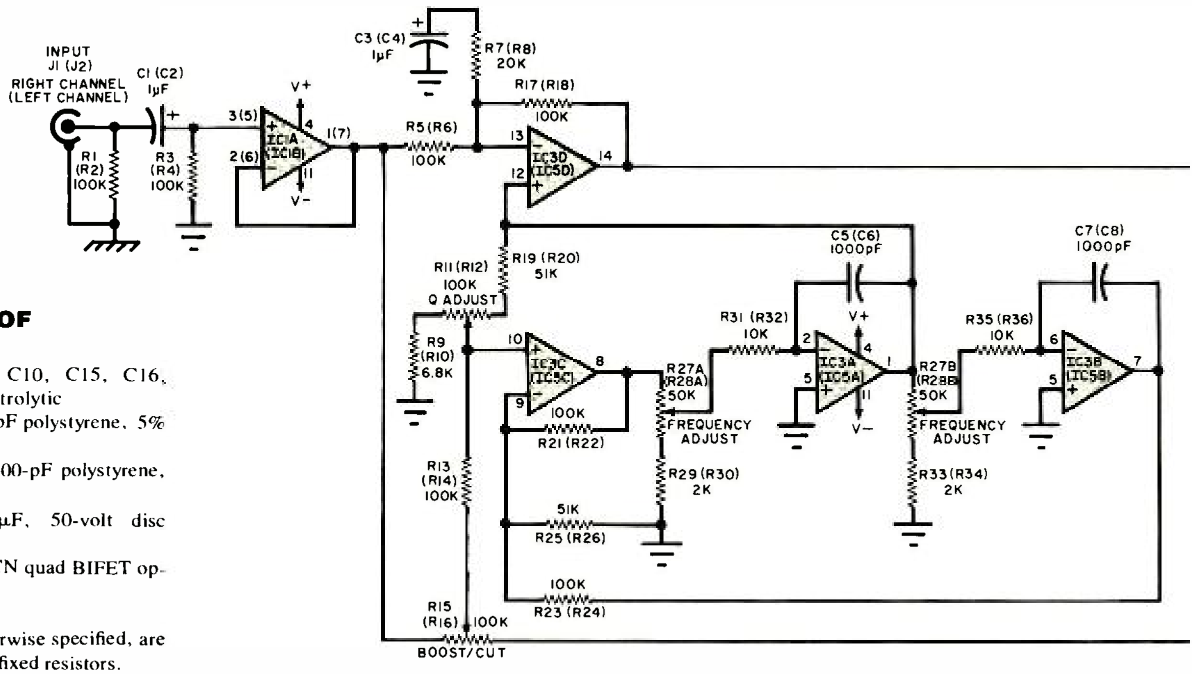


Fig. 1. Simplified schematic of one channel of equalizer shows that an inverting amplifier is interconnected with a modified state-variable active bandpass filter.

article about equalization ("The Art of Equalization" by Ethan Winer), here's a brief overview of the subject. The category of signal processors known as equalizer can be broken down into three subcategories: tone control or shelving types; graphic or peaking equalizers; and parametrics. All three are capable of boosting or cutting signal levels, but differ in the manner in which they generate the boost or cut, in the shapes of the frequency-response curves they produce, and in the size of the band of frequencies which they affect.

Tone controls are characterized by a gradual transition between the non-boosted and fully boosted (or unattenuated and maximally attenuated) frequency bands, levelling off to a fixed amount of boost or cut. The resulting frequency-response curve takes on the appearance of a shelf, giving rise to the name *shelving equalizer*.

Graphic equalizers divide the audio spectrum into a given number of bands with individual boost/cut controls for each band. The transition between the unaffected and fully affected regions is determined by the number of bands in the graphic equalizer. An inexpensive five-band or two-octave (so called because each band is two octaves wide) has a lower filter Q and therefore more effect over frequencies somewhat removed from the band of interest than a sophisticated professional equalizer which breaks the audio spectrum down into 30, one-third-octave-wide bands. In most consumer graphic equalizers, the center frequency of each band is fixed, although some more sophisticated units (and most professional graphics) allow the user some leeway in setting the center frequencies. The family of frequency-response curves generated by a graphic



MAIN PARTS LIST (TWO CHANNELS OF EQUALIZATION)

C1, C2, C3, C4, C9, C10, C15, C16, C20—1-μF, 25-volt electrolytic
C5, C6, C7, C8—1000-pF polystyrene, 5% tolerance
C11, C12, C13, C14—8200-pF polystyrene, 5% tolerance
C17**, C18**, C19*—0.1-μF, 50-volt disc ceramic
IC1 through IC5—TL074CN quad BIFET operational amplifier
J1, J2, J3, J4—Phono jack
The following, unless otherwise specified, are ¼-watt, 5% carbon-film fixed resistors.
R1 through R6, R13, R14, R17, R18, R21, R22, R23, R24, R37, R38, R45, R46, R49, R50, R53, R54, R55, R56, R74, R75—100,000 ohms
R7, R8, R39, R40, R63, R64, R67, R68—20,000 ohms
R9, R10, R41, R42—6800 ohms
R11, R12, R15, R16, R43, R44, R47, R48—100,000-ohm, linear-taper potentiometer
R19, R20, R25, R26, R51, R52, R57, R58—51,000 ohms
R27, R28, R59, R60—dual 50,000-ohm linear-taper potentiometer
R29, R30, R33, R34, R61, R62, R65, R66—2000 ohms
R31, R32, R35, R36—10,000 ohms
R69, R70—100 ohms
R71**, R72**, R73*—10 ohms
Misc.—Printed circuit board, pc standoffs, IC sockets or Molex Soldercons, hookup wire, shielded cable, solder, machine hardware, control knobs, suitable enclosure, etc.
*—Dc version only
**—Ac version only

equalizer resembles a series of peaks and valleys. That's why some audiophiles refer to graphic equalizers as "peaking" types.

The parametric equalizer is a variation on the graphic equalizer theme. In addition to an individual boost/cut control, each band of a parametric equalizer also has center-frequency and bandwidth or filter Q controls. This means that the amount of boost or cut introduced, the center frequency of the band of equalization, and the bandwidth within which the equalization is applied (as well as the transition between the frequencies that are unaffected and those which are boosted or cut the most) are all independently variable. The parametric equalizer thus gives its user the ultimate in control over the sound recorded on tape or reproduced by his speakers.

About the Circuit. A simplified schematic of the Parametric Equalizer is shown in Fig. 1. Only one equalizer section of one channel's circuit is shown, and input buffering and output decoupling details are omitted. Similarly, power supply connections are not shown. It can be seen that the simplified schematic is that of an inverting amplifier (*IC1A*, *R1*, *R2*, and *R3*) interconnected with a modified "state variable" active bandpass filter. Such a filter is composed of two active integrators connected in cascade (*IC1C*, *IC1D*, and associated passive components) and a differential amplifier (*IC1B* and associated passive components).

PERFORMANCE SPECIFICATIONS
(Supplied by the Author)

Center frequency range: 40 to 16,000 Hz in two bands—40 to 960 Hz, 500 to 16,000 Hz

Frequency response: 3 to 100,000 Hz, +0 dB, −1 dB with all controls at their flat settings

Input impedance: 50,000 ohms

Input/output gain: 0 dB

Intermodulation distortion (SMPTE): Less than 0.007%

Maximum output: 8 volts rms into a 10,000-ohm load when powered by ±15-volt supply

Maximum boost/cut: ±20 dB at 0.16-octave bandwidth

Output impedance: 100 ohms

Output noise: −70 dBm unweighted, −89 dBm "A" weighted

Range of Q adjustment: 0.16 to 2 octaves (−3-dB bandwidth)

Total harmonic distortion plus noise: below 0.04% from 20 to 20,000 Hz

This circuit was chosen for use in the Parametric Equalizer because its center frequency and Q can be varied independently of each other. The filter's center frequency is selected by adjusting dual potentiometer *R12*. Filter bandwidth and Q are dependent upon the values of *R4* and *R11* and the setting of potentiometer *R5*. For the component values employed in this project, filter bandwidth and Q can be adjusted over a range of 0.16 to 2 octaves at the −3-dB points. (The relationship between bandwidth at the −3-dB points and filter Q is given by the simple equation $BW_{-3\,dB} = 1/Q$.)

To convert a state variable active bandpass filter into the desired all-pass circuit with adjustable boost and cut, a potentiometer (*R7*) is connected between the inverting input and the output of unity-gain amplifier *IC1A*. The wiper of this potentiometer is connected to the input of differential amplifier *IC1B*. Signals appearing at the output of integrator *IC1C*, which are inverted with respect to those appearing at its input, are applied to the noninverting input of *IC1A*.

When the wiper of *R7* is at the *J1* extreme of its travel, the bandpassed signal adds to the input signal, boosting the amplitude of signals within the filter's passband. When the wiper is at the *J2* extreme of its travel, the bandpassed

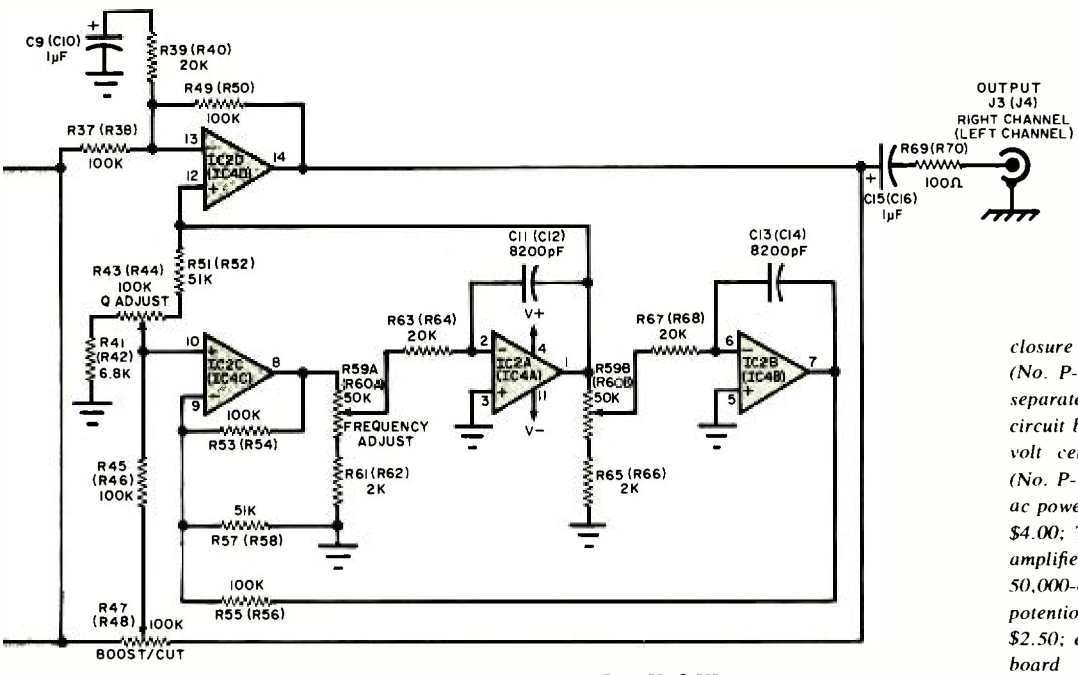


Fig. 2. The complete circuit for a two-channel equalizer. Part numbers not in parentheses are for right channel of a stereo system, others are for left channel. For components with asterisks, see Figs. 3 and 4.

Parts Availability

Note—The following are available from Phoenix Systems, 375 Springhill Road, Monroe, CT 06468 (203-261-4904): Complete kit of parts including enclosure for ac-powered stereo equalizer (No. P-94-S) for $99.00; Complete kit of parts including enclosure for dc-powered stereo equalizer (No. P-94-SC) for $89.00. Also available separately: etched and drilled main printed circuit board (No. P-94-AB) for $8.00; 20-volt center-tapped stepdown transformer (No. P-94-T) for $6.50; etched and drilled ac power supply board (No. P-04-PSB) for $4.00; TL074CN quad BIFET operational amplifier IC (No. P-94-C) for $2.50; dual 50,000-ohm, linear-taper, closely tracking potentiometer (No. P-94-2X50KB) for $2.50; etched and drilled dc power supply board (No. P-94-PSBC) for $2.00; 100,000-ohm, linear-taper potentiometer (No. P-94-100KB) for $1.00; p.c.-mount, push-on/push-off power switch (No. P-94-SL) for $1.00. Add $1.00 handling charge for orders less than $10.00. Add $1.00 for COD orders. Canadians add $2.50 postage. Connecticut residents add state tax.

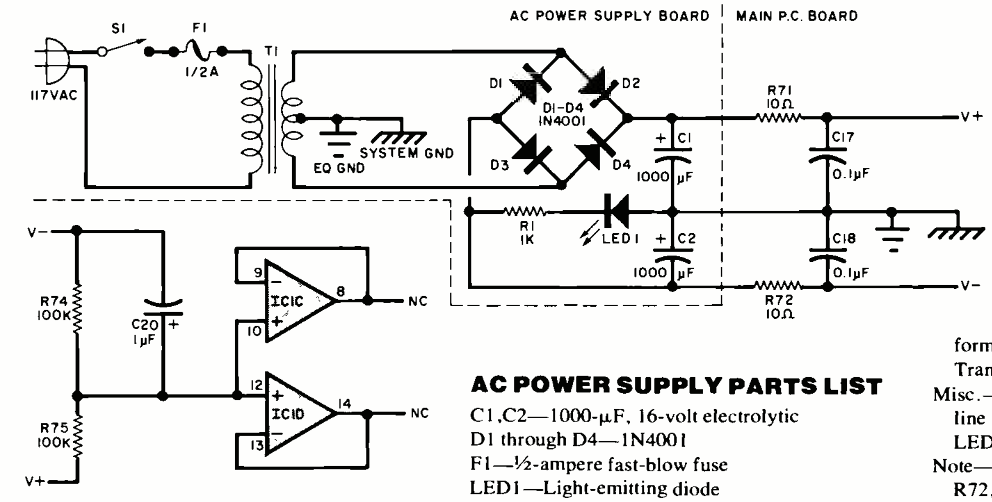


Fig. 3. Schematic of power supply to use with an ac source. It is a conventional full-wave circuit giving plus and minus 15 volts to ground.

AC POWER SUPPLY PARTS LIST

C1,C2—1000-μF, 16-volt electrolytic
D1 through D4—1N4001
F1—½-ampere fast-blow fuse
LED1—Light-emitting diode
R1—1000-ohm, ¼-watt, 5% resistor
S1—Spst switch
T1—20-volt, center-tapped stepdown transformer, secondary rating 100 mA (Signal Transformer No. ST-4-20 or equivalent)
Misc.—Printed circuit board, pc standoffs, line cord, strain relief, hookup wire, solder, LED mounting collar, hardware, etc.
Note— Components C17, C18, C20, IC1, R72, R74 and R75 are mounted on the project's main printed circuit board and are included in the Main Parts List. See Fig. 1 for Parts Availability.

signal subtracts from the input signal, attenuating input signals within the passband of the active filter. Finally, when the wiper of *R7* is at the midpoint of its travel, the output of *IC1A* cancels out that portion of the input signal appearing at the wiper because the two signals are 180° out-of-phase. This means that no signals are routed to the bandpass filter, the filter generates no output, and has no effect on *IC1A*. The result is that inverting amplifier *IC1A* exhibits a flat frequency response.

There are two equalizer sections for each signal channel. (Only one section is shown in Fig. 1.) The center frequency of the low-band equalizer can be adjusted from 40 to 960 Hz, and that of the high-band equalizer from 500 to 16,000 Hz. Both the setting of the BOOST/CUT potentiometer and the value of filter Q determine the amount of boost or cut introduced by each equalizer section. The maximum boost or cut is ±20 dB at a filter bandwidth of 0.16 octave, and ±12 dB at a bandwidth of 2 octaves. This interaction makes the Q control more convenient to use because parametric designs not incorporating it often require readjustment of equalizer gain after the filter Q has been changed.

The master schematic of the main Parametric Equalizer circuit is shown in Fig. 2. The most likely application for this project is in a stereo sound system, so the schematic describes a two-channel equalizer. All components pertaining to the right signal channel have part numbers not shown in parentheses. Those for the left channel, however, have part numbers which are shown in parentheses. The rest of this discussion will refer only to the right signal channel but is equally applicable to the left.

Input signals are applied to jack *J1*, where *R1* and *R3* (which are effectively in parallel) provide a high-impedance load. Capacitor *C1* blocks any dc level that might be accompanying the input signal. Buffering is accomplished by voltage follower *IC1A* which isolates the input from the rest of the circuit. Output signals from the voltage follower are then applied to two cascaded equalizer sections, each of which employs a TL074CN quad BIFET operational amplifier IC.

Each section closely resembles the simplified schematic shown in Fig. 1. That employing *IC3* is the high-band equalizer circuit. Its center frequency is adjustable by means of dual potentiometer *R27* over a range of 500 to 16,000 Hz. Potentiometer *R11* is the filter's Q ADJUST control and potentiometer *R15* (along with the Q of the filter) determine the amount of boost or cut introduced.

The second equalizer circuit (the one

(Continued on page 57)

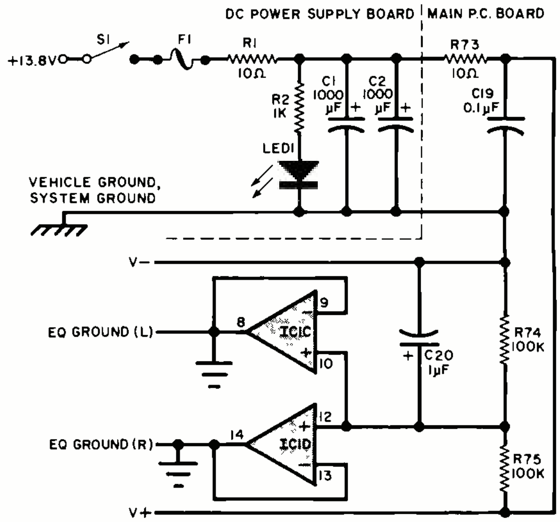


Fig. 4. Use this circuit if a dc supply is to be employed. The IC voltage followers derive an artificial equalizer ground.

DC POWER SUPPLY PARTS LIST

C1,C2—1000-μF, 16-volt electrolytic
F1—½-ampere fast-blow fuse
LED1—Light-emitting diode
R1—10-ohm, ¼-W, 5% resistor
R2—1000-ohm, ¼-W, 5% resistor
S1—spst switch
Misc.—Printed circuit board, pc standoffs, machine hardware, etc.
Note—Components C19, C20, IC1, R73, R74, and R75 are mounted on the project's main printed circuit board and are included in the Main Parts List. See Fig. 1 for Parts Availability.

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(Continued from page 50)

employing *IC2*) is the low-band unit. Dual potentiometer *R59* allows adjustment of its center frequency over a range of 40 to 960 Hz. The filter's Q is adjusted by varying the setting of potentiometer *R43*. Signals within the filter passband can be boosted or cut by means of potentiometer *R47*.

Output signals from *IC2D* are coupled to output jack *J3* via *C15* and *R69*. The electrolytic capacitor blocks any dc offset appearing at the output of the operational amplifier and the resistor provides decoupling. Signals can be routed from the output jack back to the tape monitor loop of a preamplifier or receiver, if that is where drive signals were taken, or to the input of the power amplifier if drive is obtained from the preamplifier output.

Power supply details are omitted from the main schematic for simplicity's sake, but each IC's power supply pins are denoted. The Parametric Equalizer can be powered by either the ac line or a 13.8-volt dc automotive electrical system. Schematic diagrams of the ac and dc supplies are shown in Figs. 3 and 4, respectively. The ac supply is a conventional full-wave circuit employing a 20-volt, center-tapped transformer. Diodes *D1* through *D4* rectify the low-voltage ac into bipolar, pulsating dc which is filtered by *C1* and *C2*. Light-emitting diode *LED1* functions as a pilot light. All components except for decoupling resistors and capacitors *R71*, *R72*, *C17* and *C18* are mounted on a separate power supply circuit board. The output of the supply is ±15 volts dc.

The dc supply employs voltage divider *R74R75* and voltage followers *IC1C* and *IC1D* to derive an artificial equalizer ground at one-half the full voltage delivered by the electrical system powering the circuit. Note, however, that the voltage divider should be connected to the noninverting inputs of the voltage followers even if the ac supply is used to power the circuit. This is done to prevent unwanted oscillation. The outputs of the followers are left uncommitted when the ac power supply is employed.

Light-emitting diode *LED1* acts as a pilot light, and electrolytic capacitors *C1* and *C2* filter any noise present on the dc line. Note that decoupling components *R73* and *C19* as well as the "equalizer ground" deriving circuit are located on the main printed circuit board.

In the dc-powered equalizer, the negative supply voltage pins of the quad operational amplifier IC's are connected to the vehicle and sound system ground (shown in the schematics as "earth

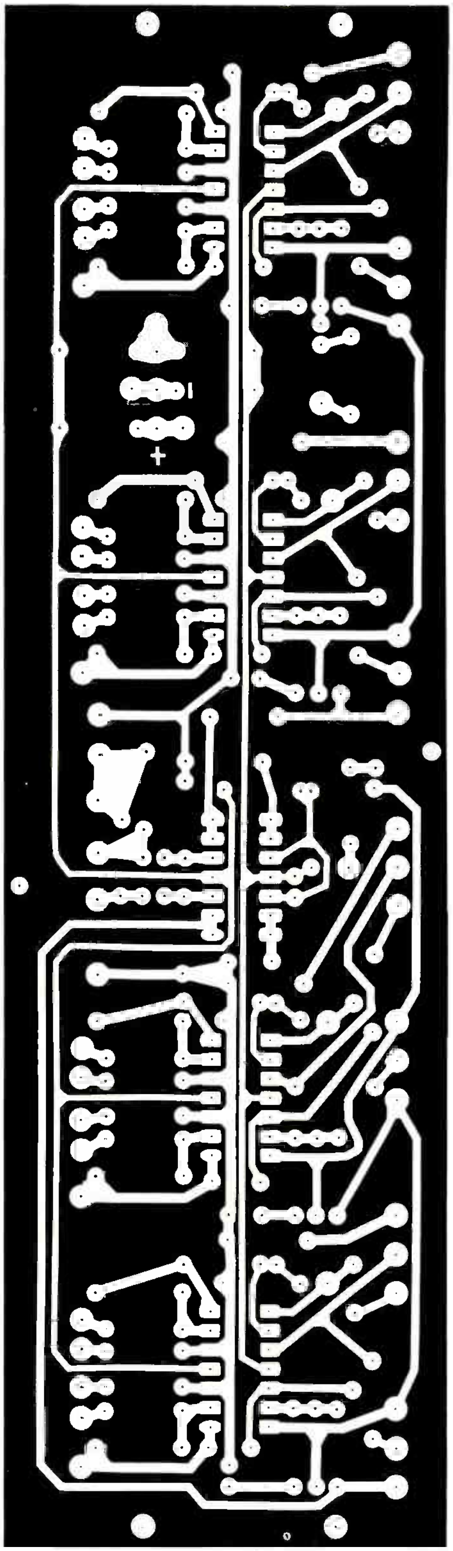

Fig. 5. Actual-size etching and drilling guide for the main printed circuit board.

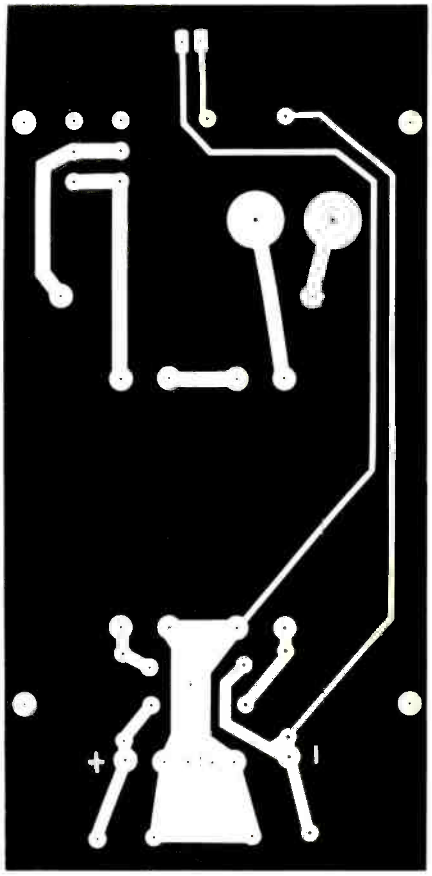

Fig. 6. Use this board for an ac power supply.

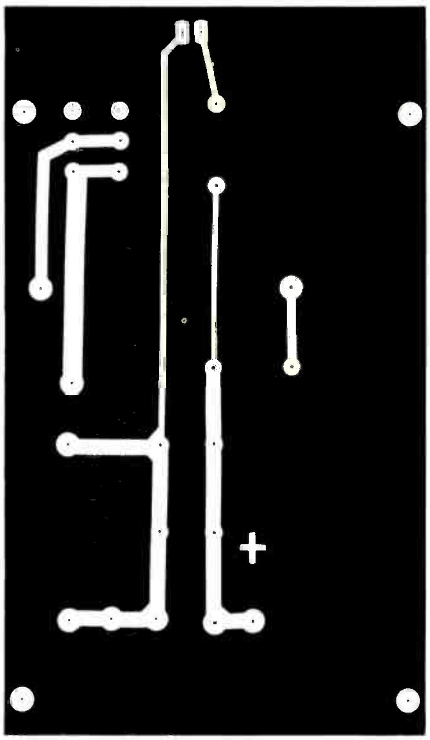

Fig. 7. If a dc supply is available, use this board.

Audio Project □ □ □

ground" symbols). The artificial grounds derived by *IC1C* and *IC1D* are shown as conventional "chassis ground" symbols. Note that the grounds within the equalizer sections (for example, the noninverting inputs of the op amp integrators) are artificial grounds above vehicle and system ground.

Capacitive coupling between the input jack and the op amp input buffer and between the output of the high-band equalizer and output jack prevents dc offsets both internal and external to the equalizer from having a deleterious effect on the performance of the entire system. It is because of the dc offsets present in the dc-powered equalizer that the "hot" sides of the input and output jacks are returned to system ground but the signal

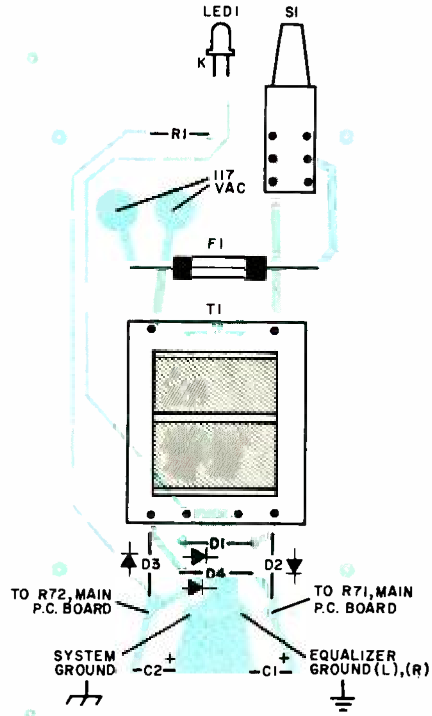

Fig. 9. Component placement for the ac power supply.

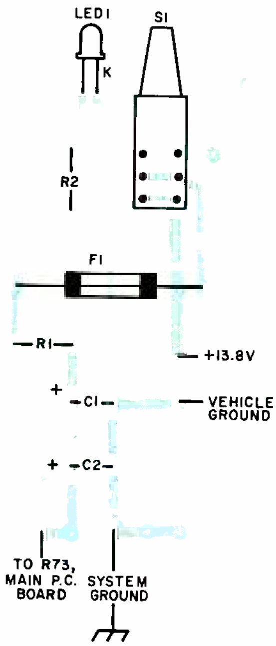

Fig. 10. Component placement for the dc power supply.

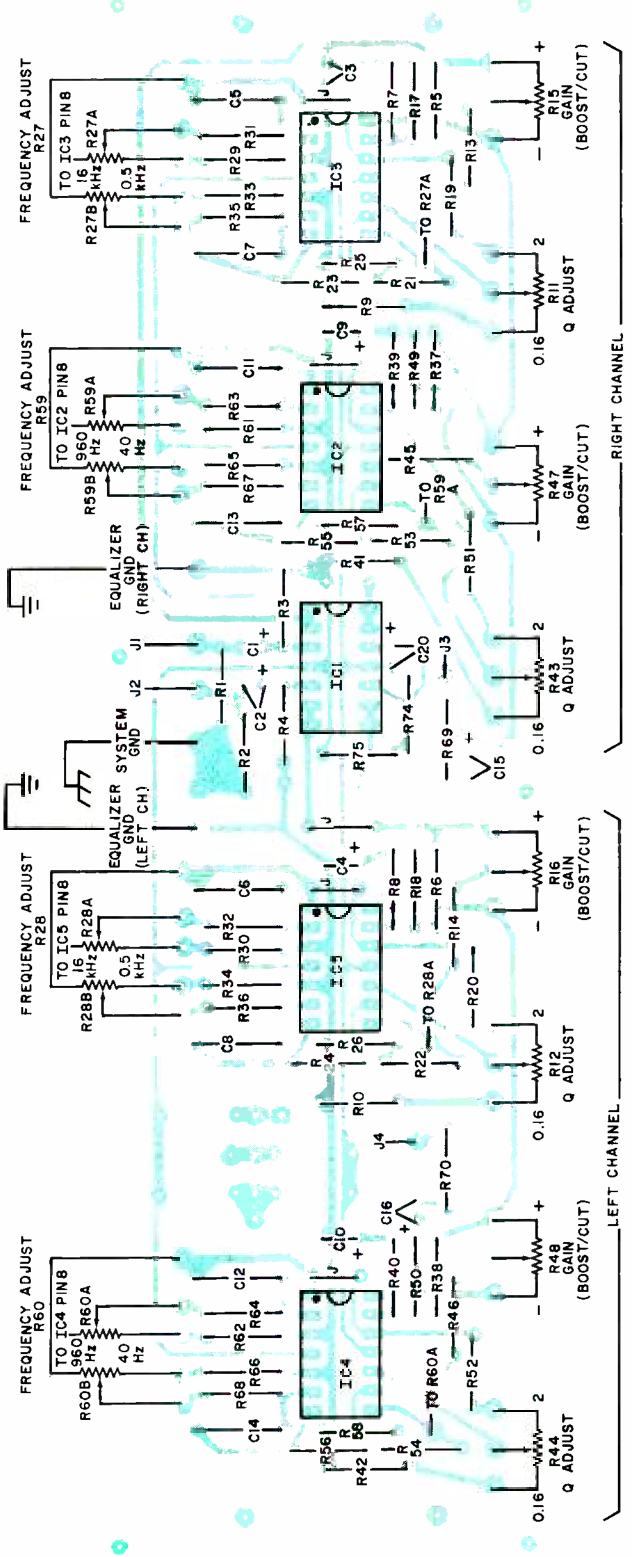

Fig. 8. Component placement for the main pc board for the equalizer. Note vacant pads near upper left to make connections to power supplies.

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At Creative Computing, we obtain new systems as soon as they are announced. We put them through their paces in our Software Center and also in the environment for which they are intended — home, business, or school. We published the first in-depth evaluations of the Texas Instruments 99/4, Atari 800, TRS-80, Ohio Scientific Challenger, Exidy Sorcerer, Apple II disk system and Heath H-8. We intend to continue this type of coverage, not only of systems, but peripherals and software as well.

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While evaluations are important, the main focus of Creative Computing magazine is computer applications of all kinds. Many of these require that data be retrieved or sorted. Unfortunately, most programming texts focus on the bubble sort (or straight insertion) and, very infrequently, another technique (usually delayed replacement) and let it go at that.

Yet, except for comparison counting, the bubble sort is the least efficient. Tutorials and articles in Creative Computing demonstrate that the Shell-Metzner and Heapsort are from 50 to 13,000 times as fast as the bubble sort! Consider a sort of 100,000 items on a DEC System 10:

Bubble sort	7.1 days
Delayed replacement	3.8 days
Heapsort	17.3 minutes
Shell-Metzner	15.0 minutes

Needless to say, on a microcomputer, a bubble sort of even 1000 items is agonizingly long.

Free Sorting and Shuffling Reprint

Because sorting and shuffling (mixing a list of items) is so vital in most programming, we are making available a 20-page reprint booklet on Sorting, Shuffling and File Structures along with our May 1979 issue which has several articles on writing user-oriented programs and making the most of available memory space. The reprint booklet and issue are free with 12-issue or longer subscriptions.

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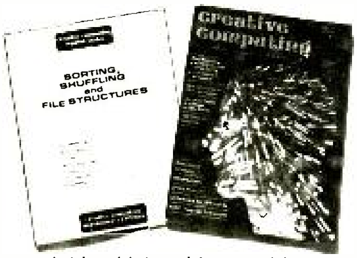

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Contributing editor Ted Nelson (L) is author of "Computer Lib/Dream Machines." Publisher David Ahl (R) is a pioneer in computer models, simulations and games.

country. We do not believe that the "Computer priesthood" should confuse and bully the public. As Ted Nelson stated in the Computer Lib Pledge, we do not treat any question as a dumb question, since there is no such thing. We are against computer terms or systems that are oppressive, insulting or unkind, and we are doing the best we can to improve or replace such terminology or systems. We are committed to doing all we can to further human understanding and make computers easy to understand, interactive wherever possible, and fun for the user. The complete Computer Lib Pledge is contained in our May 1979 issue which we are furnishing free to new subscribers.

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The Creative Computing Software Division is participating with Children's Television Workshop in an important new venture, Sesame Place. These theme parks are being designed to bring interactive computer games and simulations to young children (and their parents) and remove the mystique of computers from the youngest segment of our population. In addition, we are participating in projects with several school systems and museums to write reading comprehension and ecology simulations software. We are also involved in a major college-level computer literacy project.

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paths within each equalizer circuit are referenced to the artificial grounds. In the ac-powered equalizer, however, the bipolar dc voltages furnished by the power supply obviate the need for separate system and equalizer grounds. The two are shown connected together in the schematic of Fig. 3.

Results of tests on the prototype performed by the author at his own lab are shown in the box. You will note that all performance specifications but one are identical for both the dc and ac versions of the Parametric Equalizer. The one area in which the two differ is in the maximum voltage swing that can be generated at the output jack. The reason for this is that in the ac-powered equalizer the potential difference between the V+ and V− supply rails is 30 volts, but the potential difference between the supply rails in the dc-powered equalizer is less than half of this value if the dc power source delivers 13.8 volts. However, even in this situation there exists substantial headroom—most (if not all!) autosound power amplifiers require far less drive than 13.8 volts peak-to-peak to develop their maximum levels of output power. Greater output voltage swings can be obtained by increasing the voltage provided by the dc source. The circuit as shown can be used with supplies from +12 to +30 volts.

Construction. The use of printed circuit assembly techniques is recommended. Full-size etching and drilling guides for the main, ac power supply, and dc power supply circuit boards are shown in Figs. 5, 6, and 7, respectively. The corresponding parts placement guides are shown in Figs. 8, 9 and 10.

Mount all components on the circuit boards as shown in the parts placement guides. Begin by installing the jumpers on the main pc board. Then install the fixed resistors and nonpolarized capacitors. Taking care to observe polarities and pin basings, mount the electrolytic capacitors and semiconductors. The use of IC sockets or Molex Soldercons will facilitate replacement of ICs should that become necessary. Interconnection between the main board and the phono jacks and potentiometers can be made using flexible hookup wire. If desired, signal paths between the board and the jacks can be made with shielded cable.

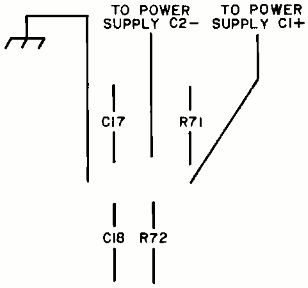

Fig. 11. Special wiring of the main pc board for use with an ac power supply.

This will not be necessary, however, if the project is housed in a grounded metallic enclosure. Special wiring of the main board for ac-powered operation is shown in Fig. 11. Wiring details for dc operation are shown in Fig. 12.

Assemble either the dc or ac power supply to fit the intended application of your Parametric Equalizer. Observe the polarities of electrolytic capacitors and diodes, including the LED pilot light. Fuse *F1* mounts directly on the board and should be soldered to it using pigtail leads. The author designed the power supply boards to accommodate a special push-on/push-off power switch, but any panel-mount switch can be used.

When assembling the circuit boards, be sure to use the minimum amount of heat and solder consistent with the formation of good solder connections. Scrutinize your work after the boards have been completed, paying close attention to polarities, pin basings, power supply wiring and interconnection between the two circuit boards. Make sure that no solder bridges have been created inadvertently.

When all wiring has been completed, mount the circuit boards, jacks and controls in a shielded enclosure. A photograph of the author's ac-powered prototype is shown in Fig. 13. Route power leads out of the enclosure using a protective strain relief. Connect the power leads to a suitable source. Using shielded patch cords, route line-level signals from the tape monitor output of your preamplifier or receiver (or from the preamplifier output) to input jacks *J1* and *J2*. Similarly, patch signals from output jacks *J3* and *J4* back to the tape monitor loop or to the input of the power amplifier. The project is now ready for use.

Using the Parametric Equalizer. Because this project is so flexible, there is no one "correct" way to use it. Its variable Q and center frequency allow the user to boost or attenuate a select group of frequencies. A high Q restricts the boost or cut introduced to a narrow part of the spectrum (less than one octave). A low Q causes broader changes to be introduced.

Adding some sharp boost at the very low and high ends of the audio spectrum allows the user to compensate for speaker rolloff. A broad dip inserted at the midband makes possible the simulation of a loudness contour to enhance low-level listening. The Parametric Equalizer is also adept at compensating for unwanted room resonances. A high-Q cut can reduce audio output at the resonant frequency with little effect on nearby frequencies.

The usual technique for coping with room resonances is as follows. Drive the system with a wideband audio signal

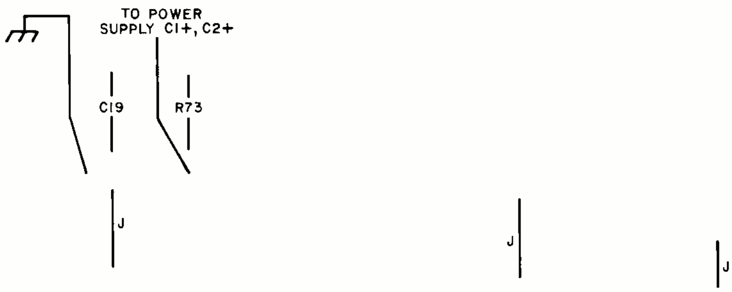

Fig. 12. Special wiring of the main pc board for use with a dc power supply. Note two jumpers on IC1 at right.

and boost the bass region using the Parametric. Using a high Q setting, vary the center frequency of the low-band equalizer until you discover the room's fundamental resonant frequency. (That's the one at which the walls start shaking and the furniture moves around the floor.) Now reduce the setting of the BOOST/CUT control for more even-sounding bass. The high-band equalizer can be used to brighten up a room that is too "dead" acoustically or to attenuate treble response in a room that is too "alive."

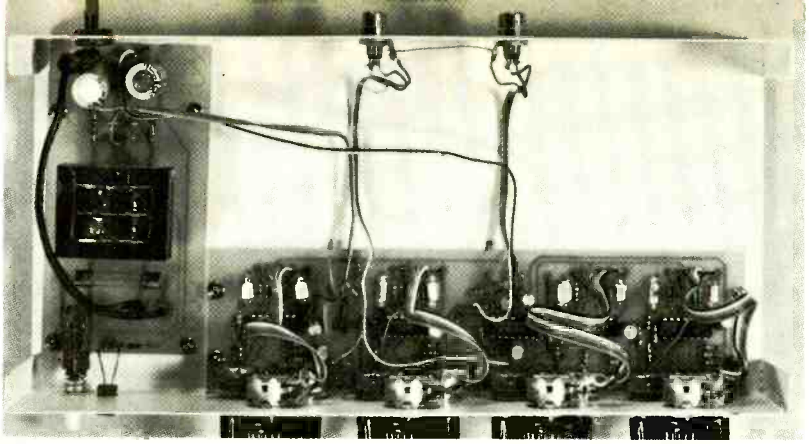

Fig. 13. Interior view of prototype using ac power supply.

You will undoubtedly find other uses for this versatile project. Those who listen to music analytically will appreciate the ability to zero in on one particular instrumental (or human) voice. Amateur recording engineers can employ the Parametric to tailor the sounds of a mix. And, of course, anyone whose speakers have response irregularities will be able to smooth them out.

One word of caution—don't blindly apply large amounts of deep bass and extreme treble boost in an attempt to flatten the response of your system at the upper and lower limits of the audible spectrum. Experience has shown that room/system combinations are best equalized by first employing acoustic methods, followed by electronic equalization. For example, you should first try repositioning the loudspeakers, modifying the absorption coefficients of the room, and adjusting the speakers' crossover level controls (if any).

Most often, a lack of deep bass and extreme highs is due to the limitations of dynamic drivers. Don't try to force flat response out of your speakers by cranking up the BOOST/CUT controls. The results of such attempts frequently include overloaded amplifiers, excessive distortion, and blown voice coils. Remember—equalization should be introduced *intelligently*.

In Conclusion. We have presented a stereo Parametric Equalizer project that is well suited for home, mobile, and portable applications. It provides a high level of performance and the flexibility of control inherent in the parametric design, enough flexibility for most readers. Those who require more bands of equalization per channel can reproduce two or more complete equalizers and connect them in cascade for even greater control over the sounds they record or reproduce. ◇

BY JOHN PFEIFFER and WILLIAM EPPLER

BUILD A

Hand-Held LED Spectrum Analyzer

Real-time octave spectrum analyzer features ten bands for performing a variety of useful audio tests and adjustments

A REAL-TIME octave spectrum analyzer is an invaluable audio test instrument for anyone who wishes to adjust an equalizer to compensate for room or system deficiencies, evaluate and compare loudspeakers, test a hi-fi system's response, and perform other types of acoustic analyses.

Usually, such a device is very expensive. The analyzer described here, however, can be built at reasonable cost, is simple to operate, and when powered by its internal battery, can be hand-held while in use.

The instrument passes the audio output of its internal microphone capsule through 10 octave-spaced bandpass filters and displays the levels in the various bands on a 10 x 7 LED matrix. Decay time of the display can be short, long, or indefinite, depending on the setting of a switch. In addition, the 31-Hz channel can be switched to read out the average level of the total audio signal, allowing the analyzer to be used as a sound-level meter.

Circuit Operation. As shown in Fig. 1, the audio input at *J1* is fed to a buffer in *IC1A*. The gain (11.8) of this stage is set by the ratio of *R5* +*R6* to *R5*. After amplification, the signal forms the common audio input to 10 two-pole bandpass filters as shown in Fig. 2. The center frequencies of the filters were chosen to match the ISO standards for 10-band octave equalizers, making the analyzer as useful as possible in consumer applications. Center frequencies are 31.25, 62.5, 125, 250, 500, 1000, 2000, 4000, 8000, and 16,000 Hz. To produce at least a 15-dB attenuation of adjacent octave center frequencies, a Q of 3.75 was chosen. This produces a clean display while retaining the excellent selectivity for measurement accuracy. The gain of each filter is −2.86 or about 9 dB.

The bandpass output of the filter is rectified (half-wave) by a diode (Fig. 2) and averaged by R_F, C_C, *R63, R64,* and *R65* (Fig. 3). The average network is peak-weighted with the attack characteristics determined by R_F and C_C. The specific value of the attack time constant varies between the filters according to the bandpass center frequency and the values of the audio energy present in that region. The decay time constants are selected by *S2B* (Fig. 3). The FAST

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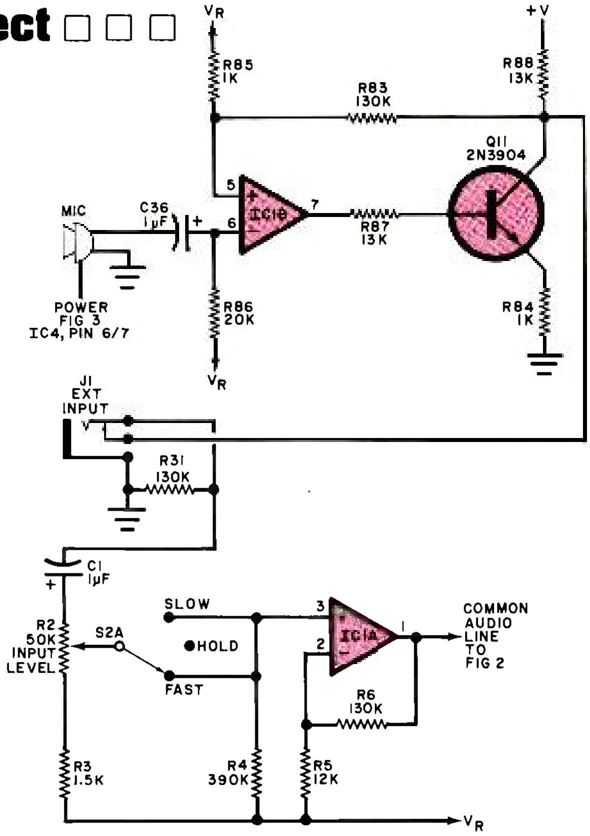


Fig. 1. Input to the analyzer can be directly through J1 or via a microphone with a preamp.

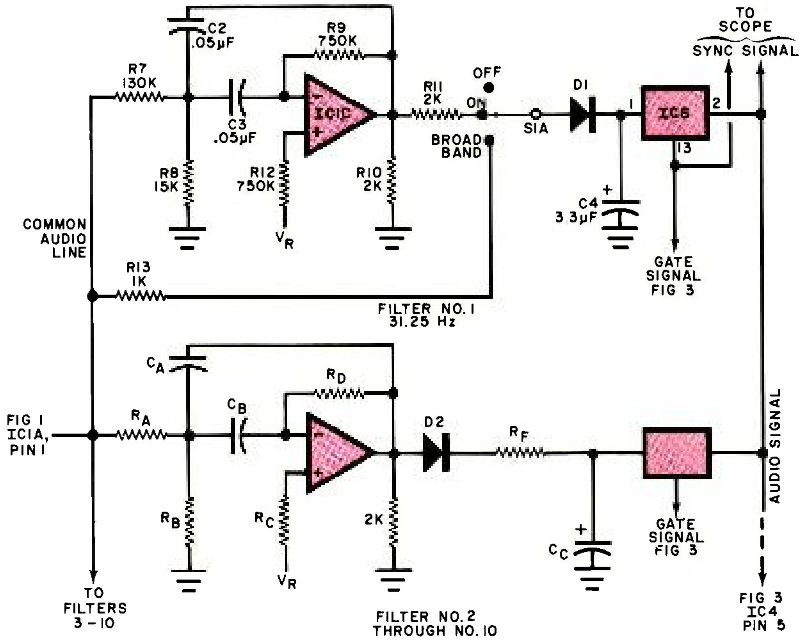


Fig. 2. Incoming audio goes to 10 bandpass filters. Values of components for filters 2 through 10 are given in table below.

Filter	Frequency (Hz)	R_A*	R_B	R_C	R_D	R_F	C_A**	C_B	C_C
2	62.5	68	7.5	390	390	2	0.05	0.05	2.2
3	125	36	3.9	200	200	2	0.047	0.05	2.2
4	250	18	2	0	100	2	0.047	0.05	2.2
5	500	8.2	0.91	0	47	2	0.05	0.05	1
6	1,000	20	1	0	75	2	0.01	0.033	1
7	2,000	11	1.2	0	62	1	0.01	0.01	1
8	4,000	11	1.5	0	75	1	0.0047	0.0033	1
9	8,000	12	1.2	0	68	0.75	0.0022	0.0022	1
10	16,000	13	1.2	0	75	0.33	0.001	0.001	1

*Resistances in kilohms.
**Capacitances in microfarads.

PARTS LIST

B1—8 AA cells
C1,C16,C19,C22,C25,C28,C31,C36—1-µF, 16-V low-leakage radial-lead electrolytic
C2,C3,C5,C6,C9,C12,C14,C15—0.05-µF, 100-V 5% Mylar
C4—3.3-µF, 16-V low-leakage radial-lead electrolytic
C7,C10,C13—2.2-µF, 16-V low-leakage, radial-lead electrolytic
C8,C11—0.047-µF, 100-V 5% Mylar
C17,C20,C21—0.01-µF, 100-V 5% Mylar
C18—0.033-µF, 100-V 5% Mylar
C23—0.0047-µF, 100-V 5% Mylar
C24—0.0033-µF, 100-V 5% Mylar
C26,C27—0.0022-µF, 100-V 5% Mylar
C29,C30,C34—0.001-µF, 100-V 5% Mylar
C32,C33—33-µF, 6-V radial-lead electrolytic
C35—33-µF, 16-V radial-lead electrolytic
D1 through D10—1N4148
DISP1,DISP2—5 x 7 LED matrix (IEE Type LRT1057R) or 70 subminiature red LEDs.
IC1,IC2,IC3—LM324 quad op amp
IC4—LM3915 LED display driver (National)
IC5—CD4017AE CMOS counter
IC6,IC7,IC8—CD4016AE CMOS quad analog switch
J1—Miniature phone jack (Radio Shack #274-296)
J2—Subminiature phone jack (Radio Shack #274-292)
LED1—Subminiature red light emitting diode
MIC—Electret condenser microphone element (Radio Shack #270-092).
Q1 through Q11—2N3904 or equivalent
Unless otherwise noted, the following are ¼-W, 5% resistors:
R1,R6,R7,R68,R83—130,000 ohms
R2—50,000-ohm audio-taper miniature thumbwheel potentiometer
R3,R47—1500 ohms
R4,R16,R19,R63,R66—390,000 ohms
R5,R51—12,000 ohms
R8—15,000 ohms
R9,R12—750,000 ohms
R10,R11,R17,R18,R23,R24,R27,R29, R30,R34,R35,R39,R40,R44,R49,R54, R59—2000 ohms
R13,R37,R45,R50,R84,R85—1000 ohms
R14,R53—68,000 ohms
R15—7500 ohms
R20—36,000 ohms
R21—3900 ohms
R22,R25—200,000 ohms
R26—18,000 ohms
R28—100,000 ohms

mode is useful for displaying the spectrum of speech, music, and other rapidly varying signals. SLOW is used for measuring noise and frequency response. HOLD removes the input signal and defeats the decay network to hold any display condition for several seconds, so the user can record data, change measurement position, etc.

To save cost and space, the LED display matrix and display driver *IC4* are multiplexed among the 10 bandpass filters as shown in Fig. 3. The outputs of *IC5*, a CMOS decade counter, are normally low and go high only at their respective decoded time slots and remain

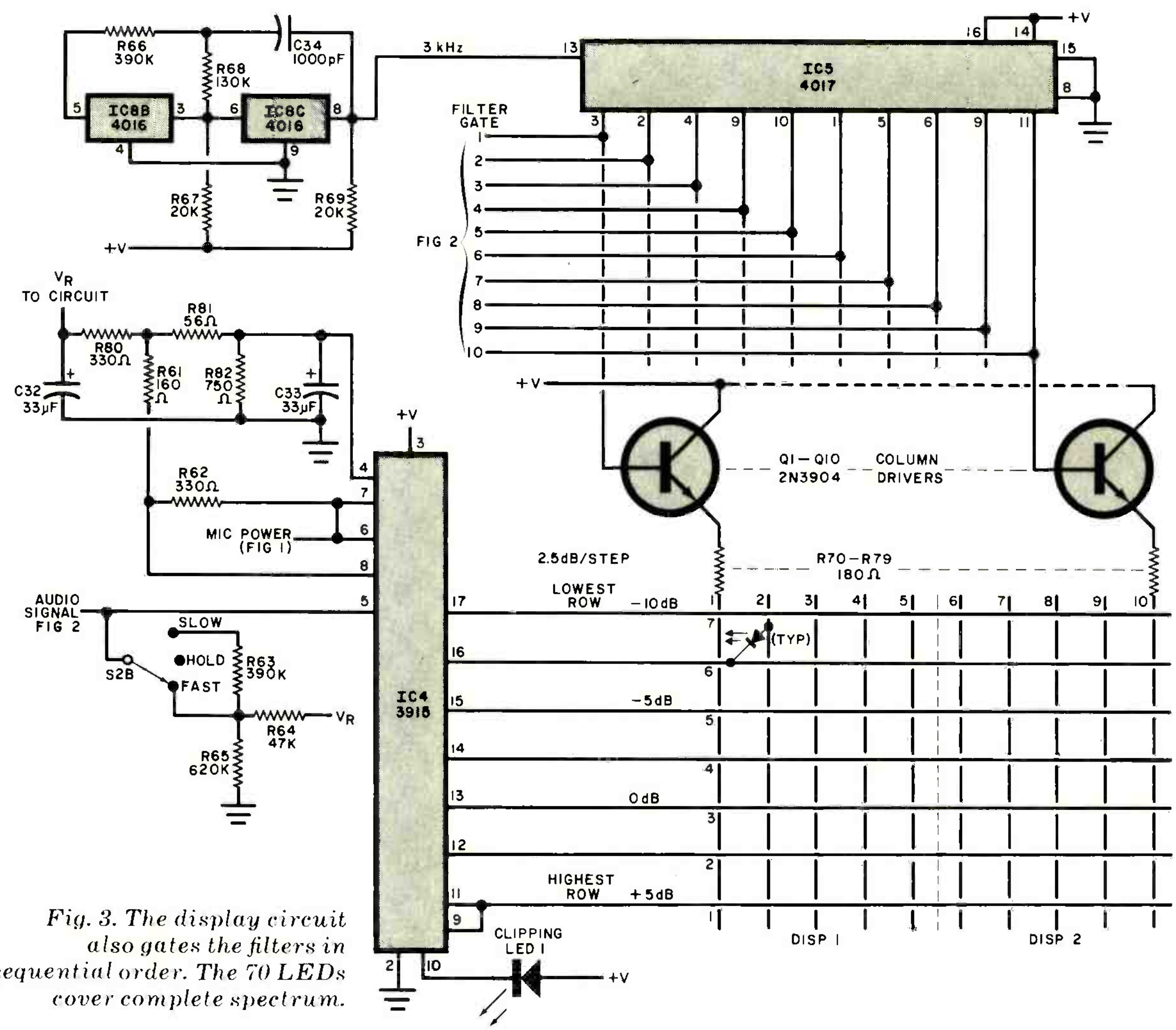


Fig. 3. The display circuit also gates the filters in sequential order. The 70 LEDs cover complete spectrum.

R31—8200 ohms
R32—910 ohms
R33,R64—47,000 ohms
R36,R67,R69,R86—20,000 ohms
R38,R48,R58—75,000 ohms
R41,R46—11,000 ohms
R42,R52,R57—1200 ohms
R43—62,000 ohms
R55,R82—750 ohms
R56,R87,R88—13,000 ohms
R60,R62,R80—330 ohms
R61—160 ohms
R65—620,000 ohms
R70 through R79—180 ohms
R81—56 ohms
S1,S2—Double-pole, triple-throw toggle switch
Misc.—Suitable enclosure, hardware, hookup wire, battery box (2) (Radio Shack 270-391), double-sided foam tape, external power source (8-15 V dc at 100 mA), etc.

Note: The following are available from Gold Line Inc., P.O. Box 20, Redding, CT 06875 (203-938-2588): Complete Model ASA-10 kit including microphone, battery box, and custom-molded case for $139. Also available separately: kit of parts excluding battery box, microphone, and case for $109; set of etched and drilled circuit boards for $18; case and microphone for $30; pc boards, LED displays, and LM3915 for $35. Connecticut residents add state sales tax.

high for one full clock period. This sequentially enables the LED matrix columns through buffers *Q1* through *Q10*.

Two transmission gates in *IC8* make up the counter clock, as shown in Fig. 3. For the values given, the oscillator frequency is approximately 3000 Hz (0.33 ms period). This frequency is not critical. Since the oscillator has active pull-down, the rise time is slow. Therefore, counter *IC5* must be toggled on the falling edge of the clock. This is accomplished by connecting the normal clock input at pin 14 to high and toggling clock-enable input pin 13.

Decoded outputs from *IC5* multiplex the bandpass filter average networks to the input of the *IC4* display drive through CMOS transmission gates located at the output of each filter network (Fig. 2). Since the decay network consisting of *R63* through *R65* is connected to any particular averaging capacitor (C_C) for one-tenth of the time and that interval is much smaller than the time constant of $R64C_C$, the effective decay resistance is 10 times greater than the actual circuit value.

In the HOLD mode, the reflected input impedance of *IC4* is also 10 times greater, producing an almost negligible drift as a sample-and-hold circuit. By far, the dominant factor in the HOLD mode is the leakage of the averaging capacitors. The decay rate in the 500-Hz channel, for example, in the FAST mode is 0.87/($R64 \times 1\ \mu F$) or about 18 dB/second. In the SLOW position, the rate is 0.87/[($R63 + R64$) $\times 1\ \mu F$] or about 2 dB/second.

Integrated circuit *IC4* is designed to sense analog voltage levels at its input and provide up to 10 individual current-regulated outputs. This allows direct LED interface for a logarithmic analog display with 3-dB/segment scaling. The IC contains its own adjustable reference and accurate 10-step voltage divider. Because of excellent on-chip matching, display nonlinearity can be held to less than 1%. A single control-pin changes the display from dot to bar-graph.

In this analyzer, the dot mode was selected to minimize current requirements and provide a pleasing display. Only

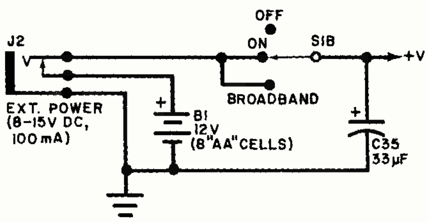


Fig. 4. Use power from internal batteries or external dc source.

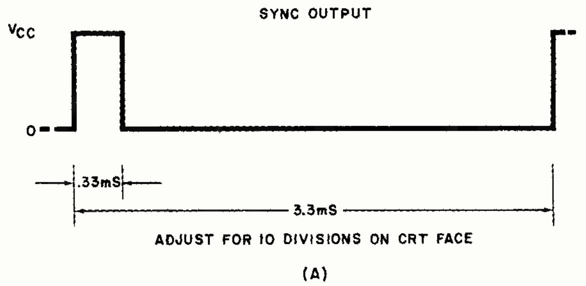
seven of the available LED outputs are used, due to display matrix size. A clipping indicator LED is wired to *IC4* at pin 10 to indicate an overrange condition. Resistors *R70* through *R79* reduce power dissipation in *IC4*.

Average current in each LED is 4 mA, and bias voltages remain constant for any supply potential between 8 and 15 volts dc. Step size also remains fixed so that calibration and LED brightness are independent of battery condition. The power source circuit for the analyzer is shown in Fig. 4.

Although *IC4* has a 3-dB/step scale factor, the voltage drop across the signal rectifier diodes (*D1* through *D10*) varies in a roughly logarithmic fashion with signal amplitude. This modifies the relationship of display increment to input level. Bias voltages and diode current have been set to make display increments of 2.5 dB/step.

In addition to controlling power to the unit, *S1*, when set to BROADBAND, changes the function of the left-most display column from 31-Hz bandpass to peak-weighted broadband. This is useful for noise measurements and level display, but note should be taken of the 9-dB gain of the spectrum display relative to the broadband channel.

When EXT INPUT jack *J1* is not used, a calibrated microphone is automatically connected to the input buffer (Fig. 1). The microphone preamplifier has a gain of 131. Transistor *Q11* increases the gain/bandwidth product of the preamp.



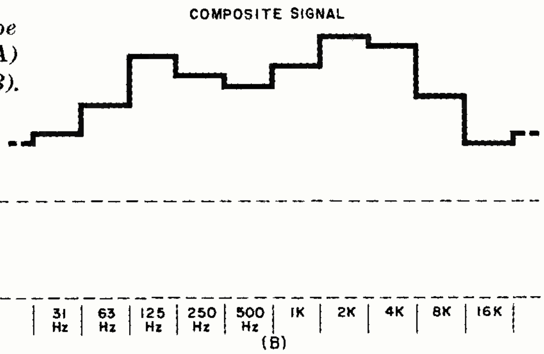


Fig. 5. Typical scope traces for sync output (A) and composite signal (B).

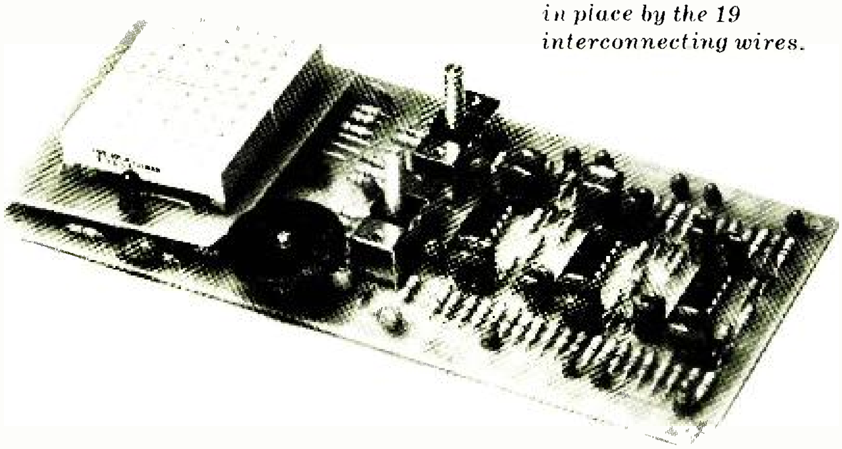


Photo of prototype shows how board with two display assemblies is mounted over the main board and held in place by the 19 interconnecting wires.

SPECIFICATIONS

External Input
Impedance: 33,000 ohms
Gain to broadband display:
11.8 (21 dB) max.
0.34 (−9 dB) min.
Input for clipping display:
Broadband: 150 mV min.
3.8 V max.
Spectrum: 57 mV min.
1.4 V max.

Microphone Input
Impedance: 20,000 ohms
Gain: 131 (42 dB)

Display
Step increment: 2.5 dB ±½ dB
Attack time/averaging window:
0.33 ms to 6.6 ms*
Decay time (500 Hz channel):
Fast: 18 dB/s
Slow: 2.2 dB/s
Hold: 10 mV/s

Scope Outputs
Sync impedance: CMOS
Composite impedance: High (use 10X probe)

Power Supply
Voltage. 8 to 15 V dc unregulated
Current: 80 mA max.
*Depending on center frequency.

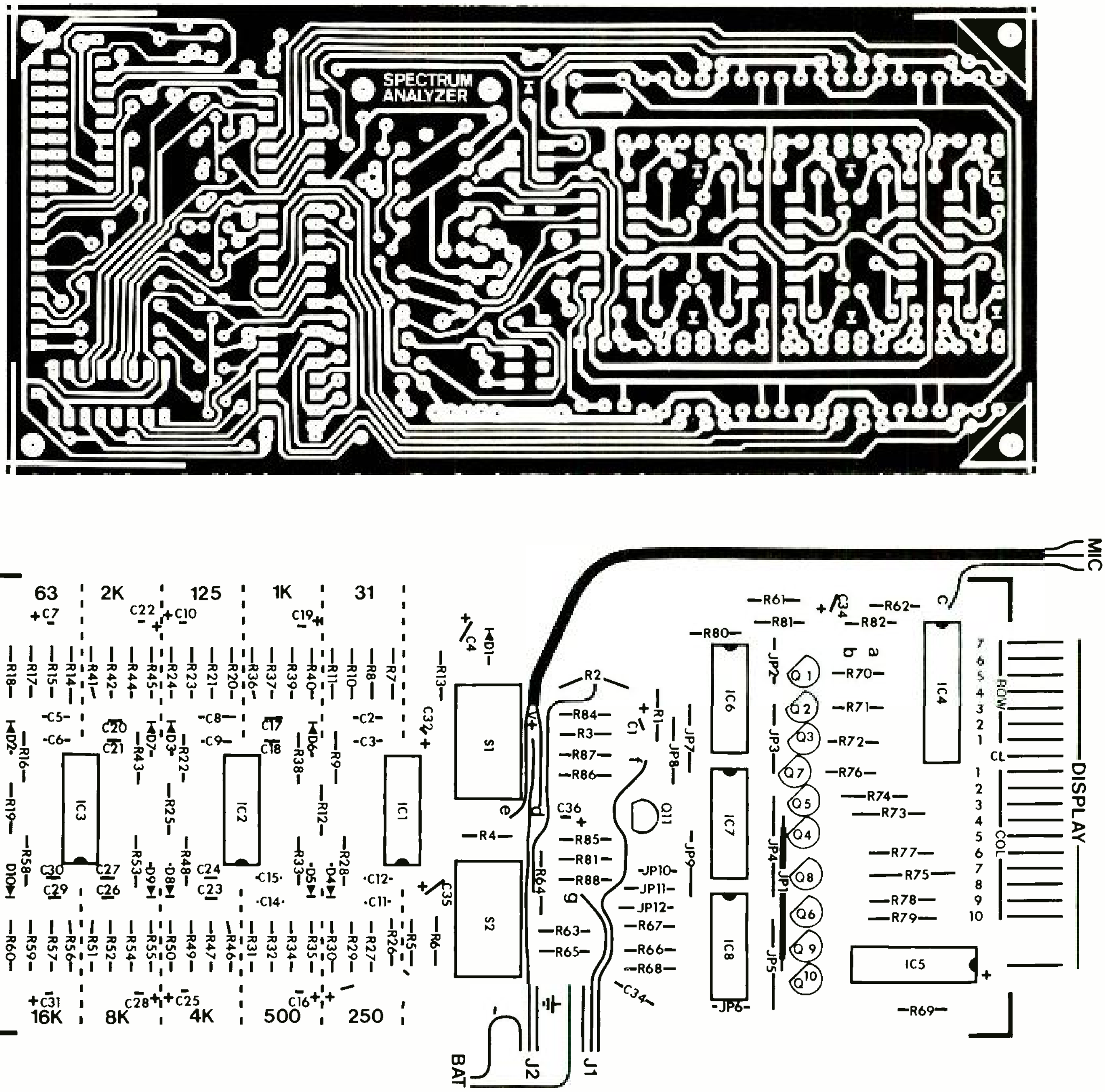


Fig. 6. Actual-size etching and drilling guide (above) and component layout for the main board of the analyzer.

An alternate display is provided by a scope signal as shown in Fig. 2. Connect the sync lead to the sync input of the scope and the signal lead to the scope's vertical input. The scope should be triggered on by the positive edge of the sync signal, and the sweep timebase should be adjusted for exactly 10 divisions between trigger edges. The resulting display will have a linear scale rather than the log scale of the LED display. A typical CRT display is shown in Fig. 5.

Construction. Owing to many components and high packing density, the use of printed circuit boards is essential. Etching and drilling guides and component installation layouts for the main and display boards are shown in Figs. 6 and 7, respectively.

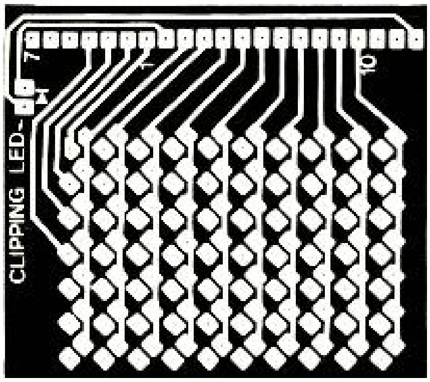
Proper orientation of diodes, ICs and polarized capacitors is critical. Also, use 5% tolerance polyester capacitors in the filters to insure accurate center frequency, gain, and Q. As discussed before, proper operation of the HOLD mode depends on the use of capacitors with very low leakage in the bandpass averaging networks. The use of tantalum or low-leakage aluminum electrolytics is urged.

Since the display board is to be mounted very close to the components at the top of the main board, IC sockets cannot be used for *IC4* through *IC8*. Transistors *Q1* through *Q10* must be mounted with as little clearance as possible between the bottoms of their cases and the top of the main pc board.

Potentiometer *R2* should be mounted on 3/16" spacers with 2-56 small-pattern hardware. The outer terminals of the potentiometer can be connected directly to the board with bare wire. The center lug then connects as indicated in Fig. 6 with a 2" insulated wire.

When assembling the display board, solder the displays directly to the board, noting proper orientation. Solder the clipping indicator LED so that it is flush with the top of the displays.

Once the two board assemblies are



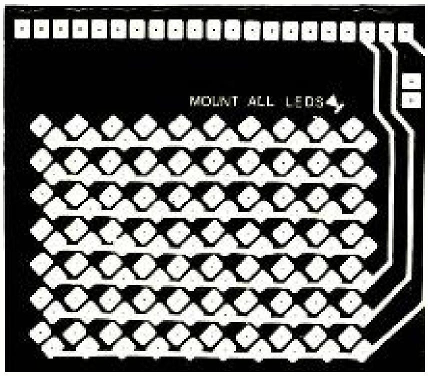


Fig.7. Actual-size foil patterns for the double-sided display board. Pattern at left is for solder side. Above is side on which components are mounted.

wired, they must be interconnected. To do this, insert ½" long bare wires through the holes along the top of the display board and solder. Carefully align the wires with the matching holes in the main board. Solder the 19 interconnects allowing ¼" space between the two boards.

When the project is completely assembled, turn on the power and aim the microphone at a music source. Adjust the level control until a display is obtained. An immediate correlation should be apparent between the sounds you hear or produce and the visual display.

If an audio oscillator is available, connect it through *J1* to the analyzer. Every performance aspect can now be checked by setting the oscillator frequency to the various filter center frequencies and changing amplitude.

LEDs of any size or color can be wired according to the schematic. This allows creating a display of nearly any size, shape or color to fit individual requirements. This option may be particularly applicable in rack-mounting. ◇

BY CLEMENT S. PEPPER

A MONOSTABLE CATALOG for Experimenters

A guide to today's IC monostable multivibrators emphasizes their usefulness in practical applications

MONOSTABLE multivibrators, sometimes called "one-shots," are electronic circuits that, when triggered, deliver an output pulse of a predetermined width.

Although today's IC monostables still provide the one-shot function, their usefulness has been greatly extended. These modern devices feature multiple inputs with both positive- and negative-edge triggering, complementary outputs, retriggerability and resetability. They are also very easy to use, lower in cost, and available in conventional and low-power TTL and CMOS.

The key features of a number of popular monostables are summarized in the "Catalog." The information is sufficient to enable using the mono without recourse to a data sheet. Summaries of the 555 and 558/559 timers (which can function as a one-shot) are included separately in Figs. 3 and 5.

Triggering. All of the monos in the catalog will trigger from a high-to-low or from a low-to-high transition. For triggering to actually occur on the transition, all inputs must conform to defined logic states. These states are shown in the "Input Table" for each device.

The logic tables in the manufacturers data sheets include inhibit as well as trigger conditions. Only trigger conditions are shown in the Catalog. Any other state is an inhibit.

Each line of the table defines a trigger mode for a "one-shot" output. "A" and "B" designators are used in the Input Tables. Several monos have multiple A and/or B inputs though not all manufacturers use this notation. An "A" input is defined as a high-to-low transition (shown as a down arrow), while a "B" input is defined as a low-to-high transition (shown as an up arrow). The CMOS 4098B/4528/14528 are exceptions—the A and B transitions being reversed.

The A and B inputs have a defined logical relationship to each other, but these are not consistent between devices. You should go by the Input Table for the mono being used. Triggering occurs at a voltage level independent of the transition time, while rise and fall times are consistent with the type of logic family.

The 74121 and the 74LS221 feature Schmitt circuitry at their B input. They trigger with a 1-volt/s rise time, and provide 1.2 volts of noise immunity.

All of the monos shown provide complementary outputs. The Q output is normally low and goes high for the pulse duration. The not-Q output is normally high and goes low. Pulse width is identical for both outputs.

The minimum pulse widths and delay times listed are subject to some conditions. They are included to provide a generalized picture of limiting conditions. If nanosecond timing is critical to your application, consult the manufacturer's data sheet.

(Continued on page 74)

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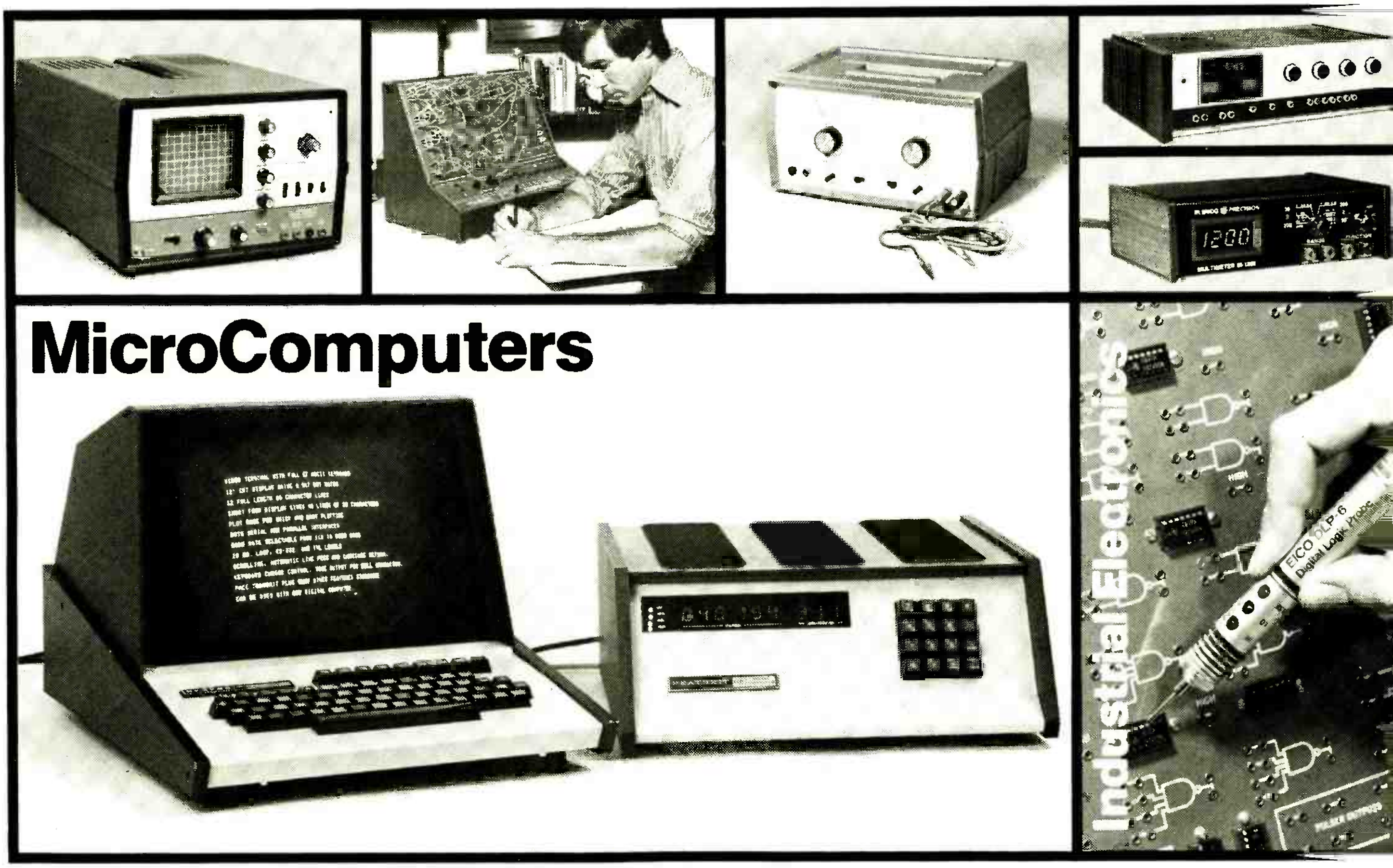

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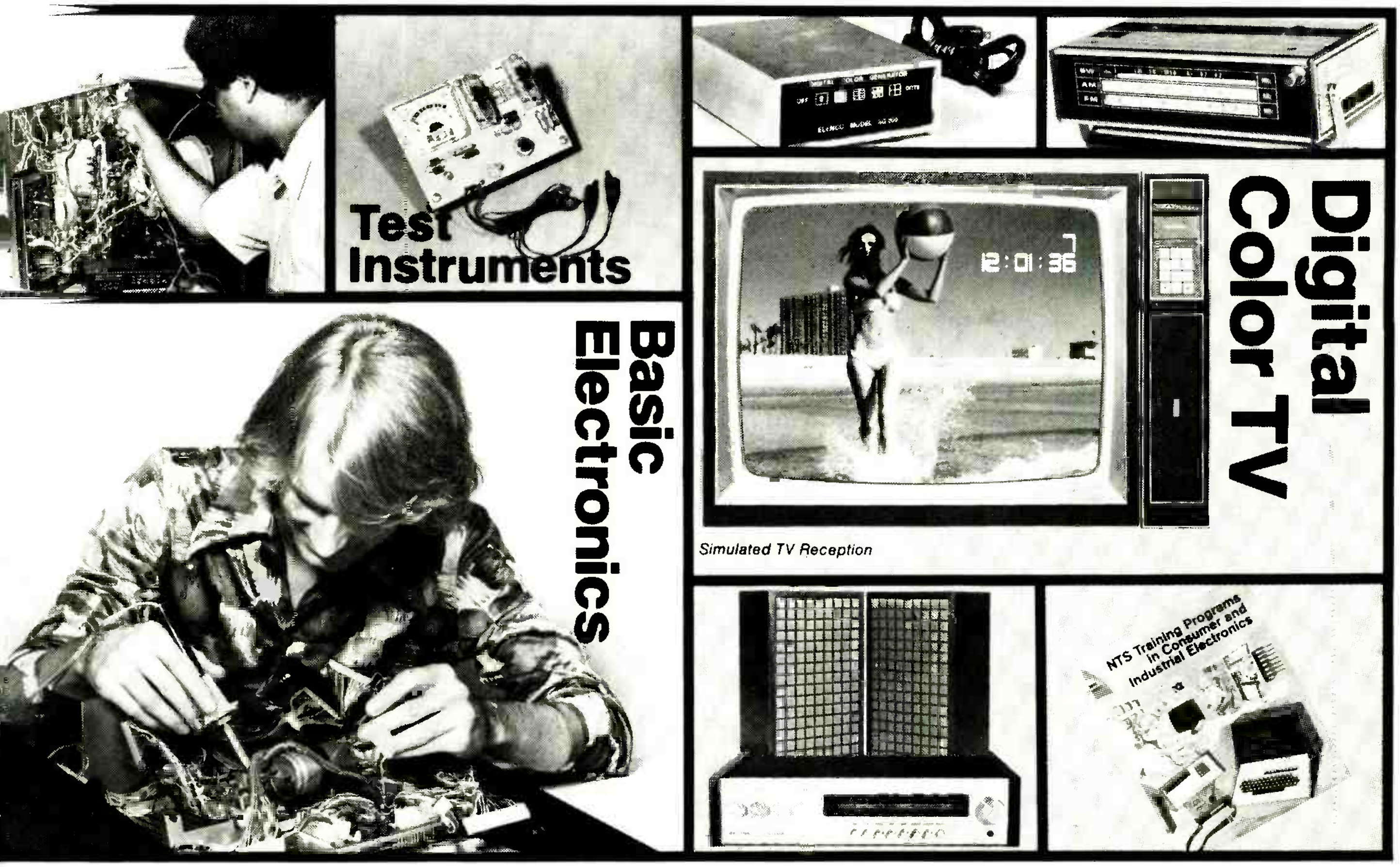

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(Continued from page 69)

Pulse Timing. A typical timing equation has the form tw=k*RC* where tw is the pulse width in nanoseconds, k is a constant, *R* is the timing resistance in kilohms, and *C* is the timing capacitance in picofarads.

For example, the pulse width for the 74121 is given as tw=.693*RC*. Assume that *R* is 10,000 ohms, and *C* is 100 pF. Then the equation is tw=.693(10)(100) =693 ns or .693 μs.

Retriggering. Some monos are retriggerable. That is, if a second trigger arrives while the output is still high from the first pulse, the output will respond to the latest trigger and remain high. The extension is for one complete cycle and a train of input triggers will result in a sustained output pulse that will have a very long duration.

Retriggering may be accomplished from either the A or B inputs, simply or intermixed. This makes for some intriguing timing possibilities.

However, there is a time restriction on retriggering some monos. As shown in the Catalog, the required delay is the number in parenthesis following "re-triggerable." Thus, the 74123 cannot be re-triggered before 0.22 ns after the previous input.

Retriggering is useful when you want it, but on the other hand, what do you do if you don't want it? Suppose, for example, you are using a 74123 dual mono because you need retrigger for one circuit, but you cannot live with it in the other. In this case, connect the B input to the not-Q output and trigger with the A input (or vice versa). When the mono triggers, B is pulled low thus inhibiting further triggering until the circuit times out. Be sure, however, that the A input(s) are in the inhibit mode at the time out, or you will have an oscillator instead of a mono.

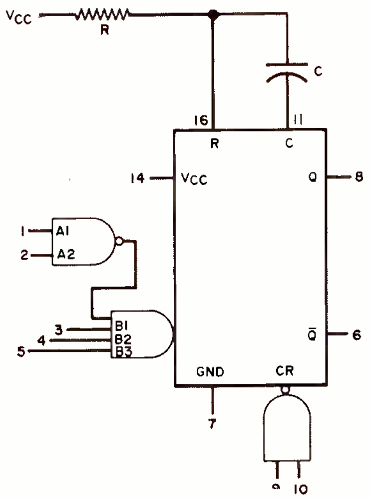
Reset. Some monos, but not all, provide for reset. This is implemented by applying a reset pulse to the CR (clear) input. The leading edge of this pulse resets the outputs to the initial state, and another trigger is required to obtain an output.

If the CR input is held in the reset state, the mono is inhibited and will not respond to an input trigger. This feature adds flexibility to the controlling logic for the mono.

R and C Limits. All monos have upper and lower limits for the range of resistance (R), while some have limits on

MONOSTABLE CATALOG-1

9600 SINGLE TTL



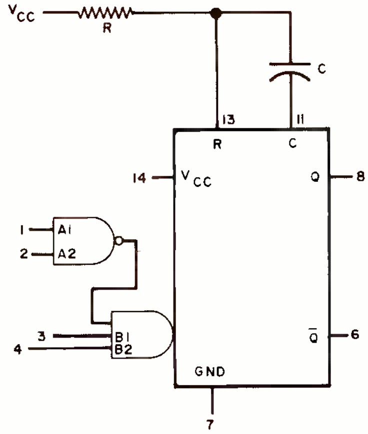
INPUT TABLE

A_1	A_2	B_1	B_2	B_3
↓	1	1	1	1
1	↓	1	1	1
0	X	↑	1	1
X	0	↑	1	1
0	X	1	↑	1
X	0	1	↑	1
0	X	1	1	↑
X	0	1	1	↑

t_w=0.32RC (1+0.7/R)

FEATURES
RETRIGGERABLE (0.3Cns)
RESET ON LOW TO
EITHER "CR" INPUT
t_{min}= 74 ns
t_{pd}=29 ns
LIMIT ON R=
$5k \leqslant R \leqslant 50k$
$(0 \leqslant T°C \leqslant 75)$
LIMITS ON C:
NONE

9601 SINGLE TTL



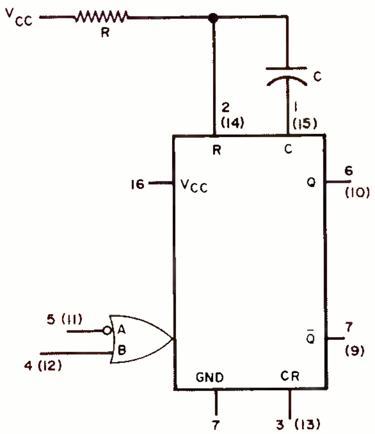
INPUT TABLE

A_1	A_2	B_1	B_2
↓	1	1	1
1	↓	1	1
0	X	↑	1
X	0	↑	1
0	X	1	↑
X	0	1	↑

t_w=0.32RC (1+0.7/R)

FEATURES
RETRIGGERABLE (0.3Cns)
NOT RESETTABLE.
t_{min}=45 ns.
t_{ps}=25ns.
LIMITS ON R:
$5k \leqslant R \leqslant 50k$
$(0 \leqslant T°C \leqslant 75)$
LIMITS ON C:
NONE

9602 DUAL TTL



INPUT TABLE

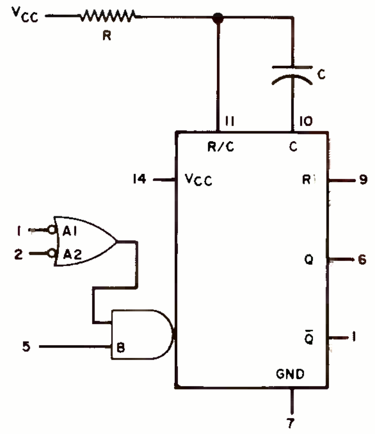
A	B
↓	0
1	↑

t_w=0.31RC (1+1/R)

FEATURES
RETRIGGERABLE (0.3Cns)
RESET ON LOW TO "CR"
t_{min}=72 ns
t_{pd}=25 ns
LIMITS ON R:
$5k \leqslant R \leqslant 50k$
$(0 \leqslant T°C \leqslant 75)$
LIMITS ON C:
NONE

MONOSTABLE CATALOG-2

74121 SINGLE TTL



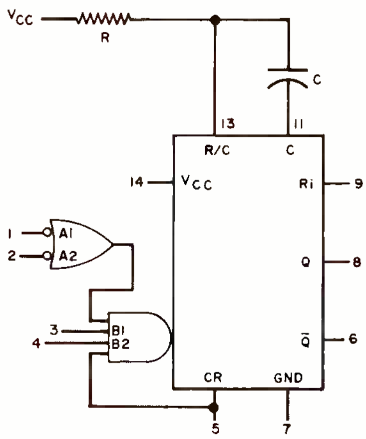
INPUT TABLE

A_1	A_2	B
0	X	↑
X	0	↑
↓	X	1
X	↓	1

t_w=0.693 RC
TO USE THE INTERNAL TIMING RESISTOR, CONNECT PIN 9 TO V_{CC}.
FOR C=0,t_w=30 ns.

FEATURES
NOT RETRIGGERABLE
NOT RESETTABLE
"B" IS A SCHMITT INPUT
t_{min}=30 ns
t_{pd}=45 ns
R_{int}=12 kΩ
LIMITS ON R:
1.4k ≤ R ≤ 40k
(0 ≤ T°C ≤ 70)
LIMIT ON C:
0 ≤ C ≤ 1000 μF

74122 SINGLE TTL



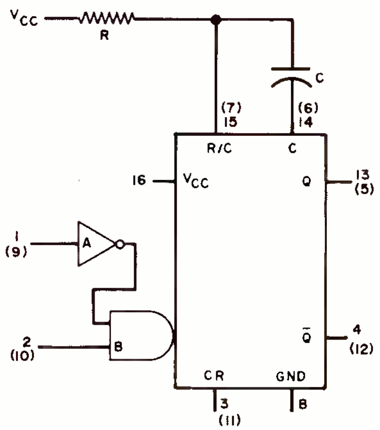
INPUT TABLE

A_1	A_2	B_1	B_2
0	X	↑	1
0	X	1	↑
X	0	↑	1
X	0	1	↑
1	↓	1	1
↓	↓	1	1
↓	1	1	1

t_w=0.32 RC (1+0.7/R)
TO USE THE INTERNAL TIMING RESISTOR CONNECT PIN 9 TO V_{CC}.

FEATURES
RETRIGGERABLE (0.22 ns)
RESET ON LOW TO "CR"
t_{min}=40 ns
t_{pd}=21 ns
LIMITS ON R:
5k ≤ R ≤ 50k
(0 ≤ T°C ≤ 70)
LIMITS ON C:
NONE

74123 DUAL TTL



INPUT TABLE

A	B
0	↑
↓	1

t_w=0.32 RC (1+0.7/R)

FEATURES
RETRIGGERABLE (0.22 ns)
RESETS ON LOW TO "CR"
t_{min}=40 ns
t_{pd}=21 ns
LIMITS ON R:
5k ≤ R ≤ 50k
(0 ≤ T°C ≤ 70)
LIMITS ON C:
NONE

capacitance (C). Typical limits for industrial devices are shown in the Catalog.

In general, try to stay away from maximum values of *R*, especially when using electrolytic capacitors for *C*.

Conventional electrolytics and aluminum electrolytics can be a problem. Most high-quality tantalums perform well. Inserting a silicon diode between the *R/C* terminal and the *RC* junction as shown in Fig, 1, will eliminate any leakage problem that may occur with reverse voltage across the capacitor. However, if you use this diode, the value of *R* must be reduced to less than 60% of its maximum value. Some circuits do use tantalums without the diode, but with reduced values of *R*. If your circuit has to operate at elevated temperature, be cautious.

Avoiding Problems. The greatest single source of problems is false triggering, and the second is no triggering at all.

IC monostables are very fast, and according to "Murphy's Law" if the inputs can couple to form a "glitch" generator, they will. Therefore, input lines should be kept short and isolated from neighboring lines to avoid the unwanted stray coupling.

A 0.1-μF or larger capacitor should be connected between the Vcc and ground right at the IC. The upper trace of Fig. 2 shows large "spikes" riding on the leading edge of each waveform. After installing the bypass capacitor, the signal cleared up as shown in the lower trace.

Using a scope whose ground lead is connected to the power supply ground, take a look at the signal ground line to make sure that it really is ground. It shouldn't be riding a half a volt or so above ground, or displaying a lush growth of grass (noise).

Always make the foil traces for Vcc and ground heavier than pin interconnections. This keeps their resistance low and current pulses passing through them do not develop voltage drops that can appear as signals to other devices connected to the lines.

If possible, test your mono outside the circuit, using the timing values you require. Don't forget the minimum retriggering time.

The 555. This timer IC, as well as the 558/559, do not conform to the standard monostable format and were not included in the Catalog. However, these timer ICs can be used as one-shots or as free-running or gated oscillators.

They do have limitations, though: they are slow when compared to the other monos, and pulses narrower than 10 μs are best obtained with a TTL device. Also, they're not retriggerable; and in the free-running mode, they have a duty-cycle limitation.

They do, however, have a single output, can operate with a wide range of supply voltages, and can sink or source 200 mA (which can save a driver transistor).

The use of a 555 as a one-shot or free-running oscillator is shown in Fig. 3. The capacitor connected to CV (pin 5) is essential to reduce noise.

In the mono mode, calculations are based on $t_W = 1.1RC$. For these timers, R is shown in ohms, C in farads and t is in seconds.

For any timing circuit, it is best to use a standard value of capacitance for C, then calculate the required resistance. It's always possible to combine different standard resistances in series, parallel or combinations, but it is difficult to locate an odd value of capacitance.

For the free-running mode, there are four defining equations:

$D = Rb/(Ra + 2Rb) = t2/t1$ = duty cycle
$t1 = 0.693(Ra + Rb)C$ = output high time
$t2 = 0.693RbC$ = output low time
$T = 0.693(Ra + 2Rb)C = t1 + t2$

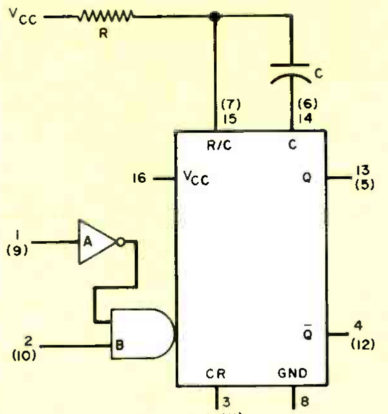
In the equation for D, note that if Ra is zero, then D becomes 0.5. This tells you not to try to get a square-wave output as you have to tie DS (pin 7) directly to V_{CC}. There is no internal current-limiting resistor within the chip, so do not try this. Select D as 0.25 or 0.3 for most cases.

It's usually best to start by selecting a value of C appropriate to the frequency and duty cycle. Rb is then computed using the equation for t2, and this is plugged into the D equation to solve for Ra. Then solve for T as a check on the values.

There are several ways to generate a square wave. The circuit shown in Fig. 3E allows a wide selection of both frequency and duty cycle from a single capacitor. This is illustrated by the composite scope traces shown in Fig. 4. In the circuit, $R1$ was 2200 ohms, $R2$ was a 10,000-ohm potentiometer and C was a 0.01-μF capacitor. The three traces represent three settings of $R2$. Overall frequency range was from 5 to 80 kHz. If trimmer potentiometers were used for both $R1$ and $R2$, the frequency and duty cycle could be trimmed to the exact requirements.

MONOSTABLE CATALOG-3

74LS221 DUAL LSTTL



INPUT TABLE

A	B
0	↑
↓	1

t_w=RC (3.03 RC)

FEATURES
NOT RETRIGGERABLE
RESETS ON LOW TO "CR"
t_w RANGE=30 ns to 70 s
t_{pd}=45 ns
LIMITS ON R
1.4k ≤ R ≤ 100k
(0 ≤ T°C ≤ 70)
LIMITS ON C
0 ≤ C ≤ 1000 μf
SCHMITT INPUT ON "B"

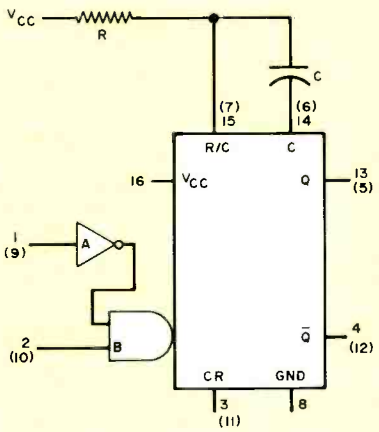
74C221 DUAL CMOS

INPUT TABLE

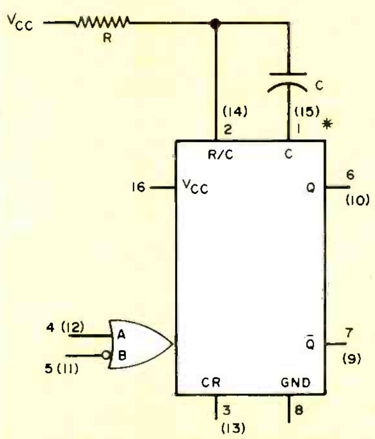
A	B
0	↑
↓	1

t_w=RC
REFERENCE:
AN-138 "USING THE CMOS DUAL MONO. MULTIVIBRATOR"
NATIONAL SEMICONDUCTOR

FEATURES
NOT RETRIGGERABLE
RESETS ON LOW TO "CR"
$t_w$min=50 ns, V_{cc}=5V
=30 ns, V_{cc}=10V
t_{pd} =250 ns, V_{cc}=5V
=120 ns, V_{cc}=10V
LIMITS ON R:
10k ≤ R ≤ 350k
(V_{cc}=5V
5k ≤ R ≤ 350k
(V_{cc}=10V)
NO LIMITS ON C.



4098B/4528B/MC14528CP DUAL CMOS



* WITH 4528, MC14528CP CONNECT PINS 1 AND 15 TO PIN 8.

INPUT TABLE

A	B
0	↓
↑	1

t_w=0.2 RC ($\log_e V_{cc}$)
$\log_e 5$=1.61
10=2.30
15=2.71

FEATURES
RETRIGGERABLE (0 ns)
RESETS ON HIGH TO "CR"
$t_w$min=75 ns (5V) } 4098B
25 ns (15V)
240 ns (5V) } 4528, 14528
90 ns (15V)
t_{pd}=300 ns (5V)
125 ns (10V)
100 ns (15V)
LIMIT ON R
5k ≤ R ≤ 1000k
(-40 ≤ T°C ≤ 85)
NO LIMIT ON C

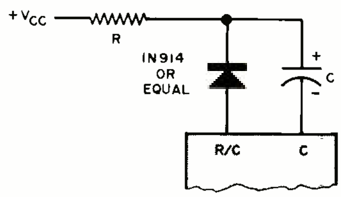


Fig. 1. Use of a diode prevents high inverse leakage currents through the timing capacitor.

The period is linear with respect to *C*. A substitution of a 0.1-μF capacitor reduced the frequency by a factor of 10 while preserving the duty cycle. This circuit allows for a low-cost pulse generator with lots of flexibility.

The 558/559 Timers. These are quad timers having a range of a few microseconds to a few hours. Each of the four monos are independent, but they share a common reset. They are edge-triggered, and several sections can be coupled in tandem to produce an output several hours long.

A function diagram and important features of these timers are shown in Fig. 5.

The 558 has an open collector output (Fig. 5D) while the 559 has a Darlington follower output (Fig. 5E). In all other respects, the two are identical.

The output pulse width is the *RC* product of the timing components. Two devices may be cross-coupled to operate in the free running mode as shown in Fig. 5C. The potentiometer connected to the CV line allows adjustment of the output pulse width and duty cycle. The CV voltage range is from 0.5 V to V_{CC} minus 1 volt.

Applications. A simple pulse can be created by *RC* coupling between gates or flip-flops. Although this approach will work, it is marginal at best. For example, take a look at the circuit shown in Fig. 6A. Operation depends on the overshoot at the trailing edge. The system malfunctioned because the overshoot was marginal. Also, 750 ohms is too small a pulldown for TTL, and the circuit is susceptible to noise because there can be a volt or more of dc offset at the input.

If a 74123 dual mono had been used, as in the circuit shown in Fig. 6B, the time delay could have been achieved at

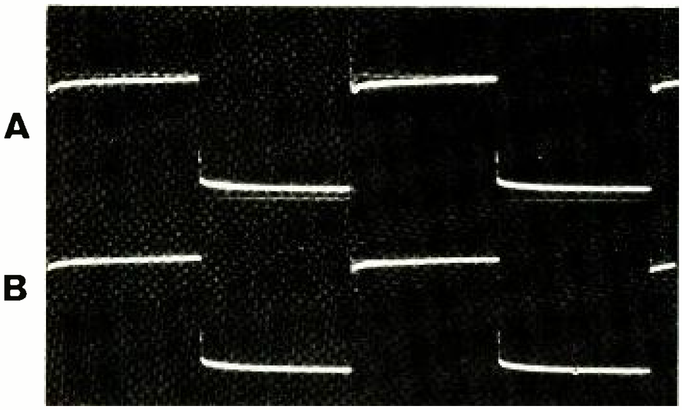
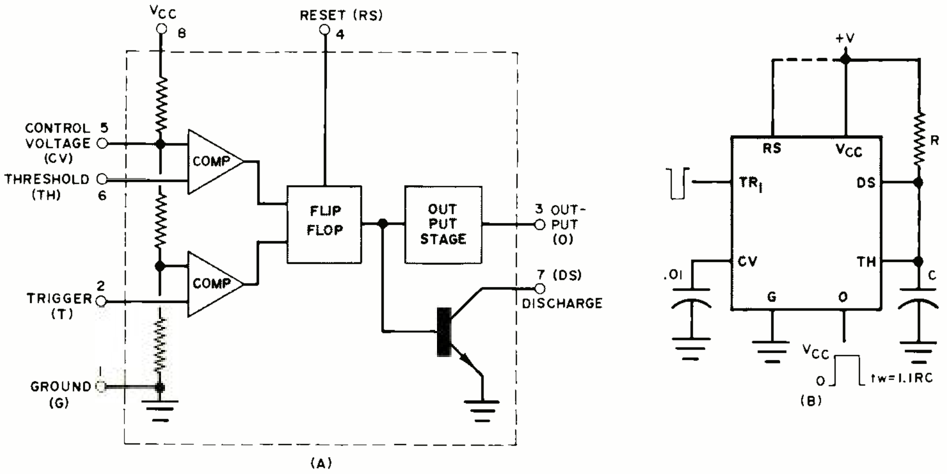


Fig. 2. A 2-volt spike on leading edge of waveform (A) is removed (B) by using a bypass capacitor from V_{cc} to ground.



555 TIMER

FEATURES:

4.5-TO-16-VOLT SUPPLY RANGE.
TIMING RANGE OF MICROSECONDS TO HOURS. ONE-SHOT AND ASTABLE OPERATION. ADJUSTABLE DUTY CYCLE. 200 mA SOURCE OR SINK.
0.005%/°C TEMP. COEFFICIENT.

APPLICATIONS:

PRECISION TIMING
PULSE GENERATION
SEQUENTIAL TIMING
TIME-DELAY GENERATION
PULSE-WIDTH MODULATION
PULSE-POSITION MODULATION
MISSING-PULSE DETECTION

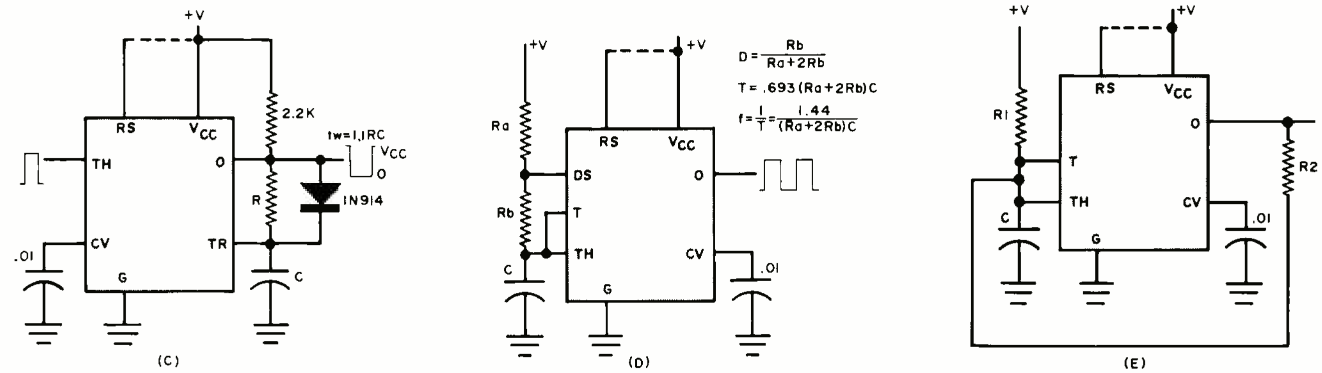


Fig. 3. The 555 timer function diagram (A), positive output with negative trigger (B), negative output for positive trigger (C), astable operation (D), and astable operation for a 50% duty cycle (E).

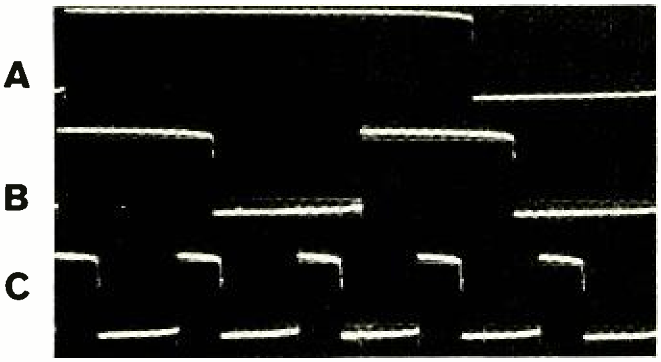
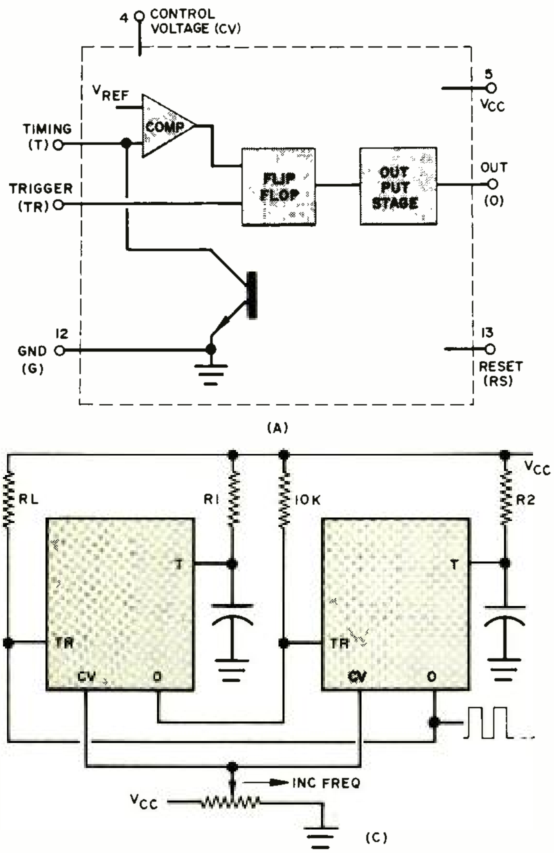


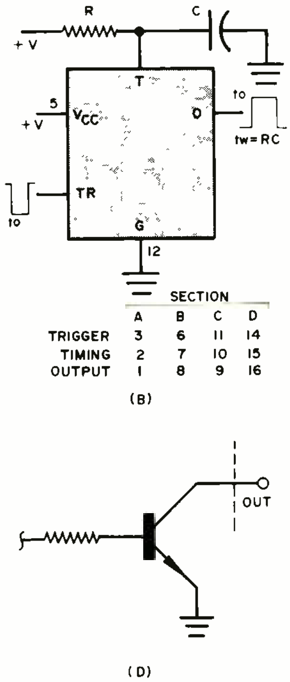
Fig. 4. Waveforms for various values or R2 in Fig. 3E. (A) is 10 kHz; (B) is 20 kHz; and (C) is 50 kHz.

no real increase in cost, but with greatly improved reliability. The output pulse would have defined and controlled width.

Occasions may arise when you need an oscillator having independent control of frequency and duty cycle. The 74123 (TTL) or the 74C221 (CMOS) dual monos perform this task very well using the circuit shown in Fig. 7.

If you use potentiometers for *R1* and *R2*, you can construct a low-cost, wide-





558/559 TIMER

FEATURES:

4.5-TO-16-VOLT SUPPLY RANGE.
TIMING RANGE OF MICROSECONDS TO HOURS. ONE-SHOT AND ASTABLE OPERATION. EDGE TRIGGERED.

APPLICATIONS:

PRECISION TIMING
SEQUENTIAL TIMING
TIME-DELAY GENERATION
QUAD ONE-SHOT

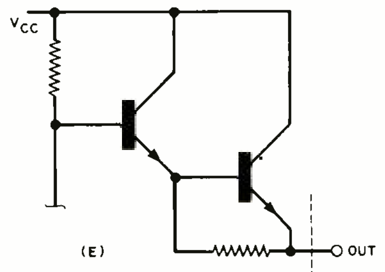


Fig. 5. Function diagram (A) of 558/559 timer; monostable connection (B); 558 as a variable-frequency oscillator with fixed duty cycle (C); 558 open-collector output structure (D) and 559 Darlington follower output structure (E).

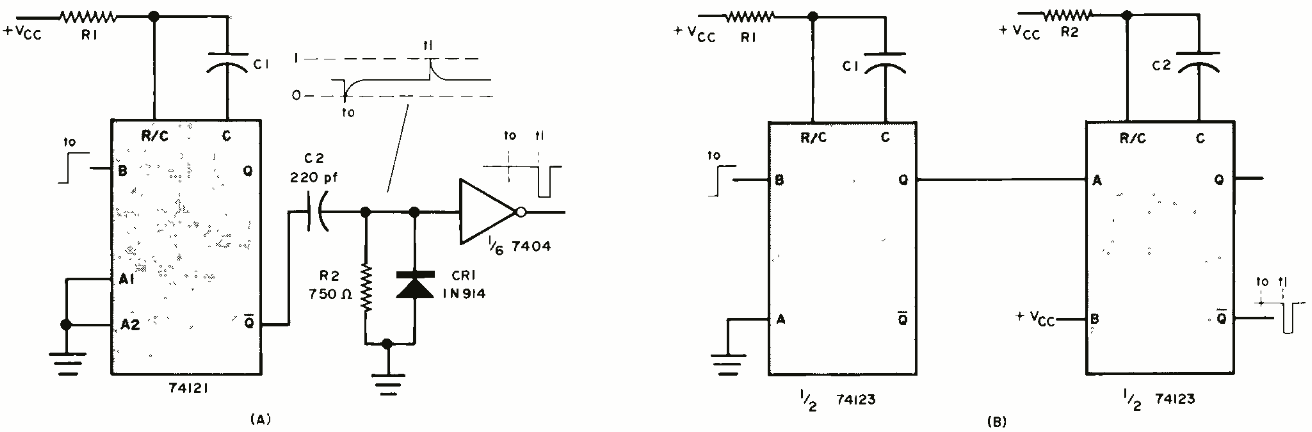


Fig. 6. RC coupling (A) used for leading edge delay for the 7404. Using a 74123 (B) provides precisely timed pulse with improved reliability.

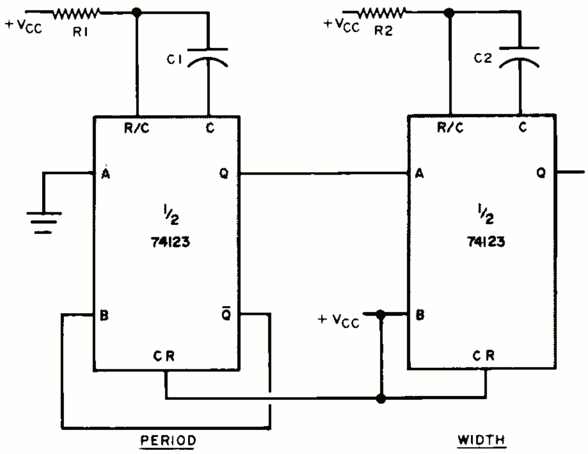


Fig. 7. A dual monostable can create an oscillator having independently adjustable period and pulse width.

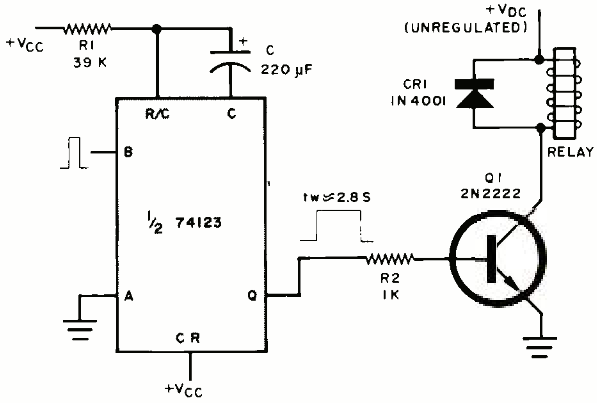


Fig. 8. A switching transistor provides relay driving power and isolates the mono from higher voltage required by the relay.

range pulse generator with lots of versatility. The capacitors may be switched to change the timing parameters.

Retriggering. This is a feature that should not be overlooked. A retriggerable mono will respond to inputs that arrive while the output is still high from the preceeding trigger. It then becomes possible to have a train of inputs that will hold the output high until the train stops.

A telephone toll restrictor was created using this effect. The problem was that there was only one signal to tell the circuit that the phone was lifted off the cradle, that the dial was being used, that dialing was completed, and that the phone was replaced on the cradle. The retriggering capability of the 74123 enabled the digits counter for the pulses from the dialer; and when the train stopped, there was a short delay, then a reset of the counter for the next digit.

Multiple Inputs. Several monos, such as the 9600,9602 and 74121 have multiple trigger inputs. These may be used as digital summing elements when you wish to form a single pulse train as a summation of triggers from several sources. Be careful here because the logic can be tricky.

Pulse Stretching. A mono can be used to stretch a brief pulse so that it can be used to drive a relay, among other applications. The basic circuit is shown in Fig. 8. The 555, 558 and 559 are well suited to this use because of their drive capabilities.

An advantage of this circuit is that the load can be powered from a higher voltage than the logic. In Fig. 8, the relay is powered from the unregulated dc supply, saving the power supply regulator. Isolating resistor *R2* is important to protect *Q1*. If heavy load current is required, the emitter of *Q1* should be returned to the power supply ground.

Summary. Because of the edge triggering features of each of the devices discussed here, many mono's can be interconnected to create complex digital waveforms that can be duplicated only with expensive commercial generators. Also, edge triggering greatly reduces the need for logic gates. ◇

BY CASS R. LEWART

Make Your Computer Work As a Control Center

Simple circuits enable small-computer owners to perform a variety of external operations.

ONCE YOU tire of playing graphic games on your home computer, have solved all the mathematical problems you care to, and exhausted your list of favorite tunes, you may start thinking about new applications for that wonderful machine. Some of the more attractive uses for a home computer are in the controlling of appliances. In this article, we will present a few simple and proven inexpensive circuits that allow your computer to turn on the coffee pot in the morning, turn lights on and off while you are away to confuse a potential burglar, or control your slide projector and tape recorder in response to various cues.

The great advantage of using a computer to control appliances is its flexibility. No more relays driving relays, where the slightest change in the logic may require redesigning and rewiring your circuit from scratch. A simple change of a few instructions in your program can now accomplish the same objectives relatively painlessly.

Computer Interface. The computer interacts with the outside world by means of I/O (input/output) ports. These ports consist of a connector where specific pins can assume either a high or a low logic status. In most cases, a high corresponds to approximately +5 volts, while a low corresponds essentially to 0 volt (ground). Specific instructions in your program (BASIC or machine language) are used to set voltages to the required values.

As a rule, computer ports can supply only a very small amount of current, usually on the order of 1 mA. Therefore, in order to control any device drawing appreciable power, it is necessary to have interface circuits that translate logic signals from computer ports into relay-contact operations, LED activation, or ac appliance and motor movements.

Because program instructions to control I/O ports differ from one computer to the next, we will not go into details of port programming. Instead, we will assume you are familiar with the programming of your particular computer and know how to set logic signals at its ports low or high.

Some computers use separate ports for input and output, while others use the same ports for both, depending on program instructions. Consult the port operation section in the programming manual for your computer.

In general, when you interface the computer, the program will provide timing and logic for whatever you are doing. Input ports connect to sensors, such as door switches, thermostats, light sensors, etc, while output ports interface to relays, LEDs and solid-state switches. The interface circuits discussed and illustrated in this article deal with computer output ports only.

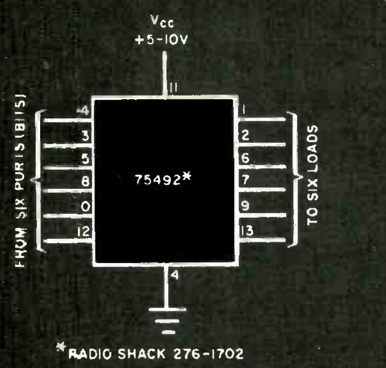


Fig. 1. Six inverters in 75492 can sink up to 200 mA each.

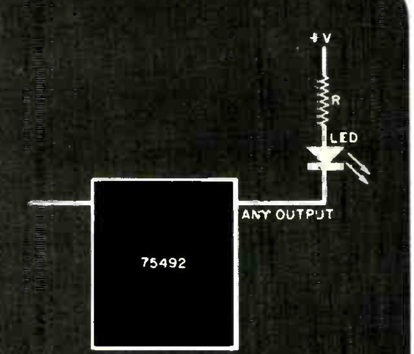


Fig. 2. LED interface circuit used to compute resistance, R.

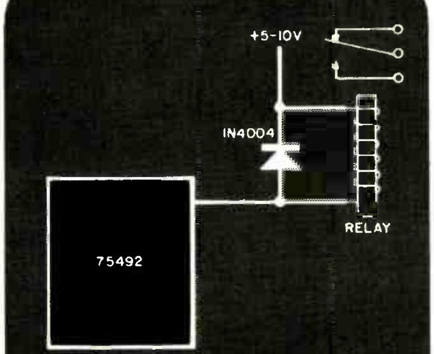


Fig. 3. Low-power relay interface requires protective diode.

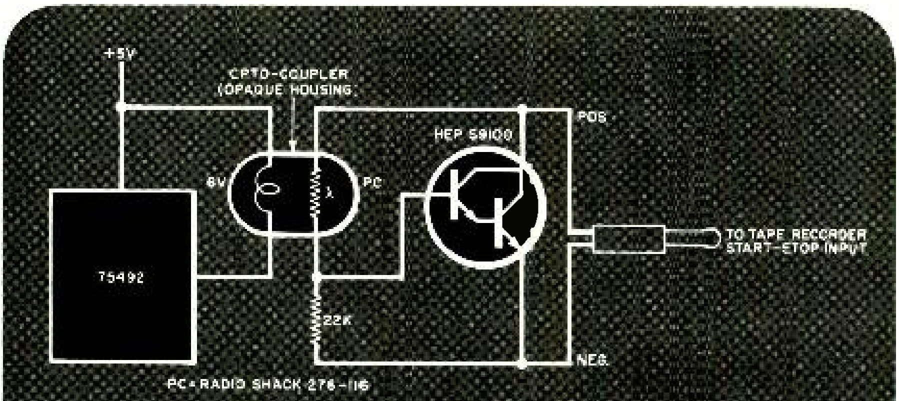


Fig. 4. Relay interface can be replaced by an optoisolator. Here is a homemade version.

Basic Interface. A basic output interface, an inexpensive SN75492 MOS LED-driver IC, is shown in Fig.1. Six computer output-port pins connect directly to the inputs of the device which can sink up to 200 mA on each of its six outputs. This current is sufficient to directly drive a small relay, LED, or optoisolator. All of the interface circuits given in this article employ the SN75492 as the basic building block.

If more than six ports of a computer are being used for control, more than one SN75492 IC can be used. The same port can also drive more than one output (for example, an ac load and a LED to indicate an *on* condition).

LED Interface. Shown in Fig. 2 is a typical LED interface circuit. To compute the values of the dropping resistor in the external circuit, use Ohm's Law: R = E/I, where R is the dropping resistor's value, E is the supply voltage, and I is the current through the LED. Remember to take into account the one-diode voltage drop of the inverter in the IC and the drop across the LED.

As an example of calculating the resistor's value, assume E = 10 volts, I = 20 mA, the voltage dropped across the LED is the typical 1.5 volts, and 0.7 volt is dropped across the internal diode of the inverter. The value of the dropping resistor is R = E/I = (10 - 1.5 - 0.7) /0.02 = 390 ohms. To determine the resistor's power rating, use the formula P = I^2R. Plugging in values, we obtain P = $(0.02)^2$ X 390 = 0.156 watt, which means you can safely use a standard ¼- or ½-watt resistor.

DC Relay Interface. A low-voltage relay whose coil draws less than 200 mA of current can be operated through the output of the IC as shown in Fig.3. Make sure that the current demand of the relay's coil does not exceed 200 mA, and install a diode as shown to protect the IC from back-emf spikes.

The relay's contacts can be used to turn on and off power for almost any electrical device whose demands are less than the volt-ampere (VA) or current (at the load's operating voltage) rating of the relay's contacts. For heavy loads, the low-power relay can be used to control a power relay with heavy-duty contacts.

Tape-Recorder Interface. Turning on and off a tape recorder under computer control can be very useful for color-slide presentations. Other attractive applications include loading programs from a cassette deck into a computer and storing of programs on tape. The tape deck you wish to control must be equipped with a start/stop control system accessed by way of a jack–usually located near the microphone jack. To turn the tape deck on and off one can connect contacts of a relay (Fig. 3) to a plug inserted in the on/off jack on the tape recorder. If you wish to eliminate the relay, an alternate circuit shown in Fig. 4 uses a Darlington transistor and an optoisolator consisting of a cadmium-sulfide (Cds) photocell and a low-voltage lamp in a light-tight housing. Because this circuit is polarized, it may be necessary to reverse the leads to the tape deck's plug to make the circuit work.

The reason for using an optoisolator in this and the following circuit is to keep the computer and the circuit it controls electrically separate. This is to provide protection for the computer. High insulation resistance between the computer and the ac power line will safeguard low-voltage logic circuits and, not incidentally, the human operator.

Control of AC Appliances. An alternative to a relay or simple light coupler is shown in Fig. 5. The Motorola HEP P5002 is an optoisolator that houses an infrared diode and a small triac. The low power triac, in turn, controls a larger triac, such as the HEP R1723 that switches the ac power to the load. The rating of the larger triac determines the maximum wattage that can be controlled. For example, the HEP R1723 will work with appliances consuming up to 600 watts. Pulsing the appropriate port under program control will result in partial power being delivered to the appliances, allowing the computer to dim lights and run motors at variable speeds.

In Conclusion. The foregoing are just a few possible schemes for interfacing your computer with practical appliances. After you familiarize yourself with these circuits and their capabilities, other schemes may suggest themselves. You may even devise interfaces that you will wish to keep permanently connected. ◇

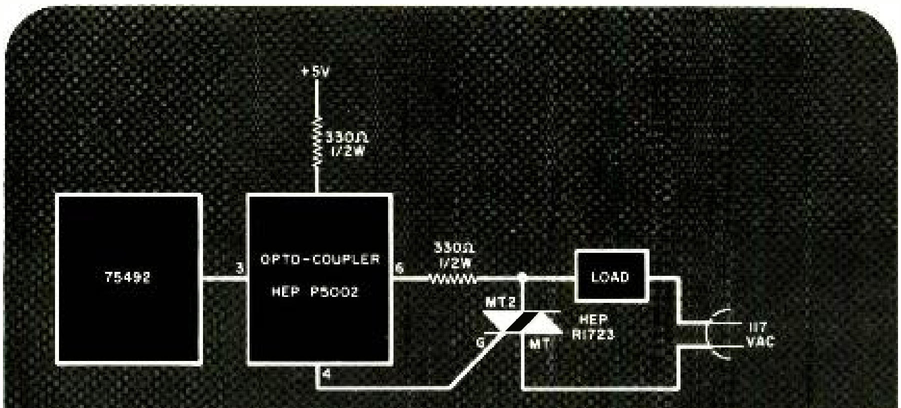


Fig. 5. This circuit, using an infrared optoisolator and a triac, can be used to control loads up to 600 watts.

Build a Smart Switch

A solid-state wall switch that "remembers" to turn off the lights when you forget!

by Richard Fermoyle

HAVE YOU ever gone into a darkened room "for just a minute," only to return an hour later and find the lights still burning? The "Smart Switch" presented here will correct this most common occurrence.

This useful project, which costs about $17 to build, is a solid-state, 117-volt ac timer switch designed to replace a conventional wall switch. Using the components specified, the Smart Switch can control loads up to 250 watts.

When a pushbutton on the Smart Switch is depressed, power will be supplied to the load (lights) connected to it for approximately one minute. At the end of that interval, power will be automatically removed. An optional bypass switch is provided to override the timer circuit and to power the load continuously. With today's high cost of energy and the need to conserve, this device is a practical and economical addition to your home.

About the Circuit. The Smart Switch is shown schematically in Fig. 1. The heart of the circuit is *IC2*, a 555 timer operating as a monostable multivibrator. When pushbutton switch *S1* is depressed, power from the 117-volt ac line is applied to the timer circuit. Parallel resistors *R3* and *R4* drop approximately 95 volts of the line voltage, resulting in the application of approximately 22 volts ac to the input of modular bridge rectifier *RECT1*. The pulsating dc output generated by *RECT1* is converted into +5 volts regulated by filter capacitor *C7* and IC regulator *IC1*.

When power is initially applied to the timer circuit, pin 3 of *IC2* goes high and forward-biases the infrared-emitting diode within *IC3*, an optically isolated triac driver. This activates the bilateral switch within *IC3* which triggers triac *Q1* into conduction. When the triac turns on, 117 volts ac is applied to the load and to the center contact of switch *S2*. If this switch is placed in position "A", as shown in the schematic, the timer circuit continues to receive line power even though pushbutton switch *S1* is released.

The load and the timer circuit will be powered for a period of time determined by values of components *R6* and *C4*. For the component values shown, this interval is approximately one minute. Once *IC2* has timed out, pin 3 of *IC2* goes low and deactivates *IC3* and triac

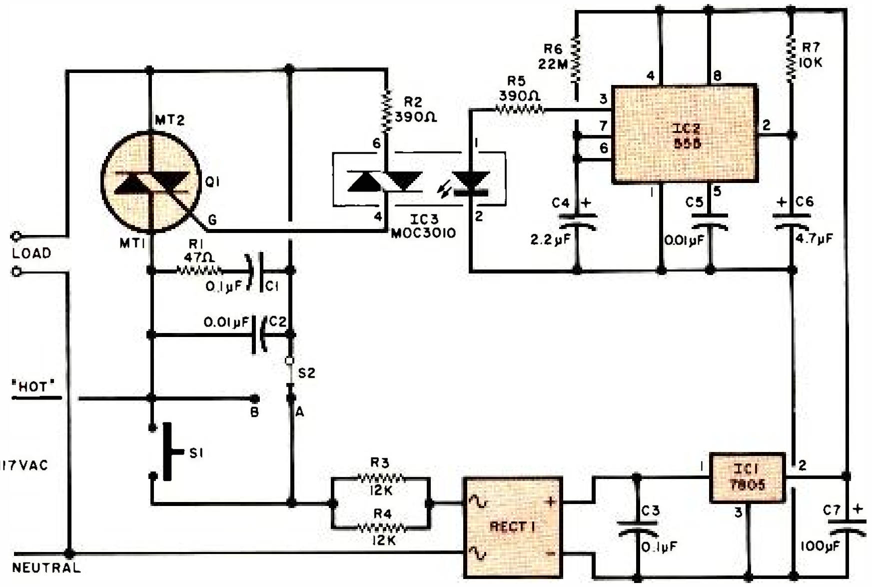


Fig. 1. When power is applied to the circuit by pressing S1, the output of IC2, through IC3, triggers Q1, which supplies power to the load (with S2 on "A") for a time determined by R6 and C4. With S2 on "B", power is supplied directly to the load.

PARTS LIST

C1—0.1-µF, 200-VDC tubular (272-1053)*
C2—0.01-µF, 200-VDC tubular (272-1051)*
C3—0.1-µF disc ceramic (272-1069)*
C4—2.2-µF tantalum (272-1407)*
C5—0.01-µF disc ceramic (272-1065)*
C6—4.7-µF tantalum (272-1409)*
C7—100-µF, 10-volt electrolytic (272-1044)*
IC1—7805 voltage regulator (276-1770)*
IC2—555 timer (276-1723)*
IC3—MOC3010 triac driver ***
Q1—6-A, 200-V Triac (276-1001)*
R1—47-ohm, ¼ -watt resistor
R2—390-ohm, ¼-watt resistor
R3, R4—12,000-ohm, 2-watt resistor
R5—390-ohm, ¼-watt resistor
R6—22-megohm, ¼-watt resistor *
RECT1—1-A, 50-PIV modular bridge rectifier (276-1161)*
S1—Single-pole, normally open pushbutton switch (34-02062V)**
S2—Spdt rocker switch (99-64248V)**
Misc.—Electrical box cover plate, printed circuit board, heat sink, silicone thermal compound, barrier strip (274-657)*, IC sockets (optional), hookup wire, spacers, mounting hardware, etc.

* Radio Shack Part Number
** Lafayette Part Number
*** Motorola Semiconductor component, available from Motorola Distributors

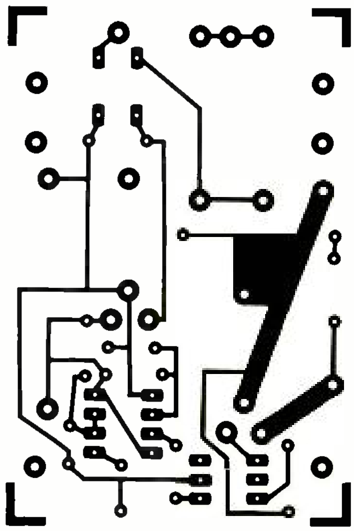


Fig. 2. Actual-size etching and drilling guide for pc board.

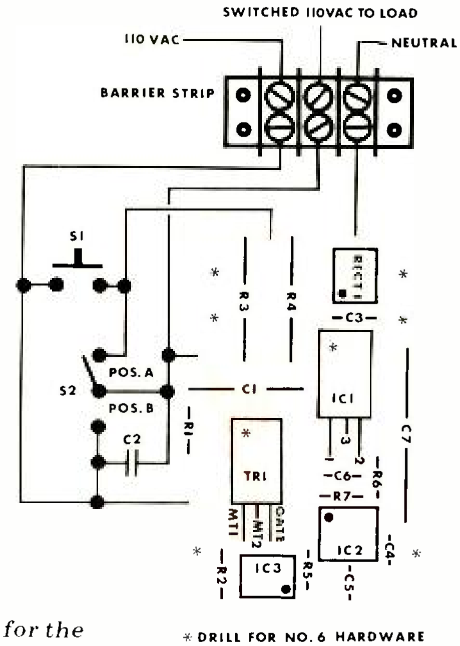


Fig. 3. Parts placement guide for the printed circuit board is shown at right.

Q1. Power is thus removed from the load and the timer circuit.

Placing switch *S2* in position "B" bypasses the triac and applies 117 volts ac directly to the load. This feature has been incorporated into the Smart Switch so that the user can manually keep the load powered for an indefinite period of time. If the bypass feature is not desired, switch *S2* and capacitor *C2* can be eliminated. In that case, however, it will be necessary to connect the *MT2* terminal of triac *Q1* directly to the junction of *S1*, *R3*, and *R4* to ensure proper operation of the timer circuit.

Construction. Most of the circuit can be mounted on a single printed circuit board. The etching and drilling and parts placement guides are shown in Figs. 2 and 3; respectively. Triac *Q1* must be mounted on a heat sink. Also, be sure to use silicone thermal compound to ensure a good heat transfer. A standard plastic electrical wall-box cover plate should be cut out and drilled to accommodate switches *S1* and *S2*. Capacitor *C2* is then mounted directly on the lugs of switch *S2*.

As shown in Figure 4, a three-terminal barrier strip is mounted on standoffs on the component side of the printed circuit board directly above *R3*, *R4*, *C3* and *RECT1*. When soldering capacitor *C3* to the pc board, leave the leads long enough so that the body of the capacitor can be bent back to lay flat on top of *RECT1*. Suitable lengths of hookup wire should be used to interconnect the board and switches *S1* and *S2*.

The completed pc board is then mounted using standoffs on the back side of the plastic cover plate. Be sure to use standoffs that are not too long, as the entire assembly must fit within a standard electrical wall box.

Installation. Before installing the Smart Switch, be sure to turn off the power at the fuse or circuit breaker box. Remove the existing wall switch and cover plate. Then, using the parts placement diagram shown in Figure 3 as a guide, connect the existing wall-switch wiring to the Smart Switch barrier strip. You might find that a neutral wire has not been brought into the wall-switch electrical box. If this is the case, wire the neutral terminal of the barrier strip directly to the metal wall box.

Carefully screw the assembled Smart Switch into place and you're ready to start using it. The finished product will look like the prototype shown in Fig. 5.

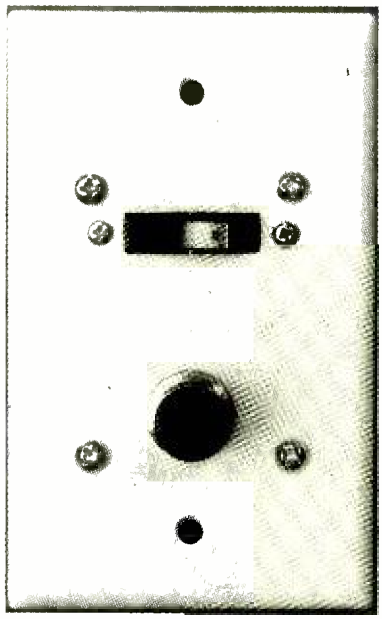


Fig. 5. Completed Smart Switch mounted and ready for use.

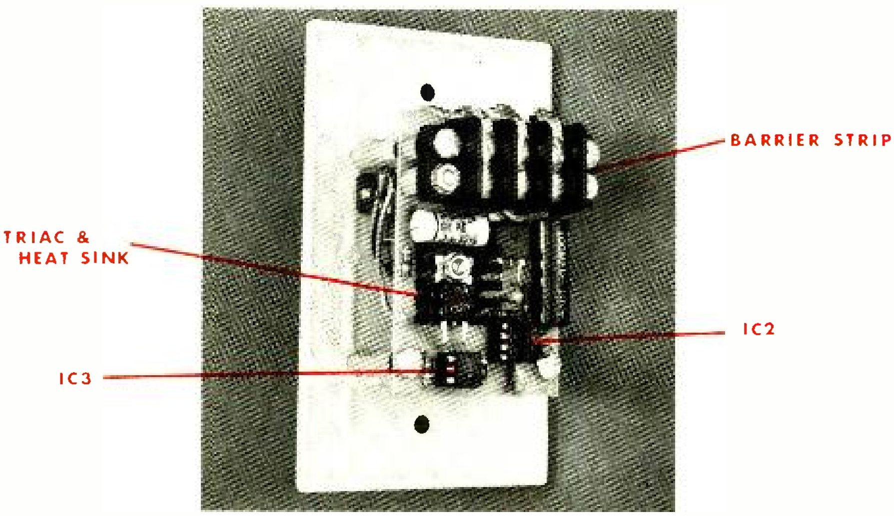


Fig. 4. Photo of the back of the Smart Switch shows how pc board is mounted on a standard plastic cover plate.

Use. If you are only going to remain in the room equipped with the Smart Switch for a short period of time, depress *S1* as you enter. The lamp controlled by the project will remain on for the period determined by the values of the components in the timing circuit, resistor *R6* and capacitor *C4*. If you intend to remain in the room for an extended period of time, place switch *S2* in its "B" position. ◇

A breakdown of transmissions, by frequency, on various public service bands

WITH THE large number of scanning receivers now available on the market, most hobby listeners are well acquainted with the three most common "utility" radio bands: 30 to 50 MHz (low vhf band), 150 to 174 MHz (high vhf band), and 450 to 512 MHz (uhf band). There are, however, a number of other segments of the vhf and uhf radio spectrum that are frequently very active but unknown to all but a few listeners. Occasionally, tactical military-maneuver information can be heard, and repeaters that assist government communications links are encountered. Telemetry tone can also be heard carrying digital data from a critical monitoring application to a vital receiver at some remote point.

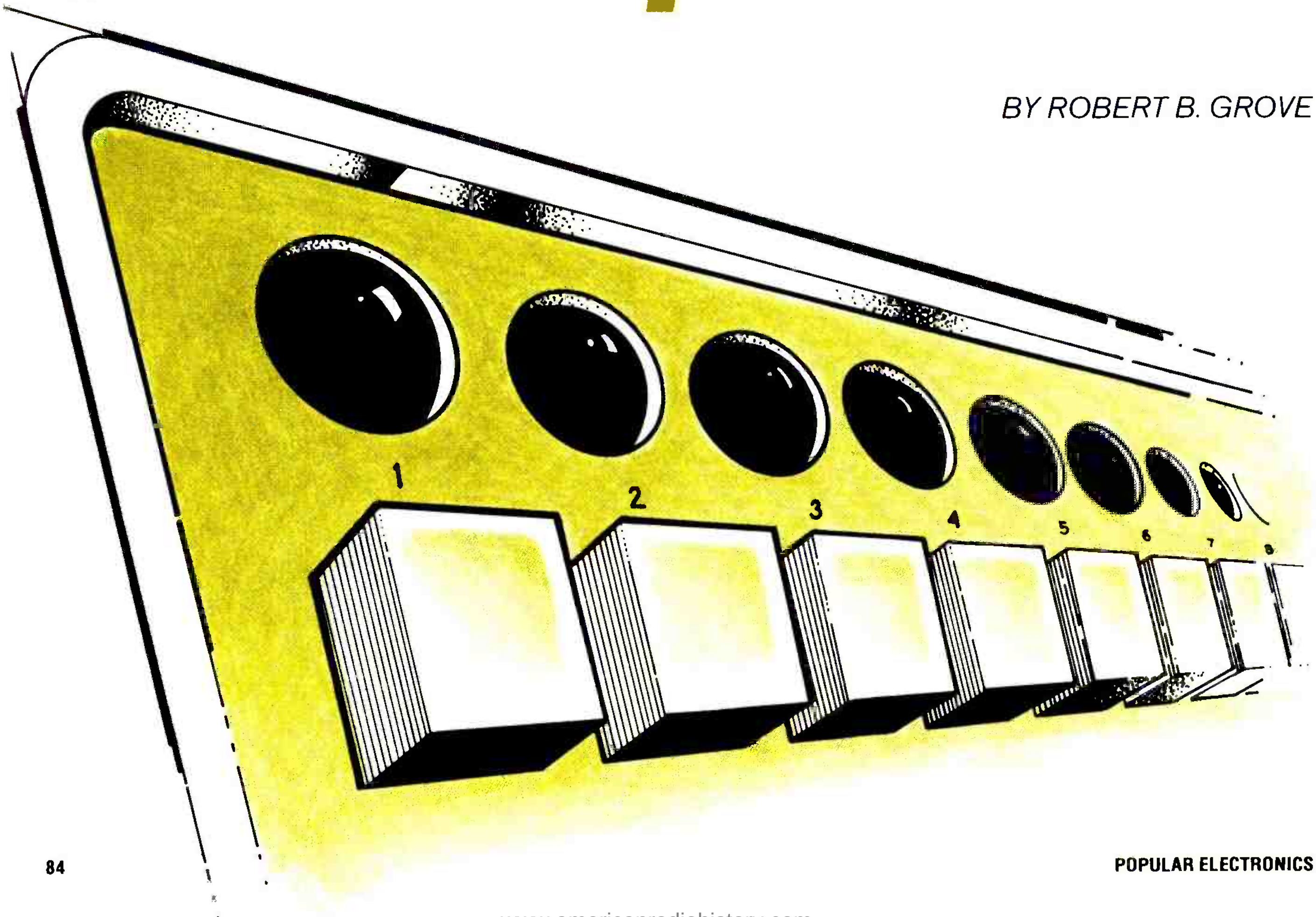
Frequency lists published by the FCC do not always help in identifying these stations. If the frequency belongs to the federal government, it is regulated by the IRAC (Interdepartmental Radio Advisory Committee), and is subject to change without notice. Some frequency assignments are kept secret and/or are in ranges not receivable on most receivers. Occasionally, military or commercial surplus equipment can be found to monitor these obscure frequencies. However, it is better to use a vhf or uhf converter ahead of your existing scanner or monitor receiver. Several excellent vhf/uhf converters are offered by JANEL, Vanguard Labs, VHF Engineering, and Hamtronics. With the exception of the 225-to-400-MHz AM aeronautical band, all communication channels use narrowband FM almost exclusively.

In the following paragraphs, we will examine what can be found on some of these lesser-used frequency bands.

50 to 54 MHz. This is primarily the 6-meter ham band. Channels between 50 and 54 MHz are shared with other services, including remote control of model

Who's on those other frequencies?

BY ROBERT B. GROVE



planes and boats on 53 to 53.5 MHz. Most hams operate on 50 to 51 MHz, and sometimes repeaters can be found between 52.5 and 54 MHz, with 52.525 MHz being the most popular repeater frequency.

72 to 76 MHz. At first glance, this frequency range appears to be within the band occupied by TV channels 2 through 6. In fact, this 4-MHz slot has a variety of users in the public safety and industrial group and is set apart from the TV channels. Although there is some voice communication here (such as army tactical communication), most of the uses are low-power tone signalling, such as in fire-alarm boxes and interstate highway motorist assistance boxes. Radio-controlled model planes and boats are often on 72 to 73 MHz. Listeners who live near airports are likely to hear the low-power, tone-modulated AM marker beacon on 75 MHz.

136 to 138 MHz. Just beyond the aircraft band, stations in the earth-satellite service use 136 to 138 MHz. Weather satellites such as the NOAA on 136.77, 137.14, 137.5, 136.62 MHz and Nimbus series on 136.5 MHz share this slot with communication satellites such as the Applied Technology Satellites (ATS) on 135.6, 137.35, and 137.5 MHz. Orbiting satellites share dozens of discrete frequencies in this band. Some satellites are geosynchronous (remain above a fixed spot on the earth), while others continually change position. The latter require tracking by antenna. Some data, available from NASA, enable listeners to keep up with the satellites. Most applications are for telemetry and data transmission, but some voice can be heard when satellites are used for long-distance relay, as in educational and scientific operations.

138 to 144 and 148 to 150.8 MHz. These ranges are used exclusively by military agencies for a variety of nontactical applications. Among the users of these channels are base operations and maintenance crews, security, rescue, and medical services; and VIP paging. Other channels are used for tone signalling. Some government navigational satellites can be heard at 150 MHz. The "hole" at 144 to 148 MHz between these two ranges is the popular 2-meter ham band.

216 to 220 MHz. Located just above TV channel 13, the 216-to-220-MHz

Other Frequencies. . .

continued

band is used primarily for telemetry (data) systems and tone signalling by both government and nongovernment services. Don't expect to hear two-way voice systems unless they are on an unusual authorization.

220 to 225 MHz. This little-used portion of the spectrum was the cause of some bitter feelings a few years ago. Although it was assigned to the Amateur Radio Service, it was rarely used. As a result, an effort was made to reassign at least a portion of the band to a new Citizens radio service. The movement has been stalled temporarily and probably permanently.

Although military radiolocation is listed as a primary user of this slot, in actual practice the Amateur Radio Service is more likely to be encounterd, especially in metropolitan areas.

225 to 400 MHz. One of the largest chunks of dedicated vhf/uhf spectrum space, this 175-MHz band is used almost exclusively by military aircraft for AM voice communications. Even the Space Shuttle will have two backup voice channels in this band, on 296.8 and 259.7 MHz, as had all the Apollo flights. Every military aircraft aloft uses this band to communicate with other aircraft in flight and with control towers. Because of the altitudes from which they transmit, aircraft can often be monitored for hundreds of miles.

400 to 406 MHz. Space telecommand (satellite control signals) and meteorological telemetry (digital weather data) signals populate this portion of the uhf spectrum. Wildlife tracking signals are also found here, such as polar bear tracking by Nimbus 6 on 401.2 MHz.

406 to 420 MHz. This band is exclusively occupied by the federal government; many agencies use it for control links to interconnect repeater sites. An example is the Department of Agriculture's Forestry nets that populate the 411- and 415-MHz regions of this range. The Department of the Interior connects its repeaters with signals in the 411-, 412-, and 417-MHz portions of the band. In addition, some tone signalling and data transmission can be heard. Although it is in common use near large metropolitan areas, remote regions are unlikely to hear much activity in this frequency range.

420 to 450 MHz. This 30-MHz portion of the spectrum is shared by the amateur radio service and military radar. A few ham repeaters, active in larger cities, operate on 420 to 450 MHz. Hams experimenting with television transmissions can be heard on 439.25 MHz; and the Amateur Radio OSCAR satellites transmit on frequencies in the 432- and 435-MHz ranges.

806 to 960 MHz. Many visionaries consider this newly opened segment of the radio spectrum as a vast, unspoiled territory. With the exception of a small government radiolocation service from 902 to 928 MHz, the entire 154-MHz band is allocated to nongovernment land mobile services, with 947 to 960 MHz usable for fixed point-to-point communication.

A band plan of allocatable frequencies and services has been prepared by the FCC, and is being opened gradually for use. A number of frequency blocks are still held in reserve, pending further studies.

Services using this portion of the spectrum run the gamut and include police, business, and broadcast relays. Many use these interference-free frequencies for control links to high-powered transmitter sites.

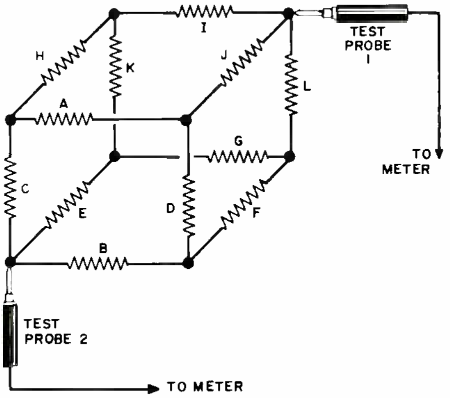
Summing Up. Although this article may help you to identify primary uses for the frequency bands listed, the FCC and IRAC reserve the right to license station operation on virtually any frequency in the spectrum even outside of normal allocations. For this reason, it is possible in some locations to hear Bell Telephone mobile service on 406 to 407 MHz, which is normally federal-government assigned; industrial FM signals in the 351-MHz range, which is for military aeronautical AM; or the U. S. Army on 75 MHz, usually assigned to airport marker beacons.

Users of these communication frequencies often resent the intrusion of uninvited listeners, but voice security systems are available to protect sensitive transmissions. The vast majority of listeners are law-abiding citizens who are interested in what is happening around them. Scanner monitoring can improve public understanding and awareness of local, state, and federal government responsibilities. ◇

THREE-DIMENSIONAL RESISTOR QUIZ

BY GARY W. SEAVER

A three-dimensional resistor array such as that shown in Fig. 1 is not likely to occur often in real life—especially made up of 12 equal 100-ohm resistors as it is here. However, complicated circuits do occur and it is handy to know how you can solve for their effective resistance by reducing them through a succession of pi and T transformations, rearrangement of components, etc. (Or, of course, the circuit can always be built up on a breadboard and checked with an ohmmeter.) For the purposes of the quiz, however, determine the resistance analytically. The answer is printed below upside-down.



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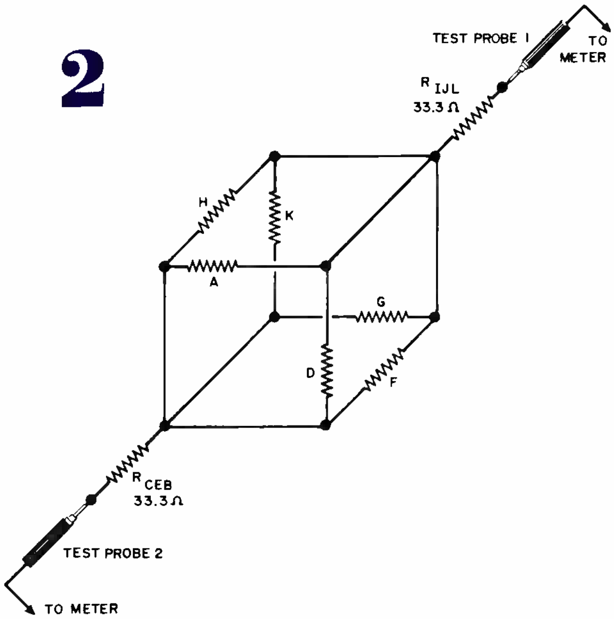

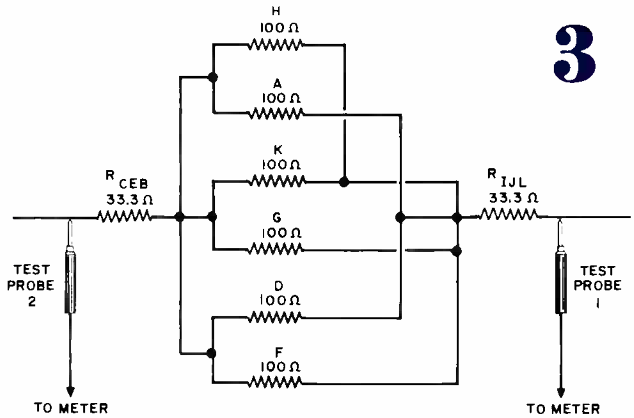

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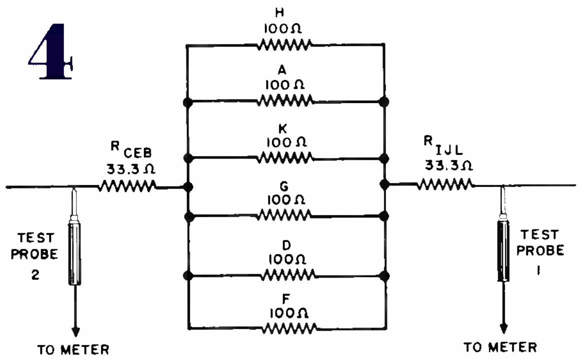
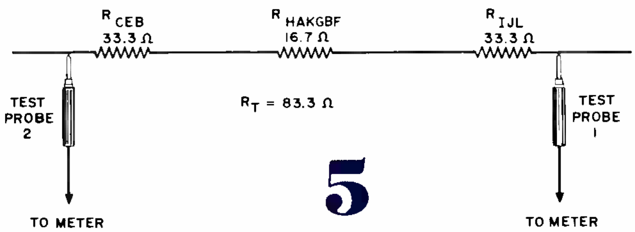




5

ANSWER

Here's one possible solution to the Three-Dimensional Resistor Quiz. Because resistors I, J, and L share a common node at test probe 1, let's assume they are in parallel. Employing the formula for resistors in parallel, we obtain an equivalent resistance of 33.3 ohms. Similarly, we assume that resistors B, C, and E are in parallel with an effective resistance of 33.3 ohms. The resulting circuit is shown in Fig. 2.

It can now be seen that resistors H, A, K, G, D, and F all share a common node with effective resistance R_{IJL}. The same resistors share a common node with R_{BCE}. If we reduce and redraw the circuit, we get that shown in Fig. 3. Further simplified, it becomes Fig. 4. Obviously, resistors H, A, K, G, E, and F are in parallel, with an effective resistance of 16.7 ohms. The final simplified version of the circuit is shown in Fig. 5. With three effective resistance in series, they can be summed to obtain a total of 83.3 ohms.

Experimenter's Corner

By Forrest M. Mims

MISSING-PULSE DETECTORS

Missing-pulse detectors can be found in applications ranging from moderately sophisticated, break-beam intrusion detectors to adjustable-duration event timers. Figure 1 is the circuit for a simple but reliable missing-pulse detector made from a 555 timer.

The circuit, which was adapted from one given in the Signetics 555 applications note, is a modified monostable multivibrator. In operation, an input pulse applied to pin 2 triggers the one-shot. The output then goes high for a period determined by the values of timing components *R1* and *C1*.

A 555 monostable ordinarily ignores trigger pulses that arrive *during* the timing period. In this circuit, however, *Q1* fools the one-shot into accepting a trigger pulse during the timing cycle. Refer to the schematic and you'll see why. Normally, *Q1* is off, but a trigger pulse biases it into conduction. This discharges *C1*. Simultaneously, the trigger pulse initiates a new timing cycle.

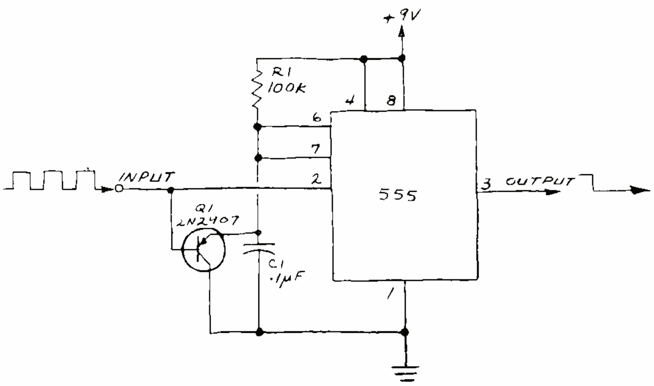


Fig. 1. Basic missing-pulse detector circuit.

If the interval between incoming pulses is *less* than the timing period, the output of the 555 will remain high. Should an incoming pulse not arrive until *after* the previous timing cycle has ended, the output will go low until the pulse arrives. By adjusting the time constant so the timing cycle is slightly longer than the interval between incoming pulses, the circuit will respond to missing pulses by switching low until a new pulse arrives. The circuit can also be adjusted to respond to a *decrease* in the frequency of incoming pulses.

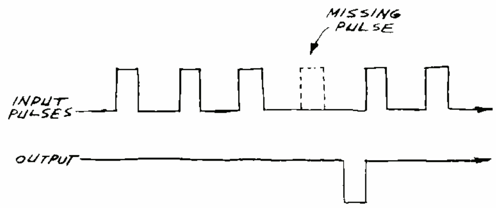


Fig. 2. Missing-pulse detector timing diagram.

If this explanation of how a missing pulse detector works seems complicated, the timing diagram in Figure 2 will help you understand what happens. Although the diagram illustrates a single missing pulse, a series of two or more missing pulses might also occur. Should this happen, the output will remain low until the pulse train is again received.

Simplified Missing-Pulse Detector. The circuit shown in Fig. 1 is commonly used in missing-pulse applications, but that shown in Fig. 3 is simpler. In this circuit, the reset pin is connected to the trigger input. A pull-up resistor connected to $+V_{CC}$ must be added, but the transistor across *C1* (*Q1* in Fig. 1) is no longer needed.

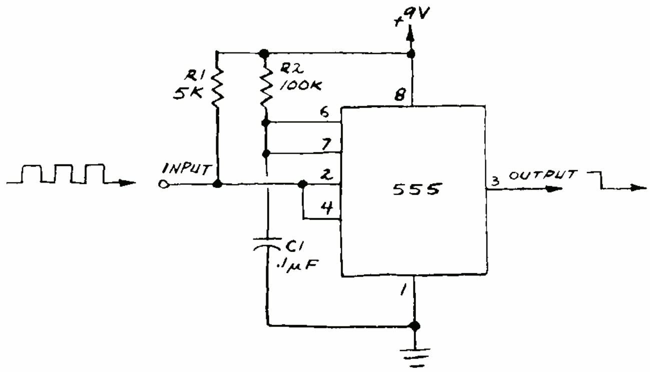


Fig. 3. Simplified circuit for a missing-pulse detector.

Break-Beam Object Detector. Figure 4 shows a simple but effective infrared, break-beam object-detection system comprising a pulsed LED transmitter optically coupled to a missing pulse detector. In operation, pulses from the transmitter are detected by phototransistor *Q3*, which is used to reset *and* trigger the one-shot before the timing cycle can be completed. Blocking the path between the transmitter LED *(LED1)* and *Q3* will cause the receiver LED *(LED2)*. to glow. The receiver LED will go off when the optical channel is reopened.

The sensitivity of the circuit is determined by *R2* and the phototransistor. The resistance of *R2* can be less than 33,000 ohms, but the receiver's sensitivity will be reduced. Sensor *Q3* can be a standard silicon phototransistor, but a Darlington phototransistor will provide higher sensitivity.

Timing components *R3* and *C2* determine the time constant of the one-shot. A fixed resistor can be used for *R3* if its value is such that the timing cycle is longer than the period between transmitter pulses. The time required for the circuit to respond

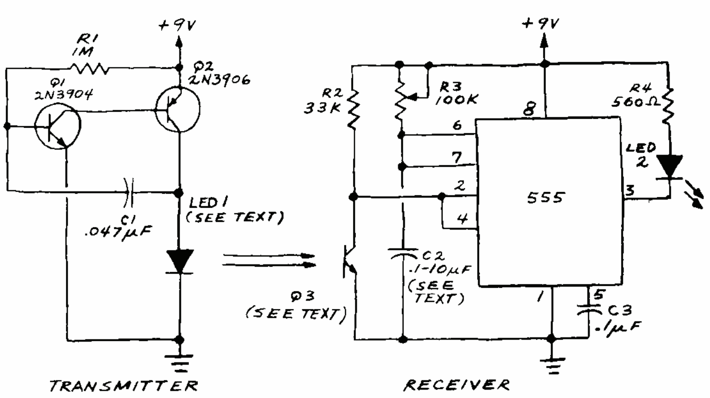


Fig. 4. Schematic for a break-beam object detector.

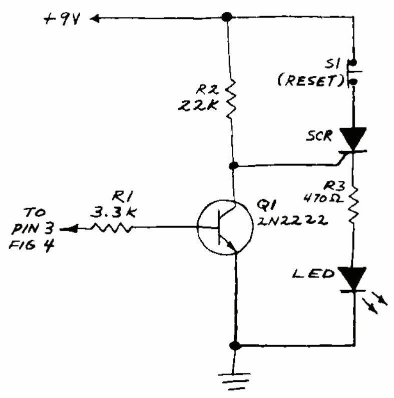


Fig. 5. SCR output circuit.

to a missing pulse is the difference between the transmitter-pulse interval and the receiver's time constant. Therefore, the circuit will appear to respond almost immediately to an obstruction placed in the optical path when the time constant is slightly longer than the pulse interval. On the other hand, the circuit will require as much as a few seconds to respond if the time constant is much longer than the pulse interval. Increasing *R3*, *C2* or both will increase the time constant.

Long time constants make possible such specialized applications as detecting slow-moving objects or long objects moving through the optical channel at the same velocity as short objects. A long time constant also provides a degree of false-alarm immunity when the system is used as an intrusion alarm because the detector can thus be adjusted to ignore falling leaves and other transient interruptions.

The range of the system is determined by the sensitivity of the receiver and the optical power radiated by the transmitter LED. For best results, use a photodarlington for *Q3* and stick to the relatively powerful transmitter circuit shown in Fig. 4. Be sure to use a GaAs:Si device for *LED1*. Suitable types include the Optron OP-190 or OP-195 and the G.E. 1N6264. Also, don't allow too much ambient light to strike *Q3* (although some dc illumination will provide base bias and increase *Q3*'s sensitivity).

With these components, the maximum detection range will be a few handbreadths. Adding lenses to both the transmitter and receiver will increase the operating range. Best results will be obtained with lenses having a focal length approximately equal to the diameter of the lens (which corresponds to an *f* number of 1). With 5-cm diameter, *f1* lenses, a range of a few meters or more can be achieved.

Adding an Output Latch. The output pin of the receiver (pin 3 of the 555) switches from a low to a high state when a missing pulse occurs and, after a timing interval, returns to its low state. In some applications, such as intrusion alarm systems, it's necessary to latch the output to a high state once a single missing pulse has been detected. Figure 5 shows one way the latching function can be achieved with the help of an SCR. This simple circuit is designed to be connected directly to pin 3 of the 555 in Figure 4.

An SCR is triggered by a positive gate voltage. Because the 555 output is normally high, *Q1* is required to invert the output. Resistor *R3* limits current flowing through the indicator LED. If the resistance of *R3* is too low, excessive current will flow through the LED and SCR. On the other hand, if the value of *R3* is too high, the current through the SCR will be less than its minimum *holding current*. This means the SCR will turn off and on, rather than latching on, when the 555 output changes states.

Reset switch *S1* is a normally closed pushbutton. If the 555 output is high (for example, when the transmitted signal is being received) and the SCR has been gated on by a previous missing pulse, pressing *S1* will turn off the SCR and prepare it to latch onto the next missing pulse.

Optically-Coupled Slot Switches. Slot switches are made by mounting a LED and phototransistor so they face one another across a narrow space in a plastic fixture. Applying a forward current to the LED switches the phototransistor. An opaque object (magnetic tape, paper card, etc.) inserted in the slot blocks the beam from the LED and turns the phototransistor off.

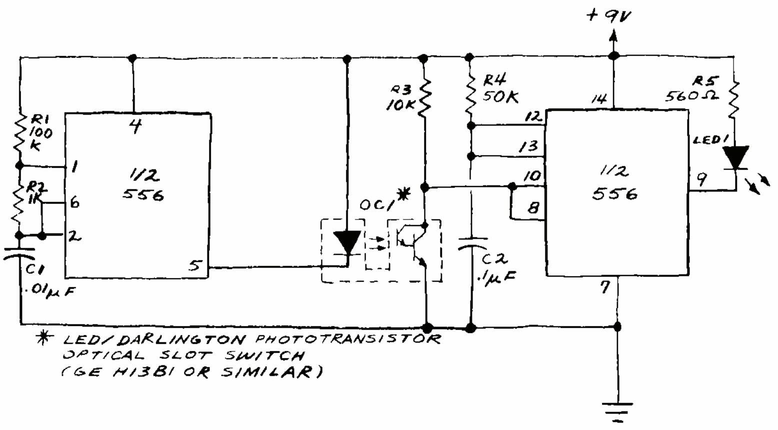
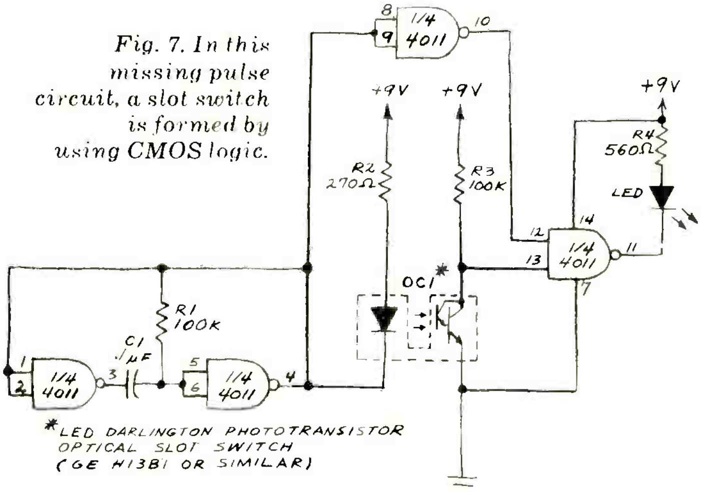


Fig. 6. In slot switch circuit, one half of 556 is a pulse generator and the other a missing-pulse detector. Blocking the slot between the LED and the photo transistor causes the detector to change states and energizes the light emitting diode.

Fig. 7. In this missing pulse circuit, a slot switch is formed by using CMOS logic.



Many optoelectronics companies make various types of optical slot switches. If you can't find one, or if you don't like the prices of those you find, it's easy to improvise by mounting an infrared LED and photodarlington on a suitable jig. The gap between the two components should be a few millimeters.

Usually, a dc bias is applied to the LED in a slot switch. It's possible to achieve the same results—and at the same time save current—by pulsing the LED and connecting the phototransistor to a missing pulse detector. Here are two examples.

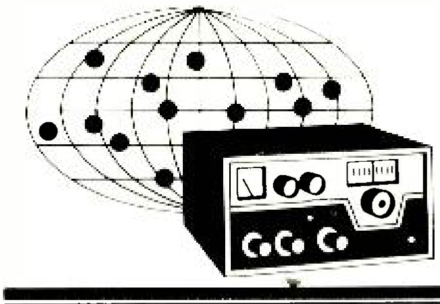
556 Slot Switch. In the circuit shown in Fig. 6, one half of a 556 dual timer serves as the pulse generator for a LED. The remaining half is connected as a missing pulse detector. Pulses from the transmitter continually reset and trigger the one-shot. Blocking the slot between the LED and phototransistor causes the missing pulse detector to change states and light the indicator LED.

The SCR latch in Fig. 5 can easily be added to this circuit. Also, you can experiment with *R4* and *C2* in the receiver portion of the circuit to alter its response time. For example, if the timing cycle of the receiver is 100 milliseconds longer than the period between pulses from the LED, the slot switch will ignore an interruption lasting less than 100 milliseconds.

CMOS Slot Switch. A single 4011 quad NAND gate can provide the bulk of the transmitter and receiver electronics for a pulsed break-beam slot switch based on the missing-pulse principle. Figure 7 is the schematic diagram of the slot switch.

In operation, the LED in the slot switch is pulse-modulated by the astable multivibrator formed by two of the gates in the 4011. Timing components *R1* and *C1* determine the pulse rate and *R2* limits the peak current through the LED. Pulses from the LED are detected by the Darlington phototransistor in the slot switch and presented to one input of a NAND gate. The inverted output from the multivibrator is presented to the second input of the NAND gate. When optical pulses are received by the phototransistor, its collector goes low, causing the output of the NAND gate to go high. When the slot is obstructed, both inputs to the NAND gate go high each time the slot switch LED is pulsed. This turns the indicator LED on.

Although the indicator LED appears to be glowing continuously when the slot is obstructed, it is actually flashing at the same rate at which the slot switch LED is pulsed. ◇



DX Listening

By Glenn Hauser

A SURVEY OF DX PROGRAMS

THIRTY shortwave stations—some grudgingly, others eagerly—devote from 3 to 90 minutes of airtime a week to DX Programs. With almost 30 different approaches, the stations attempt to provide a feature for those who regard shortwave as more than just another radio band.

Here is our review of these programs. The more stars, the better the program, in our opinion. All times are GMT, but days of week are local in North America. Frequencies are in kilohertz and are for the summer, but most should continue in the fall.

Australia. (**) "Club Forum" is nominally the voice of the *Radio Australia* listeners club, a white elephant they so far haven't dared to slay, despite the fact that they no longer have the staff to process all those reception reports which are of little value to them. Actually, it is a quickie production glaringly deficient in preparation, by Warren Moulton, a ham radio operator who is obviously not very familiar with shortwave broadcasting. Mainly plugs for various real DX clubs' publications, occasional interviews, and a few minutes of the 15 (no more than 5) given to DX tips (which is what most listeners would rather hear more of) drawn from "DX Time" a *Radio Australia* Japanese program wherein DX tips are more appreciated. Keith Glover often substitutes. Fridays at 0240 on 21740 and 17795.

Austria. (****) "Shortwave Panorama" from *Austrian Radio* is one of the more original DX programs. It rarely broadcasts tips, but it does have general news of broadcasting developments and tightly produced features on rare stations. These are complete with studio recordings of their IDs, the latter done by Jonathan Marks, a college student in England. Plagued by reception problems in North America. Try Sundays 2305 to 2320 on 12015, 9770, or 5945.

Belgium. (**) "DX Corner Belgium" from *BRT* sounds completely ad-libbed, as does much *BRT* programming. Letters from listeners are read and DX tips are given, apparently without any editorial checking. But host Frans Voosen is to be thanked for keeping the show going after the departure of Ursula. It is on the second and fourth Sundays at 1635 (1735 Oct-Mar) on 21475 and 17745, at 2245 on 15175, and 0040 on 11715 and 15175.

Bulgaria. (**) *R. Sofia*'s DX program has improved in recent years, revealing a new liberalism in giving schedules not only of socialist stations but nonsocialist ones. Has considerable ham-oriented material, often quoting ARRL. It has ham DX tips and was a major source of information on the ham operations of the *Ra* expedition and other ham news of DX interest. On Fridays at 2135 on 15135 and 11750; at 0435 on 11750 and repeated at the same times Sundays. On the last week of the month, a useful propagation forecast is broadcast.

Canada. (*****) *RCI*'s "DX Digest" squeezes a lot into about 30 minutes a week. Host Ian McFarland presents talks on a variety of subjects related to radio and introduces a number of regular rotating features, such as a handicapped aid program report on the first Sunday of the month from Jeff White. It has the most up-to-date DX news (only two or three days old at air time) of any station. The program is presented in four editions—I and II combined Sundays at 1807 on 15260 and 17820, III and IV combined Wednesdays at 2145 on 17780, 15150, and 11940. Other Sunday broadcasts contain one edition each—I at 1915 on 15325 and at 0015 (May to October) and 0115; II at 2015 on 17875 and 15325 and at 0215; III at 0315; and IV at 0415. In the evening the freqeuncy 5960 is joined by different parallel at different hours. I provide different DX news in editions I and III; two Canadians give the DX news in editions II and IV.

Canada. (****) "The Sound of Shortwave" is a weekly conversation between Steven Freygood of *CBC* Halifax and

Don Harron, host of Morningside playing straight man. Freygood picks out the oddities he's heard over the past weekend on major broadcasts and puns with the Canadian angle if he can find one. Mondays about 1325 on *CBC* Northern Service (11720 and 9625) and on *CBC* Radio throughout Canada at 9:25 a.m. local time (9:55 in Newfoundland). As a feature within a program, its time varies greatly, and at the last check before press time, it had disappeared.

Czechoslovakia. (*) *Radio Prague*'s so-called DX program is an example of everything a DX program should not be—endless incestuous discussions of Czechoslovakia's domestic broadcasting system. On Thursdays at 0135 and 0335. However, producer Oldrich Cip (A.K.A. Peter Skala) recently met with his Western counterparts in Vienna, giving us some hope for improvements.

Ecuador. (***) *HCJB*'s "DX Party Line" has far more time at its disposal than any other DX program—90 minutes a week—with three different programs each broadcast at four different times. Yet, most of this time is wasted with repeated items, irrelevant material like "Tips for Real Living", hellos, goodbyes, and thank-yous by host Clayton Howard, who speaks at about half the rate of the average person. However, this is an advantage for people whose native language is not English and for those who tape the show and can listen to it at double speed without missing a word. The show is invariably kept at the absolute-beginner level: *HCJB* is really on the lookout for converts to evangelical Christianity. The DX program is merely a means to this end, as *HCJB* candidly admits in duns to U.S. contributors. Still, the program does have some worthwhile segments, produced by Jeff White on Wednesdays. John Trautschold, who speaks at about double the speed of the average person, presents a SPEEDX report on Saturdays. Although considerable DX tips are given, they are not timely and are often out of date due to the prerecording schedule of the program and lethargic mail service. This is great potential, going to waste. Mondays, Wednesdays, and Saturdays at 0230 on 11915 and 9745. Can also be heard Mondays, Thursdays, and Saturdays at 2130 when it is to Europe on 21480, 17765, and 15295.

Finland. (**) *R. Finland* has a fortnightly "World of Radio" segment on "Sunday Best" around 1350 on 15400, when reception in North America is unreliable. David Mawby has been making a systematic study of the "communications chain"—August 12, Propagation; August 26, Reception; September 9, The Listener's Environment. Rather elementary stuff, but there may be some interesting ideas presented.

Germany East. (***)"RBI DX Club" has technical talks beyond the beginner stage, plugs for its club awards program and an ionospheric weather report. Fortnightly on Mondays, 0130 and 0300 on 9730 and at 0400 on 11890 and 11840.

Germany West. (**)*Deutsche Welle* has a "DX Programm" in some English broadcasts but not to North America. Instead, the German program goes bilingual 10 minutes a month on the second Saturdays at 2350 and 0350 on many unavoidable frequencies. It leans toward items from the broadcaster's point of view, sunspot counts, and some ham radio items. No attempt at DX tips. Written by G. G. Thiele, a ham who works at the station and has been in broadcasting since the days of Rommel.

Hungary. (**) *Radio Budapest* "Calling DXers and Radio-Amateurs" has a nice theme song. It takes up a lot of time with identically worded thank-yous after each contributor. Program content varies. They have been giving an interminable listing of DX abbreviations, a few letters at a time. Sometimes listeners' loggings are read off, in a very dull fashion, always with SINPO but without program details and without any regard as to whether they are newsworthy or even correct. The English announcers do not check with *Radio Budapest*'s Spanish announcers on pronunciation of Latin American names, producing some awful results. Sometimes there are some ham radio DX tips. Programming is liberal enough; they don't mind mentioning WYFR, for instance. Tuesdays and Fridays at 0400; Saturdays at 0215 and 0315, on 17710, 15225 and 9835.

Israel. (***)*Israel Radio*'s "DX Corner," squeezed in at the end of Sunday broadcasts (except for holidays when it is bumped to Monday), is the shortest DX program on the air. But Ben Dalfen usually comes up with an interesting topic that avoids duplication of other stations. There are never any DX tips. On the air at 2025 and 2255 on 17645, among other frequencies.

Japan. (**)*R. Japan* has a DX news segment at the end of "Tokyo Calling," compiled by the Japan SW Club, but there is hardly ever anything but routine loggings and schedules. Announcers are difficult to understand. To break up all this hard-to-digest data, some extraneous music is played every few minutes. Tune in Sundays at 1420 on 9505; 2320 on 17755; at 0025 on 17825 and 15270; at 0210 on 21640, 17825, 17725, and 15270.

Netherlands. (*****)*R. Nederland*'s "DX Jukebox" is probably the best DX program on the air. It contains a good mix of DX reports, propagation forecasts, tapes of station IDs, answers to listeners' questions, and club news. Unfortunately, the DX news isn't as timely as it might be, due to a two-week production lead time. The "jukebox" portion of rock music is supposed to ensnare passersby into DXing, while those who don't care for it have to put up with it to get the meat of the program. *R. Nederland* also offers free material by mail, such as DX Information Service Catalog and various courses. Tune in Thursdays at 1450 on 21480; at 2250 on 21640, 17810, 11740, and 11730; at 0250 on 9590 and 6165; and at 0550 on 9715 and 6165. You can hear my North American DX report on the third week and Review of International Broadcasting on the fourth week.

New Zealand. (***)"Arthur Cushen's DX World" via *R. New Zealand* is a 15-minute summary of DX news and schedules and some station ID tapes. It's on the first Sunday at 1015 (Nov. to Feb. 0915) on 6105. If you can't hear that, "DX Party Line" usually reads the whole script some weeks later on no particular schedule, and a condensed version is on "DX Juke Box" on the first Thursday.

Portugal. (**) *R. Portugal* has a DX feature every third Friday, that is on one week, off two weeks. Don't believe the announcer's promise to be back in 2 weeks. Tune in at 0315 and 0515 on 11935 and 6025.

Romania. (**) *Radio Bucharest* has a DX program Monday and Friday at 0215 on 11940 and 9570, with a ham-oriented technical talk.

South Africa. (**)Gerry Wood, a free-lancer, presented "DX Corner" until late last year. He made it a really interesting program, with thought-provoking commentaries on the DX hobby and some African DX news. But the program was turned over to *Radio RSA* employee Pieter Martins, who spends a lot more time talking about South African domestic broadcasting, a la Czechoslovakia. Tune in Saturdays at 2135 on 15155 and 0235 on 9610 and 5980, or Mondays at 1330 on 25790, 21535, or 15220.

Spain. (***)*Spanish Foreign Radio*'s "CQ, CQ" ("for amateur radio hams and DXers") has improved a lot, thanks to writer Ambrosio Wang An-Po. It has interesting talks and uncommon interval signal quizzes. You get only a few token items of "DX news," which usually aren't. The English version is an often-too-literal translation from Spanish. It has a really bouncy theme. Sundays at 0050 and 0145 on 11880 and 9630.

Sri Lanka. (***) "Radio Monitors International" via *SLBC* has a lot put into it by producer Adrian Peterson, an evangelist based in India. Various clubs from Australia to India to the USA contribute reports, as does Ian McFarland of *RCI*. But hearing it in North America is the problem. You can try on Sundays from 1100 to 1130 on 11835, 15120, and 17850, or at 1400 to 1430 on 15425 and 9720 (subject to change).

Sweden. (****)*Radio Sweden*'s "Sweden Calling DXers" is the oldest DX program still on the air, dating from the 1940s. Liberal-minded compiler and presenter George Wood deemphasizes DX news in favor of more club news and commentary, to the detriment of the program. Still, from 50 to more than 100 people send in material each week from all over the world, with Europe dominating, and very little of it ever gets on to this 10-minute program. Listen to other language versions for additional items or, better yet, write *Radio Sweden* for a free copy of the entire printed script. Tune in Tuesdays at 1415 on 21615; 2315 on 15290 and 11705; 0045 on 15290; and 0245 on 15275 and 11705.

Switzerland. (***)*SRI*'s "Swiss Shortwave Merry-Go-Round" is a very informal conversation between "The Two Bobs" (Zanotti & Thomann), mainly off-the-cuff answers to listeners' technical questions. Also, a "strange signal" is played and identified each time, and once a month there is a sunspot report. The presenters, who are both hams, should do a little more research before guessing at answers to questions. There is never any DX news, which is left to other programs. Tune in second and fourth Saturdays at 1320 on 21570; 1820 on 21585; 0150 on 15305, 11715, 9725 and 6135; and 0435 on 15305, 11715, and 9725.

Turkey. (**)*Voice of Turkey* makes a valiant effort with its "DX Corner" (original title, eh?), but the station just doesn't have enough material. As a result, DX items from other stations and acknowledgements to listeners' reception reports must be read. Tune in Monday, Thursday, and Saturdays at 2135 on 11955 and 9515.

UK. (***)The *BBC* "World Radio Club" is a weekly quarter-hour tightly-produced and superficial, as an attempt is made to squeeze too much material into the time available. (Admission to the Club is free to anyone who applies. You must be a member to participate in pennant and QSL competition.) The vast resources of the BBC Monitoring Service are barely tapped for DX news, also provided by individual DXer Noel Green. Nor is there DX news every week—it's a convenient time-filler, made up of many short, unrelated items. And the DX news is interrupted by host Peter Barsby every few seconds to make it sound like a conversation. Because of the curious station policy, producer Reg Kennedy apparently censors out any DX news about communist countries, which is a head-in-the-sand approach that is unworthy of a great world broadcaster. Henry Hatch often replies to listeners' questions in an extremely condescending tone. Scheduling could change in September. Tune in now on Sundays at 0745, Mondays at 1115, Tuesdays at 2100, or Wednesdays at 2315.

USA. To our shame, there is no DX program on an American shortwave station. However, those people who are close enough to Knoxville, TN, can hear my "Shortwave Review," most Saturdays for 5 to 20 minutes before noon eastern time on WUOT (FM) 91.9 MHz. The Review includes DX news even before it is heard on RCI DX Digest, broadcast reviews, and replays of some shortwave DX programs. It is available to other stations on a noncommercial basis.

USSR. (**)*R. Moscow*'s "DX Program" proves that the Russians really do have no qualms about plagiarism. This might be called "the illegitimate son of Sweden Calling DXers," since a few weeks after an item appears in SCDX, it turns up here with no source stated. Occasional info on Soviet broadcasting and ham radio is given. Tune in Saturdays at 1135, 1535, 1835, 2135, 2335, 0135, 0335, 0435, and 0635; Tuesdays at 0835 and 1535; Thursdays at 1435.

USSR. (*)*R. Kiev* also has a DX program that is largely ham-radio oriented and inward-looking. Tune in Wednesdays at 0045 and 0315.

USSR. *R. Tashkent* has a DX program on the second Sunday at 1200, repeated the following Saturday at 1400 on 15460, 15125, 11925, and 11730. ◇

Product Test Reports

B&K Precision Model DP50 50-MHz Digital Probe

THE Model DP50 from B&K Precision has been designed for use with RTL, DTL, TTL, HTL, MOS, CMOS, and HiNIL (high-noise-immunity logic) families. Thus, it is an almost "universal" digital electronics circuit test instrument. The 50-MHz probe is compact, measuring only 6"L × 1¼"W × ¾"D (15.2 × 3.2 × 1.9 cm) and weighs just 3.5 oz (98 g). It comes with 30" power leads, to the ends of which are attached insulated color-coded alligator clips. Suggested retail price is $50.00.

General Description. Three bright light-emitting diodes located near the probe's test tip indicate the conditions existing at any given point in a circuit under test. Two of these are assigned to indicating steady-state logic-0 and logic-1 states, while the third is a pulse-catcher display. Near these three LEDs is a MEM/PULSE slide switch for selecting either the memory or pulse mode of operation. In the PULSE position, a detected pulse can be stretched out to 200 ms so that very fast pulses, some of which may not cause the LED to light, can be observed. Set to the MEM mode, a fast transient pulse will cause the PULSE LED to come on and remain on until the logic in the probe is reset.

The probe is designed to detect pulses of less than 20 ns in width (10 ns typical). Intensity of the associated LED indicates the duty cycle of the pulse.

When the probe is operated in the PULSE mode, it can detect and stretch any pulse that crosses the threshold level, while in the MEM mode, it can detect and latch onto any threshold crossing. The logic-0 and logic-1 thresholds are 0.8 volt for TTL or 30% V_{DD} for CMOS and 2.4 volts for TTL or 70% V_{DD} for CMOS, respectively.

Overload protection of ±50 volts is provided for the input, whose impedance is rated at 2 megohms for minimum loading. The probe is designed to operate with power supplies with outputs of from 5 to 15 volts dc. Input protection on the power leads is provided up to 20 volts; reverse-polarity protection is to 50 volts.

There are only two operating controls on the probe, both slide switches. One is the MEM/PULSE switch. The other is the logic-family selector whose positions are labelled TTL and CMOS.

Test Results. The testing procedure for a simple test instrument like a digital probe is necessarily limited. In the case of the DP50 probe, we were able to check only frequency response, sensitivity, and duty cycle.

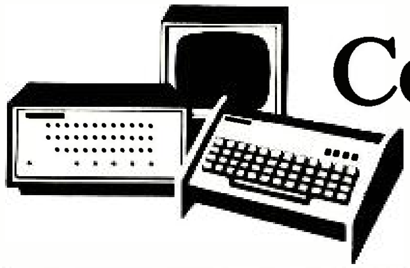
In an overall frequency-response measurement, the probe delivered reliable performance out to at least 50 MHz. We did not attempt to determine the obsolute top-end response of the probe. We did, however, obtain reliable performance with a 60-MHz input signal.

The PULSE and MEM modes permitted the logic probe to catch pulses of very short duration, at least down to 10 ns and 5% duty cycle. The triggering thresholds for the two logic levels were almost exactly as specified.

The light-emitting diode indicators were more than adequately bright. Even under bright lighting conditions, the lighted LEDS were easy to distinguish.

User Report. Unlike many digital probes we have used over the years, the DP50 stands out for its "human engineering." It is one of the best "hand-fitting" probes we have encountered. This, plus its surprisingly light weight, enabled us to rapidly troubleshoot a number of digital systems without suffering operator fatigue.

CIRCLE NO 105 ON FREE INFORMATION CARD



Computer Bits

By Hal Chamberlin

DIGITAL MAGNETIC RECORDING

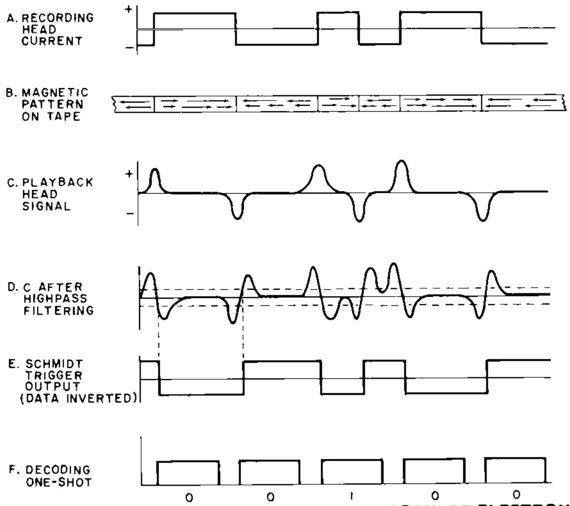
IN AN EARLIER column, many different *audio* data recording techniques were described. One feature all of them had in common was the overriding requirement for compensation for waveform distortion and frequency-response limitations of audio cassette recorders. The consequence is low speed (typically between 100 and 1000 bits per second) and an unsatisfactory reliability factor for serious personal or business use. Both of these problems can be overcome through the use of direct *digital* recording on the tape, thereby bypassing the audio circuitry.

Saturation Recording. Direct digital recording is also called saturation recording because the magnetic coating on the tape is fully saturated by the recording process. Normal audio recording uses only a small portion of the tape's "magnetic energy" to reduce harmonic distortion to acceptable levels. By magnetically saturating the tape, however, variations in tape sensitivity are masked and the higher-level playback is better able to overcome noise.

With saturation recording, referring to the waveform of the signal is no longer meaningful since everything is distorted into square waves. The basic signal element is the flux transition. As shown at (A) in the figure, the current waveform is either fully positive for north-south magnetization of the tape or fully negative for south-north magnetization. The actual magnetic pattern recorded on the tape is shown at (B).

When playing back the illustrated pattern, one would expect the playback head's signal to closely resemble the square-wave signal recorded on the tape. Actually, the action is similar to that of an induction coil so the signal on the playback head appears as at (C). A signal is produced in the coil only when the magnetic field is changing. Thus, portions of the tape with a constant magnetic field produce no signal when they pass the playback head gap. The boundary separating opposite magnetic directions, however, will produce a pulse in the playback head when it passes. As illustrated, a transition from north to south produces a positive-going pulse, while a transition from south to north produces a negative-going pulse.

At first glance, it would seem that encoding bits into flux transitions would be simple: provide a north-south (positive playback pulse) for a one and a south-north (negative pulse) for a zero. Further thought, however, reveals that it would be impossible to obtain two ones or two zeroes in a row since pulse polarity always alternates and, therefore, has no information value. In fact, the only infor-



Waveforms involved in direct digital recording (or saturation recording), from current in the recording head to decoded digital pulses.

mation content in the playback waveform is the relative timing of playback pulses.

Waveforms (D) and (E) in the figure show how these playback pulses are accurately detected and converted into digital pulses for use by a computer or logic circuit. Since information is encoded in the pulse timing, it is desirable to find the center of the playback pulse, which corresponds to the actual point of flux transition. High-pass filtering of the playback waveform (D) produces a double pulse that crosses zero at the exact center of the playback pulse. Accuracy of this center point is largely unaffected by the amplitude of the playback pulse. Fi-.al recovery of the original recorded square wave is accomplished by passing the filtered signal through a symmetrical Schmitt trigger that converts it into a logic signal suitable for computer use.

For maximum speed and data capacity, it is desirable to be able to pack flux transitions as close together as possible. The limit is reached when they are so close together that adjacent playback pulses interfere excessively with each other. The result of such interference is called peak shift since peaks of the playback pulses shift position slightly while trying to equalize their density. The effect of peak shift is to reduce data recovery reliability because timing, which contains the information, is distorted.

Encoding Bits. The information content of the playback square wave is in the timing of transitions from 1 to 0 and from 0 to 1. There are several ways to encode bits into transition timing, but the most popular is called "double-frequency encoding." In this case, a bit cell always starts with a transition. A 1-bit is signified by the occurrence of another transition a short time later. A 0-bit consists of just the initial transition. (The data pattern shown in the figure illustrates the double-frequency encoding method.) The transitions that always occur at the beginning of the bit cell are termed *clock* transitions since they mark boundaries between bits. The transitions that may occur in the middle of the bit cell are termed *data* transitions since they contain the binary information.

The main advantage of double-frequency encoding is in the ease with which it can be generated and decoded. Decoding is simple and can be done with a one-shot circuit. The trick is to use a one-shot that will trigger whenever its input changes, unless it is already triggered. For accurate recovery of data, the one-shot's pulse width is set to 3/4 of the bit-cell time. When driven by the recovered square wave, the one-shot will fire on the clock transitions. If another transition occurs while the one-shot is fired, a 1-bit is recovered. If the one-shot times out before the next transition, then a 0-bit has been recovered.

Encoding methods can be characterized by their encoding efficiency ratio. This is the ratio of the total bit-cell to the minimum spacing between flux transitions. Since the maximum density of flux transitions is limited, a higher ratio means more data storage capacity and higher speed. The encoding efficiency ratio of double-frequency encoding is ½, which is not very good. Other methods, called "double density" encoding, exhibit ratios as high as 1.0. They are much more difficult to encode and decode, however, and are more susceptable to defects in the magnetic media.

Formats. In both cassettes and floppy disks, the record data is organized into blocks called records. On cassettes, records may be any length and, in fact, are usually entire programs. On floppy disks, however, the records are fixed in size to allow easy addressing and updating of data. A typical record size is 128 bytes, which is large enough to minimize the percentage of "overhead" yet small enough for convenient use.

On a disk, data records are called sectors. Some method of marking off sector boundaries and separating them is necessary if an individual sector is to be updated without disturbing adjacent sectors. The simplest method of doing this is called *hard* sectoring because holes punched into the disk itself determine the sector boundaries by means of a light and photocell arrangement. Another method uses special patterns in the data itself to mark sector boundaries and is, therefore, called *soft* sectoring. Since these special patterns take additional space, the overhead associated with soft sectoring is greater. In fact, a full-size floppy disk using hard sectoring can put 32 sectors on a track, while a soft sector disk can manage only 26—a 23% difference.

Besides a reduction in capacity, the soft sector format is much more difficult to decode. The use of integrated circuits specifically designed to handle soft sectoring, however, effectively masks this complexity from the user. Today, most floppy-disk systems use soft sectoring in spite of the data capacity reduction. ◇

Software Sources

By Leslie Solomon
Technical Director

MBS BASIC. Written for the Fairchild F8 processors, this BASIC occupies 16K including code, work area and text buffer. It features 9-digit precision and a full complement of BASIC statements, functions, operators, variables and has special control characters, commands, and some planned enhancements that include file handling capability. $175 on Fairbug format paper tape. Further information from Micro Business System, Inc., Box 8255, JFK Station, Boston, Mass. 02114 (Tel: 617-682-1854).

Disk Payroll. Written for the TRS-80, this interactive payroll system has automated file handling and an output for the TRS-80 line printer. It includes quarterly summaries. $59.95. Hebbler Software Services, 7142 Elliot Dr., Dallas, TX 75227.

PET BASIC Compleat. This program features 20 lessons on PET BASIC, cursor control, screen editing, and the use of graphic characters. Over 400 screenfulls of information are contained in the two cassettes. The manual is 170 pages. $39.95 from ARESCO, Box 43, Audubon, PA 19407 (Tel: 215-631-9052).

IDSWORD. Written in North Star BASIC (version 6), and DOS (release 4.0), this word processor features: insertion, deletion and block moves of text; global searches; complete text editing; variable speed scrolling; page number and titling (top or bottom); reformatting data for maximum line size; control of merging and justification; processing of non-IDSWORD files; merging of up to 10 files; form letter printing with justification and text insertion from up to 20 mailing list files; and sorting and printing of mailing labels. Basic system is $125, complete word processor is $245 (CRT) and $220 (printer). Add $50 for form letter, labels and name/address file maintenance and sort modules. CW Applications, 1776 E. Jefferson St., Rockville, MD 20852 (Tel: 301-468-0455).

General Catalog. A number of programs ranging from games to financial packages for just about any computer and disc or cassette interface is covered in a catalog from Soft-One, 315 Dominion Drive, Newport News, VA 23602.

TRS-80 Cassette. Running in any 4K, Level-II TRS-80, this cassette includes a financial program with amortization, interest, etc., a biorhythm program including a perpetual calendar, a doodle program that uses TRS-80 graphics, a decision-making program, and a Mastermind program. $12.95. Complete Computer Services, 8188 Heather Drive, Newburgh, IN 47630 (Tel: 812-853-5140).

Speech Vocabularies. An application note describing how to swap, save and restore vocabularies is now available. Written for users of the Model 20 speech recognition systems as used in Apple II and S100 systems, the approach enables recognition of multiples of 32 words, thus providing virtually unlimited vocabulary size. Heuristics, Inc., 900 San Antonio Road, Los Altos, CA 94022 (Tel: 415-948-2542).

Accounting Package. Version 1.0 of the Alpha Accounting software package includes general ledger, inventory control and payroll. Full documentation and test data is included. The package is designed for use with systems using the Alpha AM-100 CPU board. Alpha Micro, 17881 Sky Park North, Irvine, CA 92714 (Tel: 714-957-1404).

TRI-STATE LED DEMONSTRATOR

PROJECT OF THE MONTH

BY FORREST M. MIMS

THE TRI-STATE LED is one of the most interesting optoelectronic components available to the experimenter. The most common version incorporates separate red and green LED chips mounted very close to one another in a clear or milky-white epoxy package. The two chips are connected as shown in Fig. 1 in what is called an inverse parallel configuration. This ensures that one of the two diodes is forward-biased regardless of the polarity of the applied voltage.

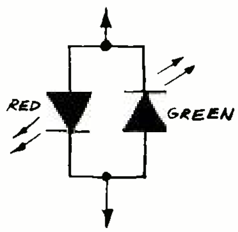


Fig. 1. Schematic symbol for a tri-state LED.

The three states of a tri-state LED usually are defined as red, green and off. Actually, a total of seven optical states is available: off, steady, or flashing red, green, or yellow. Yellow radiation is obtained by rapidly switching the polarity of the applied voltage. The pulsed red and green radiation from the two chips visually merge. Although the color the eye perceives is not a true yellow, it is distinctly recognizable as being neither red nor green.

The schematic diagram of a circuit that has been adapted from one given in the data sheet of Monsanto's MV5491 tri-state LED is shown in Fig. 2. The circuit incorporates two series resistors to provide an optimized current to each LED to balance their brightness. The 1N914 diode (*D1*) bypasses *R2* when the green LED is selected. This compensates for the green LED's higher barrier potential so that the same forward current flows through each diode.

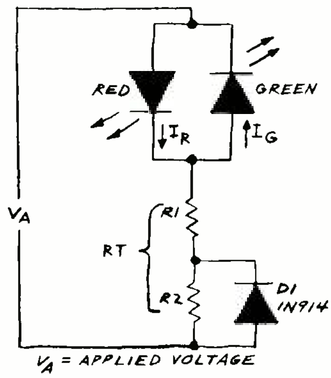


Fig. 2. Circuit used to calculate needed resistances.

The formulas employed to calculate the values of *R1* and *R2* for specific red and green LED forward currents are: $R1 = (V_A - 3.3)/I_G$; $R_T = (V_A - 1.63)/I_R$; $R2 = R_T - R1$; where I_G and I_R are the forward current through the green and red LEDs, respectively, and V_A is the applied voltage. For example, to bias both diodes at 20 mA when V_A is 5 volts, *R1* and *R2* should be 102 and 68 ohms, respectively. The MV5491 data sheet includes a table that gives resistance for *R1* and *R2* for a range of forward currents.

Incidentally, don't be concerned if the exact resistor values the equations dictate are unavailable. Just try to obtain the closest standard value. If you're not concerned with matching brightnesses, simply insert a single 270-ohm resistor in series with the LED when powering it from a 5-volt supply.

Figure 3 is a simple astable multivibrator that demonstrates six of the seven states of a tri-state LED. You can assemble the entire circuit on a miniature solderless breadboard in several minutes. When the wiper of *R1* is at the midpoint of its travel, the LED will alternately flash red and green. The effect is visually striking, particularly if you are used to viewing monochromatic (single-color) LEDs.

Rotating the wiper of *R1* will increase or decrease the red-green flash rate. At one extreme, the red and green flashes will merge into a washed-out orange or yellow color. Both diodes are still flashing, but the flash rate is faster than the flicker response of the eye. (You can hear the flash rate as a series of clicks by connecting the input of a small audio amplifier to ground and through a 0.1-microfarad capacitor to either pin 3 or 6 of the 7400.) At the other extreme, the LED will stop flashing and glow a steady red or green depending on the direction it is connected.

So far, we've accounted for five of the seven states. The sixth state occurs when the circuit is turned off and the LED is extinguished. The seventh state, which this circuit does not provide, is flashing yellow. It can be obtained by gating the pulse train applied to the LED with a low-frequency pulse train at the cost of somewhat increased circuit complexity.

I've seen only a few commercial applications for tri-state LEDs. One is the indicator lamp on the power switch of the Realistic STA-2100 AM/FM stereo receiver. The LED glows red when the switch is pressed.

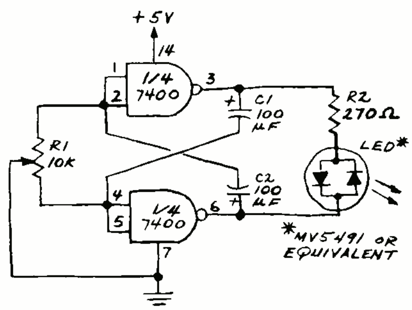


Fig. 3. Tri-state demonstration circuit

After a few seconds, it glows green as the unit begins operation.

Building and experimenting with the simple project in Fig. 3 will give you some ideas about the novel display and indicator possibilities for tri-state LEDs. (Model railroaders will find these devices to be ideally suited for use in block signals.) You can buy tri-state LEDs from some of the companies that advertise in the Electronic Market Place in this magazine. Keep in mind that you can simulate some of the functions of a tri-state LED by connecting a pair of standard red and green LEDs in inverse parallel. ◇

 CIRCLE NO. 33 ON FREE INFORMATION CARD

CIRCLE NO. 52 ON FREE INFORMATION CARD

7400 TTL

SN7400N	16	SN7470N	29	SN74160N	89
SN7401N	18	SN7472N	29	SN74161N	89
SN7402N	18	SN7473N	35	SN74162N	1 95
SN7403N	18	SN7474N	35	SN74163N	89
SN7404N	18	SN7475N	49	SN74164N	89
SN7405N	20	SN7476N	35	SN74165N	89
SN7406N	29	SN7479N	5 00	SN74166N	1 25
SN7407N	29	SN7480N	50	SN74167N	1 95
SN7408N	20	SN7482N	99	SN74170N	1 59
SN7409N	20	SN7483N	59	SN74172N	6 00
SN7410N	18	SN7485N	79	SN74173N	1 25
SN7411N	25	SN7486N	35	SN74174N	89
SN7412N	25	SN7489N	1 75	SN74175N	79
SN7413N	40	SN7490N	45	SN74176N	79
SN7414N	70	SN7491N	59	SN74177N	79
SN7416N	25	SN7492N	43	SN74179N	1 95
SN7417N	25	SN7493N	43	SN74180N	79
SN7420N	20	SN7494N	65	SN74181N	1 95
SN7421N	29	SN7495N	65	SN74182N	79
SN7422N	39	SN7496N	65	SN74184N	1 95
SN7423N	25	SN7497N	3 00	SN74185N	1 95
SN7425N	29	SN74100N	89	SN74186N	9.95
SN7426N	29	SN74107N	35	SN74188N	3 95
SN7427N	29	SN74109N	59	SN74190N	1 25
SN7429N	39	SN74116N	1 95	SN74191N	1 25
SN7430N	20	SN74121N	35	SN74192N	79
SN7432N	25	SN74122N	39	SN74193N	79
SN7437N	25	SN74123N	49	SN74194N	89
SN7438N	25	SN74125N	49	SN74195N	69
SN7439N	25	SN74126N	49	SN74196N	89
SN7440N	20	SN74132N	75	SN74197N	89
SN7441N	89	SN74136N	75	SN74198N	1 49
SN7442N	49	SN74141N	79	SN74199N	1.49
SN7443N	75	SN74142N	2 95	SN74S200	4 95
SN7444N	75	SN74143N	2 95	SN74251N	1 79
SN7445N	75	SN74144N	2 95	SN74279N	79
SN7446N	69	SN74145N	79	SN74283N	2 25
SN7447N	59	SN74147N	1 95	SN74284N	3.95
SN7448N	79	SN74148N	1 29	SN74285N	3 95
SN7450N	20	SN74150N	89	SN74365N	69
SN7451N	20	SN74151N	59	SN74366N	69
SN7453N	20	SN74152N	59	SN74367N	69
SN7454N	20	SN74153N	59	SN74368N	69
SN7459A	25	SN74154N	99	SN74390N	1 95
SN7460N	20	SN74155N	79	SN74393N	1 95
		SN74156N	79		
		SN74157N	65		

C/MOS

CD4000	23	CD4028	89	CD4070	55
CD4001	23	CD4029	1 19	CD4071	23
CD4002	23	CD4030	49	CD4072	49
CD4006	1 19	CD4035	99	CD4076	1 39
CD4007	25	CD4040	1 19	CD4081	23
CD4009	49	CD4041	1 25	CD4082	23
CD4010	49	CD4042	99	CD4093	99
CD4011	23	CD4043	89	CD4098	2 49
CD4012	25	CD4044	89	MC14409	14 95
CD4013	39	CD4046	1 79	MC14410	14 95
CD4014	1 39	CD4047	2 50	MC14411	14 95
CD4015	1 19	CD4048	1 35	MC14419	4 95
CD4016	49	CD4049	49	MC14433	19 95
CD4017	1 19	CD4050	49	MC14506	75
CD4018	99	CD4051	1 19	MC14507	99
CD4019	49	CD4053	1 19	MC14562	14 50
CD4020	1 19	CD4056	2 95	MC14583	3 50
CD4021	1 39	CD4059	9 95	CD4508	3 95
CD4022	1 19	CD4060	1 49	CD4510	1 39
CD4023	23	CD4066	79	CD4511	1 29
CD4024	79	CD4068	39	CD4515	2 95
CD4025	23	CD4069	45	CD4518	1 29
CD4026	2 25			CD4520	1 29
CD4027	69			CD4566	2 25

74C00

74C00	39	74C85	2 49	74C163	2 49
74C02	39	74C90	1 95	74C164	2 49
74C04	39	74C93	1 95	74C173	2 60
74C08	49	74C95	1 95	74C192	2 49
74C10	39	74C107	1 25	74C193	2 49
74C14	1 95	74C151	2 90	74C195	2 49
74C20	39	74C154	3 00	74C922	5 95
74C30	39	74C157	2 15	74C923	6 25
74C42	1 95	74C160	2 49	74C925	8 95
74C48	2 49	74C161	2 49	74C926	8 95
74C73	89			80C95	1 50
74C74	89			80C97	1 50

LINEAR

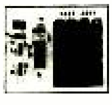
78MG	1 75	LM340K-18	1 35	LM710N	79
LM106H	99	LM340K-24	1 35	LM711N	39
LM300H	80	LM340T-5	1 25	LM723N/H	55
LM301CN/H	35	LM340T-6	1 25	LM733N	1 00
LM302H	75	LM340T-8	1 25	LM739N	1 19
LM304H	1 00	LM340T-12	1 25	LM741CN/H	35
LM305H	60	LM340T-15	1 25	LM741-14N	39
LM307CN/H	35	LM340T-18	1 25	LM747N/H	79
LM308CN H	1 00	LM340T 24	1 25	LM748N/H	39
LM309H	1 10	LM358N	1 00	LM1310N	2 95
LM309K	1 25	LM370N	1 95	LM1458CN/H	59
LM310CN	1 15	LM373N	3 25	MC1488N	1 39
LM311N/H	90	LM377N	4 00	MC1489N	1 39
LM312H	1 95	LM380N	1 25	LM1496N	95
LM317K	6 50	LM380CN	99	LM1556V	1 75
LM318CN/H	1 50	LM381N	1 79	MC1741SCP	3 00
LM319N	1 30	LM382N	1 79	LM2111N	1 95
LM320K-5	1 35	NE501N	8 00	LM2901N	2 95
LM320K-5 2	1 35	NE510A	6 00	LM3053N	1 50
LM320K-12	1 35	NE529A	4 95	LM3065N	1 49
LM320K-15	1 35	NE531H/V	3 95	LM3900N(3401)	49
LM320K-18	1 35	NE536T	6 00	LM3905N	89
LM320K 24	1 35	NE540L	6 00	LM3909N	1 25
LM320T-5	1 25	NE544N	4 95	MC5558V	59
LM320T-5 2	1 25	NE550N	1 30	8038B	4 95
LM320T-8	1 25	NE555V	39	LM75450N	49
LM320T-12	1 25	NE556N	99	75451CN	39
LM320T-15	1.25	NE560B	5 00	75452CN	39
LM320T-18	1 25	NE561B	5 00	75453CN	39
LM320T-24	1 25	NE562B	5 00	75454CN	39
LM323K-5	5 95	NE565N/H	1 25	75491CN	79
LM324N	1 80	NE566CN	1 75	75492CN	89
LM339N	99	NE567V/H	99	75493N	89
LM340K-5	1 35	NE570N	4 95	75494CN	89
LM340K-6	1 35	LM703CN/H	69	RC4136	1 25
LM340K-8	1 35	LM709N/H	29	RC4151	2 85
LM340K-12	1 35			RC4194	5 95
LM340K-15	1 35			RC4195	4 49

74LS00TTL

74LS00	29	74LS47	89	74LS138	89
74LS01	29	74LS51	29	74LS139	89
74LS02	29	74LS54	29	74LS151	89
74LS03	29	74LS55	29	74LS155	89
74LS04	35	74LS73	45	74LS157	89
74LS05	35	74LS74	45	74LS160	1 15
74LS08	29	74LS75	59	74LS161	1 15
74LS09	35	74LS76	45	74LS162	1 15
74LS10	29	74LS78	49	74LS163	1 15
74LS11	75	74LS83	89	74LS164	1 25
74LS13	59	74LS85	1 25	74LS175	99
74LS14	1 25	74LS86	45	74LS181	2 49
74LS15	35	74LS90	59	74LS190	1 15
74LS20	29	74LS92	75	74LS191	1 15
74LS21	35	74LS93	75	74LS192	1 15
74LS22	35	74LS95	99	74LS193	1 15
74LS26	35	74LS96	1 15	74LS194	1 15
74LS27	35	74LS107	45	74LS195	1 15
74LS28	35	74LS109	45	74LS253	99
74LS30	29	74LS112	45	74LS257	89
74LS32	35	74LS123	1 25	74LS258	1 75
74LS37	45	74LS125	89	74LS260	69
74LS40	35	74LS132	99	74LS279	75
74LS42	89	74LS136	49	74LS367	75
				74LS368	75
				74LS670	2 49

EXCITING NEW KITS

NEW JE600 HEXADECIMAL ENCODER KIT



FEATURES:
- Full 8 bit latched output for micro-processor use
- 3 User Define keys with one being bi-stable operation
- Debounce circuit provided for all 19 keys
- LED readout to verify entries
- Easy interfacing with standard 16 pin IC connector
- Only +5VDC required for operations

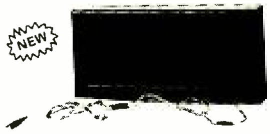
FULL 8 BIT LATCHED OUTPUT—19 KEYBOARD

The JE600 Encoder Keyboard provides two separate hexadecimal digits produced from sequential key entries to allow direct programming for 8 bit microprocessor or 8 bit memory circuits. Three (3) additional keys are provided for user operations with one having a bistable output available. The outputs are latched and monitored with LED readouts. Also included is a key entry strobe.

JE600 .... $59.95
Hexadecimal Keypad only $10.95

Digital Thermometer Kit

NEW



- Dual sensors—switching control for in-door/outdoor or dual monitoring
- Continuous LED .8" ht. display
- Range: -40°F to 199°F / 40°C to 100°C
- Accuracy: ±1° nominal
- Set for Fahrenheit or Celsius reading
- Sim. walnut case - AC wall adapter incl.
- Size: 3-1/4"H x 6-5/8"W x 1-3/8"D

JE300 ....$39.95

DISCRETE LEDS

.200" dia.			**.125" dia.**		
XC556R	red	5/$1	XC209R	red	5/$1
XC556G	green	4/$1	XC209G	green	4/$1
XC556Y	yellow	4/$1	XC209Y	yellow	4/$1
XC556C	clear	4/$1			
.200" dia.			**.185" dia.**		
XC22R	red	5/$1	XC526R	red	5/$1
XC22G	green	4/$1	XC526G	green	4/$1
XC22Y	yellow	4/$1	XC526Y	yellow	4/$1
.170" dia.			XC526C	clear	4/$1
MV108	red	4/$1	**.190" dia.**		
.085" dia.			XC111R	red	5/$1
MV50	red	6/$1	XC111G	green	4/$1
			XC111Y	yellow	4/$1
			XC111C	clear	4/$1

INFRA-RED LED 1/4"x1/4"x1/16" flat 5/$1

TIMEX T1001 LIQUID CRYSTAL DISPLAY CLASS II

FIELD EFFECT

4 DIGIT – .5" CHARACTERS
THREE ENUNCIATORS
2.00" X 1.20" PACKAGE
INCLUDES CONNECTOR

T1001-Transmissive	$7.95
T1001A-Reflective	8.25

DISPLAY LEDS

TYPE	POLARITY	HT	PRICE	TYPE	POLARITY	HT	PRICE
MAN 1	Common Anode red	270	2 95	MAN 6730	Common Anode-red ± 1	560	99
MAN 2	5 x 7 Dot Matrix-red	300	4 95	MAN 6740	Common Cathode-red-D D	560	99
MAN 3	Common Cathode-red	125	25	MAN 6750	Common Cathode-red ± 1	560	99
MAN 4	Common Cathode-red	187	1 95	MAN 6760	Common Anode-red	560	99
MAN 7G	Common Anode-green	300	1 25	MAN 6780	Common Cathode-red	560	99
MAN 7Y	Common Anode-yellow	300	99	DL701	Common Anode-red + 1	300	99
MAN 72	Common Anode-red	300	99	DL704	Common Cathode-red	300	99
MAN 74	Common Cathode-red	300	1.25	DL707	Common Anode-red	300	99
MAN 82	Common Anode-yellow	300	99	DL728	Common Cathode-red	500	1 49
MAN 84	Common Cathode-yellow	300	99	DL741	Common Anode-red	600	1 25
MAN 3620	Common Anode-orange	300	99	DL746	Common Anode red ± 1	630	1 49
MAN 3630	Common Anode orange ± 1	300	99	DL747	Common Anode-red	600	1 49
MAN 3640	Common Cathode orange	300	99	DL749	Common Cathode-red ± 1	630	1 49
MAN 4610	Common Anode-orange	300	99	DL750	Common Cathode-red	600	1 49
MAN 4640	Common Cathode-orange	400	99	DL338	Common Cathode-red	110	35
MAN 4710	Common Anode-red	400	99	FND70	Common Cathode	250	69
MAN 4730	Common Anode-red + 1	400	99	FND358	Common Cathode ± 1	357	99
MAN 4740	Common Cathode red	400	99	FND359	Common Cathode	357	75
MAN 4810	Common Anode-yellow	400	99	FND503	Common Cathode(FND500)	500	99
MAN 4840	Common Cathode-yellow	400	99	FND507	Common Anode (FND510)	500	99
MAN 6610	Common Anode-orange-D D	560	99	5082-7730	Common Anode-red	300	1 30
MAN 6630	Common Anode-orange ± 1	560	99	HDSP-3400	Common Anode-red	800	2 10
MAN 6640	Common Cathode-orange D D	560	99	HDSP-3403	Common Cathode red	800	2 10
MAN 6650	Common Cathode-orange ± 1	560	99	5082-7300	4 x 7 sgl Digit-RHDP	600	19 95
MAN 6660	Common Anode-orange	560	99	5082-7302	4 x 7 Sgl Digit-LHDP	600	19 95
MAN 6680	Common Cathode-orange	560	99	5082-7304	Overrange character (±1)	600	15 00
MAN 6710	Common Anode-red-D D	560	99	5082 7340	4 x 7 Sgl Digit-Hexadecimal	600	22 50

RCA LINEAR

CA3013T	2 15	CA3082N	2 00
CA2023T	2 56	CA3083N	1 60
CA3035T	2 48	CA3086N	85
CA3039T	1 35	CA3089N	3 75
CA3046N	1 30	CA3130T	1 39
CA3059N	3 25	CA3140T	1 25
CA3060N	3 25	CA3160T	1 25
CA3080T	85	CA3401N	49
CA3081N	2 00	CA3600N	3 50

CALCULATOR CHIPS/DRIVERS

MM5725	$2 95
MM5738	2 95
DM8864	2 00
DM8865	1 00
DM8887	75
DM8889	75
9374 7 seg C A LED driver	1 50

CLOCK CHIPS

MM5309	$4 95
MM5311	4 95
MM5312	4 95
MM5314	4 95
MM5316	6 95
MM5318	9 95
MM5369	2 95
MM5387/1998A	4 95
MM5841	9 95

MOTOROLA

MC1408L7	$4 95
MC1408L8	5 75
MC1439L	2 95
MC3022P	2 95
MC3061P	3 50
MC4016(74416)	7 50
MC4024P	3 95
MC4040P	6 95
MC4044P	4 50

IC SOLDERTAIL — LOW PROFILE (TIN) SOCKETS

	1-24	25-49	50-100		1-24	25-49	50-100
8 pin LP	$17	16	15	22 pin LP	$ 37	.36	35
14 pin LP	.20	19	18	24 pin LP	38	37	36
16 pin LP	22	21	20	28 pin LP	45	44	43
18 pin LP	29	28	27	36 pin LP	60	59	58
20 pin LP	34	32	30	40 pin LP	63	62	61

SOLDERTAIL STANDARD (TIN)

14 pin ST	$ 27	25	24	28 pin ST	$ 99	90	.81
16 pin ST	30	27	25	36 pin ST	1 39	1 26	1 15
18 pin ST	35	32	30	40 pin ST	1 59	1 45	1 30
24 pin ST	49	45	42				

SOLDERTAIL STANDARD (GOLD)

8 pin SG	$ 30	.27	24	24 pin SG	$ 70	63	57
14 pin SG	35	32	29	28 pin SG	1 10	1 00	.90
16 pin SG	38	35	32	36 pin SG	1 65	1 40	1 26
18 pin SG	52	47	43	40 pin SG	1 75	1 59	1 45

WIRE WRAP SOCKETS (GOLD) LEVEL #3

8 pin WW	$ 39	.38	31	22 pin WW	$ 95	85	75
10 pin WW	.45	41	37	24 pin WW	1 05	95	85
14 pin WW	39	38	37	28 pin WW	1 40	1.25	1 10
16 pin WW	43	42	41	36 pin WW	1 59	1 45	1.30
18 pin WW	75	68	62	40 pin WW	1.75	1 55	1 40

1/4 WATT RESISTOR ASSORTMENTS – 5%

ASST. 1	5 ea	10 OHM / 27 OHM	12 OHM / 33 OHM	15 OHM / 39 OHM	18 OHM / 47 OHM	22 OHM / 56 OHM	50 PCS	$1.75
ASST. 2	5 ea	68 OHM / 180 OHM	82 OHM / 220 OHM	100 OHM / 270 OHM	120 OHM / 330 OHM	150 OHM / 390 OHM	50 PCS	1.75
ASST. 3	5 ea	470 OHM / 1.2k	560 OHM / 1.5k	680 OHM / 1.8k	820 OHM / 2.2k	1k / 2.7k	50 PCS	1.75
ASST. 4	5 ea	3.3k / 8.2k	3.9k / 10k	4.7k / 12k	5.6k / 15k	6.8k / 18k	50 PCS	1.75
ASST. 5	5 ea	22k / 56k	27k / 68k	33k / 82k	39k / 100k	47k / 120k	50 PCS	1.75
ASST. 6	5 ea	150k / 390k	180k / 470k	220k / 560k	270k / 680k	330k / 820k	50 PCS	1.75
ASST. 7	5 ea	1M / 2.7M	1.2M / 3.3M	1.5M / 3.9M	1.8M / 4.7M	2.2M / 5.6M	50 PCS	1.75

ASST. 8R Includes Resistor Assortments 1-7 (350 PCS.) **$9.95 ea.**

TELEPHONE/KEYBOARD CHIPS

AY-5-9100	Push Button Telephone Dialler	$14.95
AY-5-9200	Repertory Dialler	14.95
AY-5-9500	CMOS Clock Generator	4.95
AY-5-2376	Keyboard Encoder (88 keys)	14.95
HD0165	Keyboard Encoder (16 keys)	7.95
74C922	Keyboard Encoder (16 keys)	5 95

ICM CHIPS

ICM7045	CMOS Precision Timer	24.95
ICM7205	CMOS LED Stopwatch/Timer	19 95
ICM7207	Oscillator Controller	7 50
ICM7208	Seven Decade Counter	19.95
ICM7209	Clock Generator	6.95

NMOS READ ONLY MEMORIES

MCM6571	128 X 9 X 7 ASCII Shifted with Greek	13.50
MCM6574	128 X 9 X 7 Math Symbol & Pictures	13.50
MCM6575	128 X 9 X 7 Alphanumeric Control Character Generator	13 50

MISCELLANEOUS

TL074CN	Quad Low Noise bi-fet Op Amp	2.49
TL494CN	Switching Regulator	4 49
TL496CP	Single Switching Regulator	1.75
11C90	Divide 10/11 Prescaler	19.95
95H90	Hi-Speed Divide 10/11 Prescaler	11.95
4N33	Photo-Darlington Opto-Isolator	3 95
MK50240	Top Octave Freq. Generator	17 50
DS0026CH	5Mhz 2-phase MOS clock driver	3 75
TIL308	27" red num display w/integ. logic chip	10.50
MM5320	TV Camera Sync. Generator	14.95
MM5330	4½ Digit DPM Logic Block (Special)	3 95
LD110/111	3½ Digit A/D Converter Set	25 00/set

LITRONIX ISO-LIT 1
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(Same as MCT 2 or 4N25)
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Generates Complex Sounds
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XR205	$8 40			XR2242CP	1.50
XR210	4.40			XR2264	4.25
XR215	4.40			XR2556	3.20
XR320	1 55	JE2206KA	14.95	XR2567	2.99
XR-L555	1 50	JE2206KB	19 95	XR3403	1.25
XR555	.39	XR1800	3.20	XR4136	1.25
XR556	.99	XR2206	4.40	XR4151	2.85
XR567CP	.99	XR2207	3.85	XR4194	4 95
XR567CT	1.25	XR2208	5.20	XR4202	3.60
XR1310P	1.30	XR2209	1.75	XR4212	2.05
XR1468CN	3.85	XR2211	5.25	XR4558	.75
XR1488	1.39	XR2212	4.35	XR4739	1 15
XR1489	1.39	XR2240	3.45	XR4741	1 47

DIODES

TYPE	VOLTS	W	PRICE	TYPE	VOLTS	W	PRICE
1N746	3 3	400m	4/1 00	1N4002	100 PIV	1 AMP	12/1 00
1N751	5 1	400m	4/1 00	1N4003	200 PIV	1 AMP	12/1 00
1N752	5 6	400m	4/1 00	1N4004	400 PIV	1 AMP	12/1 00
1N753	6 2	400m	4/1 00	1N4005	600 PIV	1 AMP	10/1 00
1N754	6 8	400m	4/1 00	1N4006	800 PIV	1 AMP	10/1 00
1N757	9 0	400m	4/1 00	1N4007	1000 PIV	1 AMP	10/1 00
1N759	12 0	400m	4/1 00	1N3600	50	200m	6/1 00
1N959	8 2	400m	4/1 00	1N4148	75	10m	15/1 00
1N965	15	400m	4/1 00	1N4154	35	10m	12/1 00
1N5232	5 6	500m	28	1N4305	75	25m	15/1 00
1N5234	6 2	500m	28	1N4734	5 6	1w	28
1N5235	6 8	500m	28	1N4735	6 2	1w	28
1N5236	7 5	500m	28	1N4736	6 8	1w	28
1N5242	12	500m	28	1N4738	8 2	1w	28
1N5245	15	500m	28	1N4742	12	1w	28
1N456	25	40m	6/1 00	1N4744	15	1w	28
1N458	150	7m	6/1 00	1N1183	50 PIV	35 AMP	1 60
1N485A	180	10m	5/1 00	1N1184	100 PIV	35 AMP	1 70
1N4001	50 PIV	1 AMP	12/1 00	1N1185	150 PIV	35 AMP	1 70
				1N1186	200 PIV	35 AMP	1 80
				1N1188	400 PIV	35 AMP	3 00

SCR AND FW BRIDGE RECTIFIERS

C36D	15A @ 400V	SCR(2N1849)	$1 95
C38M	35A @ 600V	SCR	1 95
2N2328	1 6A @ 300V	SCR	.50
MDA 980-1	12A @ 50V	FW BRIDGE REC	1 95
MDA 980-3	12A @ 200V	FW BRIDGE REC	1 95

TRANSISTORS

C106B1	50			2N3904	4/1 00
MPSA05	30	2N3055	89	2N3905	4/1 00
MPSA06	5/1 00	MJE3055	1 00	2N3906	4/1 00
TIS97	6/1 00	2N3392	5/1 00	2N4013	3/1 00
TIS98	6/1 00	2N3398	5/1 00	2N4123	6/1 00
40409	1 75	PN3567	3/1 00	PN4249	4/1 00
40410	1 75	PN3568	4/1 00	PN4250	4/1 00
40673	1 75	PN3569	4/1 00	2N4400	4/1 00
2N918	4/1 00	MPS3638A	5/1 00	2N4401	4/1 00
2N2219A	2/1 00	MPS3702	5/1 00	2N4402	4/1 00
2N2221A	4/1 00	2N3704	5/1 00	2N4403	4/1 00
2N2222A	5/1 00	MPS3704	5/1 00	2N4409	5/1 00
PN2222 Plastic	7/1 00	2N3705	5/1 00	2N5086	4/1 00
2N2369	5/1 00	MPS3705	5/1 00	2N5087	4/1 00
2N2369A	4/1 00	2N3706	5/1 00	2N5088	4/1 00
MPS2369	5/1 00	MPS3706	5/1 00	2N5089	4/1 00
2N2484	4/1 00	2N3707	5/1 00	2N5129	5/1 00
2N2906	4/1 00	2N3711	5/1 00	PN5134	5/1 00
2N2907	5/1 00	2N3724A	65	PN5138	5/1 00
PN2907 Plastic	7/1 00	2N3725A	1 00	2N5139	5/1 00
2N2925	5/1 00	2N3772	2 25	2N5210	5/1 00
MJE2955	1 25	2N3823	1 00	2N5449	3/1 00
2N3053	2/1 00	2N3903	5/1 00	2N5951	3/1 00

CAPACITOR CORNER

50 VOLT CERAMIC DISC CAPACITORS

	1-9	10-99	100		1-9	10-99	100
10 pf	05	04	03	001µF	05	04	035
22 pf	05	04	03	0047µF	05	04	035
47 pf	05	04	03	01µF	05	04	035
100 pf	05	04	03	022µF	06	05	04
220 pf	05	04	03	047µF	06	05	04
470 pf	05	04	035	1µF	12	09	075
100 VOLT MYLAR FILM CAPACITORS							
001mf	12	10	07	022mf	13	11	08
0022	12	10	07	047mf	21	17	13
0047mf	12	10	07	1mf	27	23	17
01mf	12	10	07	22mf	33	27	22
+20% DIPPED TANTALUMS (SOLID) CAPACITORS							
1/35V	28	23	17	1 5/35V	30	26	21
15/35V	28	23	17	2 2 25V	31	27	22
22/35V	28	23	17	3 3 25V	31	27	22
33/35V	28	23	17	4 7/25V	32	28	23
47/35V	28	23	17	6 8/25V	36	31	25
68/35V	28	23	17	15/25V	63	50	40
1 0/35V	28	23	17				
MINIATURE ALUMINUM ELECTROLYTIC CAPACITORS							
Axial Lead				Radial Lead			
47/50V	15	13	10	47/25V	15	13	10
1 0/50V	16	14	11	47/50V	16	14	11
3 3/50V	14	12	09	1 0/16V	15	13	10
4 7/25V	15	13	10	1 0/25V	16	14	11
10 25V	15	13	10	1 0/50V	16	14	11
10/50V	16	14	12	4 7/16V	15	13	10
22/25V	17	15	12	4 7/25V	15	13	10
22/50V	24	20	18	4 7/50V	16	14	11
47/25V	19	17	15	10/16V	14	12	09
47 50V	25	21	19	10/25V	15	13	10
100/25V	24	20	18	10/50V	16	14	12
100/50V	35	30	28	47 50V	24	21	19
220/25V	32	28	25	100/16V	19	15	14
220/50V	45	41	38	100/25V	24	20	18
470/25V	33	29	27	100 50V	35	30	28
1000/16V	55	50	45	220/16V	23	17	16
2200/16V	70	62	55	470/25V	31	28	26

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DIODES/ZENERS

QTY.				
	1N914	100v	10mA	.05
	1N4005	600v	1A	.08
	1N4007	1000v	1A	.15
	1N4148	75v	10mA	.05
	1N4733	5.1v	1 W Zenner	.25
	1N4749	24v	1W	.25
	1N753A	6.2v	500 mW Zener	.25
	1N758A	10v	"	.25
	1N759A	12v	"	.25
	1N5243	13v	"	.25
	1N5244B	14v	"	.25
	1N5245B	15v	"	.25
	1N5349	12v	3W	.25

SOCKETS/BRIDGES

QTY.					
8-pin	pcb	.16	ww	.35
14-pin	pcb	.20	ww	.40
16-pin	pcb	.25	ww	.45
18-pin	pcb	.30	ww	.95
20-pin	pcb	.35	ww	1.05
22-pin	pcb	.40	ww	1.15
24-pin	pcb	.45	ww	1.25
28-pin	pcb	.50	ww	1.35
40-pin	pcb	.55	ww	1.45
Molex pins	.01	To-3 Sockets		.35
2 Amp Bridge		100-prv		.95
25 Amp Bridge		200-prv		1.50

TRANSISTORS, LEDS, etc.

QTY.		
2N2222M	(2N2222 Plastic .10)	.15
2N2222A		.19
2N2907A	PNP	.19
2N3906	PNP (Plastic)	.19
2N3904	NPN (Plastic)	.19
2N3054	NPN	.55
2N3055	NPN 15A 60v	.60
T1P125	PNP Darlington	1.95
LED Green,	Red, Clear, Yellow	.19
D.L.747	7 seg 5/8" High com-anode	1.95
MAN72	7 seg com-anode (Red)	1.25
MAN3610	7 seg com-anode (Orange)	1.25
MAN82A	7 seg com-anode (Yellow)	1.25
MAN74	7 seg com-cathode (Red)	1.50
FND359	7 seg com-cathode (Red)	1.25

9000 SERIES

QTY.		QTY.	
9301	.85	9322	.65
9309	.50	9601	.30
		9602	.45

MICRO's, RAMS, CPU's, E-PROMS

QTY.	
8T13	2.50
8T23	2.50
8T24	3.00
8T97	1.75
74S188	3.00
1488	1.25
1489	1.25
1702A	4.50
AM 9050	4.00
ICM 7207	6.95
ICM 7208	13.95
MPS 6520	10.00
MM 5314	4.00
MM 5316	4.50
MM 5387	3.50
MM 5369	2.95
TR 1602B	3.95
UPD 414	4.95
Z 80 A	22.50
Z 80	17.50
Z 80 P10	10.50
2102	1.45
2102L	1.75
2107B-4	4.95
2114	9.50
2513	6.25
2708	11.50
2716 D.S.	34.00
2716 (5v)	69.00
2758 (5v)	26.95
3242	10.50
4116	11.50
6800	13.95
6850	7.95
8080	7.50
8085	22.50
8212	2.75
8214	4.95
8216	3.50
8224	4.25
8228	6.00
8251	7.50
8253	18.50
8255	8.50
TMS 4044	9.95

C MOS

QTY.		QTY.		QTY.		QTY.	
4000	.15	4017	.75	4034	2.45	4069/74C04	.45
4001	.20	4018	.75	4035	.75	4071	.25
4002	.25	4019	.35	4037	1.80	4081	.30
4004	3.95	4020	.85	4040	.75	4082	.30
4006	.95	4021	.75	4041	.69	4507	.95
4007	.25	4022	.75	4042	.65	4511	.95
4008	.75	4023	.25	4043	.50	4512	1.50
4009	.35	4024	.75	4044	.65	4515	2.95
4010	.35	4025	.25	4046	1.25	4519	.85
4011	.30	4026	1.95	4047	2.50	4522	1.10
4012	.25	4027	.35	4048	1.25	4526	.95
4013	.40	4028	.75	4049	.65	4528	1.10
4014	.75	4029	1.15	4050	.45	4529	.95
4015	.75	4030	.30	4052	.75	MC14409	14.50
4016	.35	4033	1.50	4053	.95	MC14419	4.85
				4066	.75	74C151	2.50

– T T L –

QTY.		QTY.		QTY.		QTY.	
7400	.20	7492	.45	74H20	.25	74LS76	.70
7401	.20	7493	.35	74H21	.25	74LS86	.95
7402	.20	7494	.75	74H22	.40	74LS90	.85
7403	.20	7495	.60	74H30	.30	74LS93	.85
7404	.20	7496	.80	74H40	.35	74LS96	2.00
7405	.35	74100	1.15	74H50	.30	74LS107	.90
7406	.25	74107	.35	74H51	.30	74LS109	1.50
7407	.55	74121	.35	74H52	.20	74LS123	1.95
7408	.20	74122	.55	74H53	.25	74LS138	2.00
7409	.25	74123	.55	74H55	.25	74LS151	.95
7410	.20	74125	.45	74H72	.35	74LS153	1.15
7411	.25	74126	.45	74H74	.35	74LS157	1.15
7412	.25	74132	.75	74H101	.95	74LS160	1.15
7413	.45	74141	.90	74H103	.55	74LS164	2.90
7414	.75	74150	.85	74H106	1.15	74LS193	2.00
7416	.25	74151	.95	74L00	.30	74LS195	1.15
7417	.40	74153	.95	74L02	.30	74LS244	2.90
7420	.25	74154	1.15	74L03	.35	74LS259	1.50
7426	.25	74156	.70	74L04	.40	74LS298	1.50
7427	.25	74157	.65	74L10	.30	74LS367	1.95
7430	.20	74161/9316	.75	74L20	.45	74LS368	1.25
7432	.30	74163	.85	74L30	.55	74LS373	2.50
7437	.20	74164	.75	74L47	1.95	74S00	.45
7438	.30	74165	1.10	74L51	.65	74S02	.45
7440	.20	74166	1.75	74L55	.85	74S03	.35
7441	1.15	74175	.90	74L72	.65	74S04	.35
7442	.55	74176	.95	74L73	.70	74S05	.45
7443	.45	74177	1.10	74L74	.75	74S08	.45
7444	.45	74180	.95	74L75	1.05	74S10	.45
7445	.75	74181	2.25	74L85	2.00	74S11	.45
7446	.70	74182	.75	74L93	.75	74S20	.35
7447	.70	74190	1.25	74L123	1.95	74S22	.55
7448	.50	74191	1.25	74LS00	.40	74S40	.30
7450	.25	74192	.75	74LS01	.40	74S50	.30
7451	.25	74193	.85	74LS02	.45	74S51	.35
7453	.20	74194	.95	74LS03	.45	74S64	.15
7454	.25	74195	.95	74LS04	.45	74S74	.70
7460	.40	74196	.95	74LS05	.45	74S112	.60
7470	.45	74197	.95	74LS08	.45	74S114	.85
7472	.40	74198	1.45	74LS09	.45	74S133	.85
7473	.25	74221	1.50	74LS10	.45	74S140	.75
7474	.30	74298	1.50	74LS11	.45	74S151	.95
7475	.35	74367	1.35	74LS20	.45	74S153	.95
7476	.40	75491	.65	74LS21	.45	74S157	.98
7480	.75	75492	.65	74LS22	.45	74S158	.80
7481	.85	74H00	.20	74LS32	.50	74S194	1.50
7482	.95	74H01	.30	74LS37	.45	74S196	2.00
7483	.95	74H04	.30	74LS38	.65	74S257 (8123)	2.50
7485	.75	74H05	.25	74LS40	.70	8131	2.75
7486	.55	74H08	.35	74LS42	.95		
7489	1.05	74H10	.35	74LS51	.75		
7490	.55	74H11	.25	74LS74	.95		
7491	.70	74H15	.45	74LS75	1.20		

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8038	3.95	LM320T5	1.65	LM377	3.95
LM201	.75	LM320T12	1.65	78L05	.75
LM301	.45	LM320T15	1.65	78L12	.75
LM308	.65	LM323K	5.95	78L15	.75
LM309H	.85	LM324	1.25	78M05	.75
LM309 (340K-5)	1.50	LM339	.75	LM380 (8-14 Pin)	1.19
LM310	.85	7805 (340T5)	1.15	LM709 (8-14 Pin)	.45
LM311 (8-14 Pin)	.75	LM340T12	.95	LM711	.45
LM318	1.50	LM340T15	.95	LM723	.40
LM320H6	.79	LM340T18	.95	LM725	2.50
LM320H15	.79	LM340T24	.95	LM739	1.50
LM320H24	.79	LM340K12	1.25	LM741 (8-14)	.45
7905 (LM320K5)	1.65	LM340K15	1.25	LM747	1.10
LM320K12	1.65	LM340K18	1.25	LM1307	1.75
LM320K15	1.65	LM340K24	1.25	LM1458	.65
				LM3900	.95
				LM75451	.65
				NE555	.45
				NE556	.85
				NE565	1.15
				NE566	1.25
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				76477	2.95
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74LS13	276-1911	.99
74LS20	276-1912	.59
74LS27	276-1913	.69
74LS30	276-1914	.59
74LS32	276-1915	.69
74LS47	276-1916	1.29
74LS51	276-1917	.59
74LS73	276-1918	.69
74LS74	276-1919	.69
74LS75	276-1920	.99
74LS76	276-1921	.79
74LS85	276-1922	1.29
74LS90	276-1923	.99
74LS92	276-1924	.99
74LS93	276-1925	.99
74LS123	276-1926	1.19
74LS132	276-1927	.99
74LS151	276-1929	.99
74LS157	276-1930	1.19
74LS161	276-1931	1.49
74LS164	276-1932	1.49
74LS175	276-1934	1.19
74LS192	276-1935	1.49
74LS193	276-1936	1.49
74LS194	276-1937	1.49
74LS196	276-1938	1.59
74LS367	276-1835	1.19
74LS368	276-1836	1.19
74LS373	276-1943	2.39
74LS374	276-1944	2.39

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Type	Cat. No.	EACH
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4013	276-2413	.99
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4020	276-2420	1.69
4021	276-2421	1.69
4023	276-2423	.69
4027	276-2427	.99
4028	276-2428	1.29
4046	276-2446	1.69
4511	276-2447	1.69
4049	276-2449	.79
4050	276-2450	.79
4051	276-2451	1.49
4066	276-2466	1.39
4070	276-2470	.79
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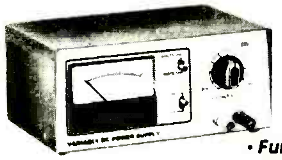

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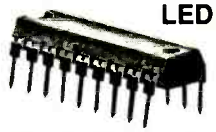

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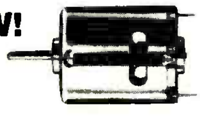

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8224		2.95			
8226		1.98	6810		3.95
8228	~~4.75~~	3.98	6820		3.95
8238	~~4.75~~	3.98	6821		3.95
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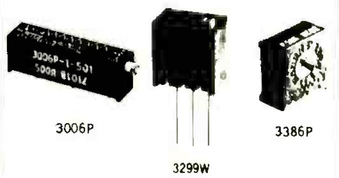

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Z80A-SIO/0	~~[illegible]~~	$45.00
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Z80A-SIO/1	~~[illegible]~~	$45.00
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LED212	T-1 3mm Yellow	.13
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LED222	T-1-3/4 5mm Green	.15
LED224	T-1-3/4 5mm Yellow	.14

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FND567	500"	Common Anode	~~$1.40~~	$1.29
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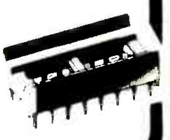
20 PIN	20		



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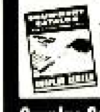

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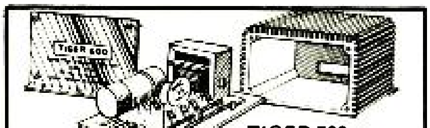

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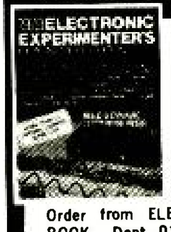

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Popular Electronics

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ELECTRONICS WORLD® Personal Electronics News

A digital audio disc system has been demonstrated by North American Philips Corp. The Compact Disc is 4 ½" (114 mm) in diameter, 0.04" (1.1 mm) thick, and can store up to 60 minutes of audio with 20 to 20,000 Hz bandwidth, less than 0.05% distortion, and S/N of better than 85 dB. It is recorded on one side only and is made of polyvinyl chloride coated with a thin

metallic layer that holds a helical track of pits acting as carriers of the digital information. A transparent plastic layer protects the metal. The audio is encoded via a 14-bit linear system, with a sample rate of 44.3 kHz. The player reads the disc by means of a solid-state laser whose light is scattered by the pit as the disc rotates. Tentatively scheduled for introduction late in 1981, the Compact Disc is expected to be competitive in price with standard LPs. Target price for the player is about as much as a mid-priced turntable.

FM broadcast channels of reduced bandwidth, proposed in a petition to the FCC by the National Telecommunications Information Administration, are strongly opposed by the Institute of High Fidelity. The NTIA claims that an increase in the number of FM channels is in the public interest and sees the reduction in bandwidth as a means of accomplishing this end. In answer to NTIA's petition, the IHF contends that reducing FM bandwidth to 150 or 100 kHz from 200 kHz would cause a return to "the type of performance that FM tuners and recievers had in the 1950s and 1960s." The institute noted further that if adopted, the proposal would have an adverse effect on millions who own FM receiving equipment, pointing out that owners of frequency-synthesized tuners might not even be able to tune to the new channels.

A new energy-saving product, said to reduce home heat loss by as much as 24%, has been developed by a 17-year-old with the help of a Perkin-Elmer 1100 computer terminal he won at the 1978 Personal Computing show. Nicholas Naumovich, Jr., a senior at Lake Highlands High School in Dallas, TX, won second prize with a computer system he developed to perform energy studies on how efficiently a home is insulated. He used his data as a basis for inventing Thermo-Brite, a material that reduces air infiltration and reflects heat away from a home to keep cooling costs down during summer months. The product is an aluminized film that is designed to cover the exterior of a house. Heating and cooling cost reduction are claimed to be high as $800 annually.

A new Amateur Radio hobbyist class operation has been requested by the Washington State CB Radio Association. In a petition filed with the FCC, the Association stated that the new designation--using SSB transmissions between 27.41 and 28.00 MHz--is necessary because of overcrowding and interference in the CB Radio Service and increase in operations on unauthorized frequencies.

Free software programs are being offered to 8080 Etc. members who have a communications modem. More than 85 types of business, medical, accounting, research, and hobby programs are listed. Acoustic couplers or the IDS card for the S-100 bus is recommended, and transmission rate must be 300 baud. For information about 8080 Etc. membership, dial (209) 638-6392 and type "Hello-w101, 8080-Etc." Annual membership is $25. Send SASE for free list of program titles (include type of system and specific components) to: Membership, The 8080 Etc., P.O. Box 894, Fresno, CA 93714.

Keep a cool head with a new electronic device announced by Majima Co. Ltd. of Tokyo. The new "Stop Sleep" device is designed to cool a driver's head to prevent dozing while behind the wheel. It uses a patented thermoelectronic element and plugs into the vehicle's cigar-lighter socket.

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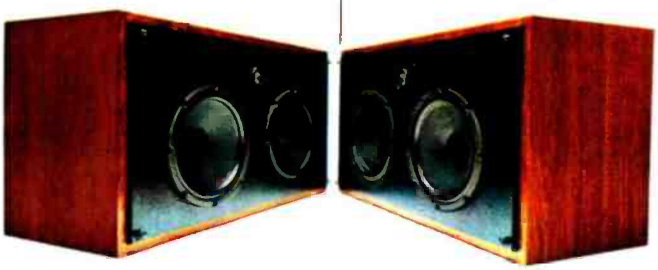

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